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REVIEW

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The relationship between perinatal circadian rhythm and postnatal depression: an overview, hypothesis, and recommendations for practice

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Abstract

Postnatal depression (PND) is an important public health problem with far-reaching consequences for mothers, families, and society. Current treatment approaches tend to focus on the depressive symptoms of the mother. We propose the need for a shift in the conceptualisation of PND and its management, by focusing on circadian rhythm as an early manifestation of mother-infant synchrony. We have reviewed the relevant interdisciplinary literature to formulate a hypothesis and suggest recommendations for practice. We hypothesise that, after a mother's circadian rhythm becomes 'desynchronised' immediately following birth, persistence of this disruption is implicated in the development of PND. This has important implications for novel treatment strategies in the critical and vulnerable postnatal period, for example the use of outdoor-based interventions and light.

Keywords: Postnatal depression, Circadian rhythm, Mother-infant dyad, Nature-based interventions, Light therapy

Introduction

Postnatal depression (PND), also called postpartum depression, is functionally defined as a major depressive episode occurring within 12 months of giving birth. There is mixed evidence about whether PND is distinct from major depressive disorder at other times of life (Batt et al., 2020). Symptoms can include low mood, loss of interest or pleasure, low energy levels, feelings of worthlessness as a mother, guilt or hopelessness, difficulty sleeping, changes in appetite, and can feature agitation or anxious thoughts including about the infant (Symptoms - Postnatal depression, 2022). PND is thought to affect between 10 and 20% of mothers (Gavin et al., 2005; Gelaye et al., 2016; Woody et al., 2017) from diverse cultures (Gelaye et al., 2016; Affonso et al., 2000), and yet it remains understudied (Payne & Maguire, 2019). It is the most common complication of childbirth, with maternal suicide remaining a leading cause of direct deaths occurring within the first postpartum year (Knight et al., 2022). In addition to causing suffering to mothers, mental health problems in the perinatal period increase the risk of intergenerational transmission of mental health difficulties, which itself is considered a substantial contributor to psychiatric morbidity (Netsi et al., 2018; Stein et al., 2014). A key mechanism for transmission risk to infants is impairment of the parent-infant relationship (van IJzendoorn & Bakermans-Kranenburg, 2019; Erickson et al., 2019). When healthy, this relationship is believed to provide the foundation for healthy and secure attachment relationships and mental health of the infant, forming the backbone for positive child outcomes across development domains (Erickson et al., 2019). Children encountering relational challenges in their early caregiving environment, related to low maternal sensitivity and parental mentalisation (van IJzendoorn & Bakermans-Kranenburg, 2019; Erickson et al., 2019), are at

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increased risk of sub-optimal socioemotional, cognitive developmental and physical health outcomes (Erickson et al., 2019; Howard & Khalifeh, 2020).

The underlying precursors to PND are complex and not fully understood (Yim et al., 2015; Howard et al., 2014). Despite sleep being notoriously disrupted in the postpartum period, its importance in the pathophysiology of PND is often overlooked and understudied. Postpartum mothers experience more fragmented, less efficient, and shorter sleep than before and during pregnancy (Gay et al., 2004; Hunter et al., 2009; Montgomery-Downs et al., 2010). Poor sleep quality in this period is linked to depressive symptoms (Dørheim et al., 2009; Lewis et al., 2018; Okun et al., 2018). Disturbed maternal sleep has been associated with more negative maternal perceptions of the mother-infant relationship (Tikotzky, 2016), with poorer objective sleep continuity being related to reduced ability to sustain sensitivity towards their infant (King et al., 2020). Postpartum sleep disturbances are also associated with impairments in maternal emotional, physical, and metabolic wellbeing (Dørheim et al., 2009; Lewis et al., 2018; Taveras et al., 2011; Gunderson et al., 2008), increased stress, and impaired physical functioning (Hunter et al., 2009).

There is increasing interest in the underlying role of circadian rhythm disturbance as a potential cause of sleep disruption which may contribute to major depressive disorder (Wirz-Justice & Benedetti, 2019; Sharkey et al., 2013; Obeysekare et al., 2020). Moreover, emerging evidence suggests that altered perinatal circadian rhythms correlate strongly with PND (Gallaher et al., 2018). Circadian rhythms are natural physical, mental, and behavioural changes, occurring over a 24-hour cycle, that affect most living things including animals, plants, and microbes (Walker et al., 2021). One of the most evident manifestations in humans is the sleep-wake cycle. The relevance of these rhythms to sleep, mood and higher cortical functions in humans are increasingly recognised (Plano et al., 2017). Given the importance sleep and mood in the postpartum period, research is needed into modifiable personal, environmental and social/structural factors that may improve outcomes for mothers and infants, which may have important implications for practice. In this article, we argue that circadian rhythm disturbance affecting the mother-infant dyad (which also involves and affects co-parents and other family members) and its role in PND deserves particular attention as a potentially highly important modifiable factor. This is because the postnatal period represents a particularly vulnerable time for changes in maternal circadian rhythm and also changes in mood, in that these changes occur more commonly and have serious consequences during this time (Gallaher et al., 2018). We review the literature on the association between these phenomena, and explore implications for clinical practice.

Method

The following overview and hypothesis have evolved from a wide range of reading across different disciplines within our research team. To inform the review, PsycINFO, Medline, CINAHL and EMBASE were searched via Healthcare Databases Advanced Search (HDAS), with the latest search being run in March 2022. Please see Appendix 1. for an example search strategy used. KH, JH and RP screened, categorised and discussed all results deemed relevant to this review. We have incorporated ideas from evolutionary biology, anthropology, neuroscience, sleep science, lactation science, and psychiatry, in addition to drawing from our clinical, personal and research experience.

The mother-infant chronobiological dyad hypothesis

Most current treatment modalities for PND, including pharmacological and psychological therapies, tend to focus solely on maternal depressive symptoms, without being informed by dyadic circadian rhythms at play (Forman et al., 2007). These reflect dominant conceptualisations of PND, from which the following hypothesis differs in two substantial ways. First, although perinatal sleep and its links to PND have been studied, there has been little consideration of the potentially underpinning role of circadian rhythm in the development of PND. Secondly, the postpartum period is observed through the lens of the mother-infant dyad, rather than focusing solely on maternal depressive symptoms.

Thomas et al. proposed that initial circadian desynchronisation following childbirth may be an evolutionary adaptation allowing responsive care of the newborn both day and night (Thomas et al., 2014). We further hypothesise that *persisting* abnormalities in circadian rhythm may both increase the risk of PND in the mother and adversely affect the development of the newborn's circadian rhythm, risking additional long-term adverse health consequences. This scenario is outlined in Fig. 1.

We propose the importance of the mother-infant dyad establishing healthy biosocial rhythms, which might reduce the risk of PND, by mitigating the risk of a longer period of maternal circadian desynchronisation, leading to suboptimal infant circadian entrainment.

Alternative to the scenario in Fig. 1, a positive cycle can result from the bi-directional relationship between mother and infant rhythms (see Fig. 2). In this scenario, the infant receives rich multi-sensory stimulation (including light) and biosocial cues during the daytime, enabling faster circadian entrainment, improved infant

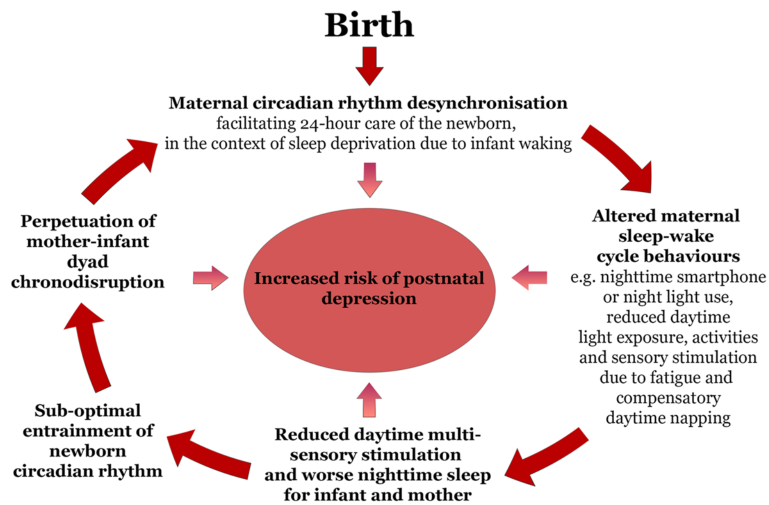

Fig. 1 Perpetuating circadian desynchronisation within the mother-infant dyad

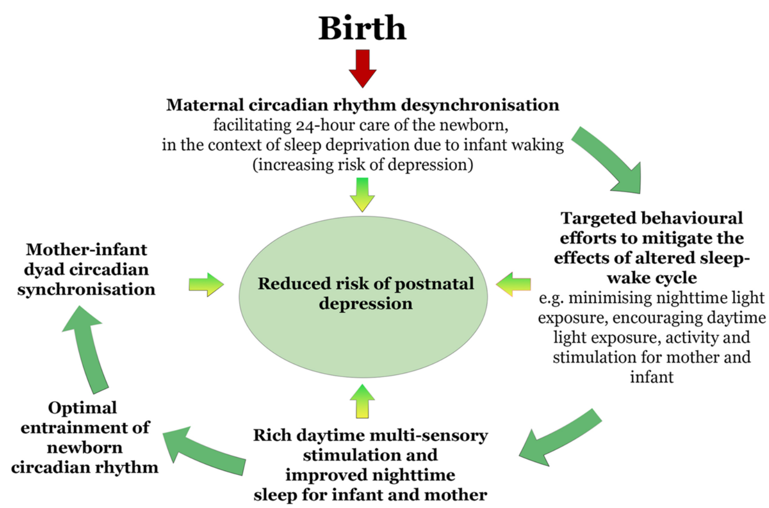

Fig. 2 Optimal circadian resynchronisation within the mother-infant dyad

sleep, and less maternal fatigue. Reduced fatigue allows for further light exposure and diverse activity during the daytime, which continues to strengthen the infant's developing circadian rhythm, and reinforces this positive cycle.

The notion of optimum infant circadian entrainment is used in this context to mean harnessing rich social activity and light stimulation during the daytime and minimising light exposure at night, whilst preserving maternal sensitivity and responsiveness towards the infant throughout the 24-hour cycle (Higley & Dozier, 2009; Deans, 2020). When combined with circadian synchronicity, this would be expected to confer advantageous long-term outcomes for the mother-infant relationship.

Background to the mother-infant chronobiological dyad hypothesis

a) *Circadian rhythm desynchronisation immediately after birth may pose an evolutionary advantage to healthy mother*

The postpartum period is a unique time in a woman's life for major alterations in sleeping patterns, with postnatal women experiencing significantly more subjective and objective sleep disturbance than controls (McBean & Montgomery-Downs, 2013). Studies of circadian rhythm parameters of healthy postpartum women are rare, with most focusing on participants with a history of mood disorders (Sharkey et al., 2013; Krawczak et al., 2016; Parry et al., 2008; Kudo et al., 2021). One small study has compared 24-hour melatonin level and timing in 38 postpartum and 20 non-pregnant nulliparous women (Thomas & Burr, 2006). The findings that postpartum women had significantly higher baseline, lower maximum, lower percentage rise, and differing pattern of 6-sulfatoxymelatonin compared to nonpregnant nulliparous women suggested possible circadian rhythm disruption in the postnatal period. The continued uncertainty regarding healthy postpartum mothers' circadian rhythm status has been attributed to a lack of clarity about appropriate circadian phase markers in clinical settings (Kudo et al., 2021). Objective data derived from actigraphy show decreased circadian amplitude up to 12 weeks after birth, and altered time patterns of activity and rest compared to pre-pregnancy 24-hour diurnal rhythms, indicating that maternal rest/activity rhythms may become desynchronised after giving birth (Wulff & Siegmund, 2000; Nishihara et al., 2002; Matsumoto et al., 2003). We note that the sample sizes in these studies are often small, and that rest-activity rhythms derived from actigraphy are susceptible to multiple masking effects, so cannot always be assumed to reflect the underlying rhythm of the circadian clock. Nevertheless, Thomas et al. (2014) examined the longitudinal pattern of maternal-infant rest/activity rhythm and rhythm synchrony as measured by activity rhythm parameters of 43 healthy mother-infant pairs (Thomas et al., 2014). Healthy mothers were shown to experience early disruption of rest/activity rhythm, with re-establishment of a rhythm over time, and mother-infant rhythms becoming more synchronised by around 12 weeks. An initial decrease in the robustness of the maternal circadian rhythm immediately after birth may thus facilitate nighttime feeding and aids responsive care of the newborn infant, in whom a mature circadian rhythm is yet to be established (Thomas et al., 2014). This is likely to have conferred an evolutionary advantage, but we describe below how this phenomenon may come at a cost.

b) *Abnormally persisting abnormalities in maternal circadian rhythm postnatally may increase the risk of PND*

Perinatal sleep disturbance is associated with PND (Bhati & Richards, 2015; Lawson et al., 2015; Swanson et al., 2020), with disturbed sleep cited as a risk factor for postnatal depressive symptoms (Okun, 2016), and also mothers' postpartum psychological distress found to predict poorer sleep quality (Cohen et al., 2022). Longitudinal studies have sought to clarify pathways linking sleep and PND, concluding that sleep difficulties after the birth of a child may increase the risk of depression, contributing to a vicious cycle between impaired sleep and the persistence of depression (Saxbe et al., 2016). The nature of the sleep difficulties associated with depression after childbirth include poor sleep efficiency and sleep maintenance, and fragmented sleep (Dørheim et al., 2009; Goyal et al., 2009; Bei et al., 2010).

Moreover, Gallaher et al. (2018) provide an important review of how altered circadian rhythms during pregnancy and postpartum correlate strongly with depression (Gallaher et al., 2018). Since their review, Obeysekare et al. (2020) have examined whether sleep timing during the third trimester of pregnancy predicted postpartum symptoms of mania, depression, and obsessive-compulsive disorder (OCD) (Obeysekare et al., 2020). They found that a 'late sleep' group, defined as average sleep onset after 11.27 pm, reported significantly more manic and depressive symptoms at postpartum week 2. This is in keeping with previous research suggesting that evening circadian preference may make postnatal women more vulnerable to depressive symptoms (Sharkey et al., 2013), and with the association between delayed circadian phase and depression severity observed in non-perinatal populations (Emens et al., 2009; Meyer et al., 2022). It can be hypothesised that postnatal mothers who have difficulty adapting to an earlier circadian preference, which accommodates an earlier bedtime, may be less able to maximise their sleep in the face of inevitable infant night wakenings (Sharkey et al., 2013). Kudo et al. (2021) studied whether salivary melatonin concentrations at awakening in healthy postpartum mothers can identify misalignment between awakening time and the biological clock system (Kudo et al., 2021). They found that melatonin levels either higher than 16 pg/ml or lower than 4 pg/ml were a significant predictor of higher Edinburgh Postnatal Depression Scale (EPDS) scores. The authors suggested that these unusually high or low melatonin levels could identify a phase-delayed circadian rhythm in postpartum mothers that could be associated with depressed mood. In keeping with earlier work, these studies build the picture that circadian rhythm is an important but hitherto neglected factor influencing postnatal mood.

c) *Maternal circadian disruption adversely affects the development of the newborn's circadian rhythm*

Although the human foetus already starts to exhibit circadian rhythmicity in many physiological functions (Serón-Ferré et al., 2012), major establishments in the sleep-wake cycle occur in the infant through entrainment by the maternal circadian rhythm and postnatal light experience (Wieduwilt et al., 2020; Brooks & Canal, 2013).

Studies from Neonatal Intensive Care Units (NICUs) represent extreme examples of environment-related circadian disruption, in which maternal entrainment of the newborn rhythm is often limited by the separation of the dyad under these circumstances (Bueno & Menna-Barreto, 2016; Lee et al., 2010). In term infants who are not separated from the mother, less is understood about the impact of their newborn circadian rhythm being entrained by a disrupted maternal circadian rhythm. There is paucity of human research in this area, although animal studies have found long-term negative implications for progeny health following maternal chronodisruption from pregnancy (Varcoe et al., 2018).

The postnatal period appears to offer important opportunities for mothers and other caregivers to expose their infants to healthy circadian lighting and feeding conditions. Further research is required on this important issue, given that a functioning circadian rhythm postpartum is important for the long-term health of the newborn (Thomas et al., 2014; Yates, 2018). Failure to establish an organised circadian rhythm in the infant is associated with infant feeding difficulties, poor weight gain, altered parent-infant interaction, and an erratic sleep-wake pattern (Thomas et al., 2014). These issues may compound postnatal maternal mood difficulties, creating a potentially vicious cycle.

What causes perpetuation of postnatal mother-infant circadian desynchronisation, and what can help?

The biological master clock located in the suprachiasmatic nuclei in the hypothalamus requires daily resetting by external cues in order to maintain a regular circadian rhythm (Wright et al., 2013). These external cues include light, meals, exercise and social activity (Wright et al., 2013). There are many reasons why re-establishing a robust circadian rhythm during the postnatal period may pose difficulties. Life with a new baby can continue to disrupt the master clock (Kudo et al., 2021). This is especially the case in modern human civilisation, in which patterns of light exposure, feeding methods and activities diverge significantly from lifestyles believed to be typical throughout human evolutionary history (Hahn-Holbrook & Haselton, 2014).

Light

Ambient light is a powerful environmental stimulus required for the running of a healthy circadian rhythm and healthy sleep (Walker et al., 2021). Modern humans spend significantly more time indoors, which has led to several concerns, including inadequate daytime light exposure. Tsai and colleagues found that, on average, 7-week postpartum mothers and infants spent ~71% and ~80% respectively of the time between 06:00 and 21:59 h in < 50 lux dim light, and only ~6% and ~2% respectively in > 1000 lux bright light (Tsai et al., 2009). A further small study using actigraphy identified that infants spent only one-eighth of their daytime hours in an environment with > 100 lux light level, and that increased duration of daily exposure to > 100 lux of illumination was associated with stronger circadian patterns of infant activity (Tsai et al., 2012). The authors explain the benefits of new parents spending more time outdoors with their infants in natural sunlight. The benefits of spending more time outdoors may not be limited to those concerning circadian rhythm, but may include those from experiencing greater contact with the natural environment (Frumkin et al., 2017; Bratman et al., 2019). In addition, spending time outdoors is likely to present opportunities for physical and social activity, which may also be beneficial for sleep by increasing sleep drive, as well as enhancing circadian rhythmicity.

Earlier studies in NICUs have provided opportunities to study the effects of light exposure on preterm infants. Findings include, for example, that preterm infants show an earlier emergence of the 24-hour sleep-wake rhythm compared to term infants, suggesting that the length of exposure to external time cues, such as light, play an important role in circadian rhythm maturation (Guyer et al., 2015). It has also been suggested that the abnormal postnatal lighting environments of NICUs have masking effects on biological rhythm expression in newborns, inducing an ultradian pattern, although some authors have found that this masking effect improved when infants are delivered home (Bueno & Menna-Barreto, 2016).

Healthy term infants may face fewer abnormal lighting conditions than those found in NICUs, but modern lifestyles result in far-from-ideal exposures to nighttime light in the home environment. Many caregivers report the use of light sources when caring for infants at night, such as night lights, smartphones and televisions (McBean & Montgomery-Downs, 2015). The blue light emitted from these screens has been found in general populations to phase-delay endogenous circadian rhythm (Krishnan et al., 2020). This problem has been likened to that faced by night shift workers, who are themselves at an increased risk of depression (Kudo et al., 2021; Chellappa et al., 2020). If a night light is required, dim red light is thought not to suppress nocturnal melatonin as does blue light, although there is still some question as to whether it affects other circadian parameters such as cortisol (Figueiro & Rea, 2010; Petrowski et al., 2021).

Given the long-term adverse health consequences of maladaptive infant circadian rhythm entrainment described earlier, recommendations about encouraging light exposure during the daytime and maximising darkness at night for newborns should arguably be disseminated to new parents.

Activity, social interaction and exercise

Lee at al. conducted exploratory work in a sample of 51 mothers of preterm infants to describe their daytime activity levels and the association with sleep, fatigue and depressive symptoms (Lee et al., 2012). Circadian activity rhythms (CARs) were ascertained by actigraphy; mothers with low daytime activity slept less at night and napped more during the day, and reported more postpartum depressive symptoms, compared to high activity mothers. The issue of reverse causality threatens causal inference here, in that depression could itself lead to low daytime activity and poor sleep at night. Nevertheless, this theory has implications for psychoeducation about strategies which may confer important circadian benefits to mothers and infants.

The hypothesis outlined in this article provides further support for postnatal interventions prioritising neuroprotective developmental care, which emphasise supporting parents to engage with rich biosocial cues in the daytime (including activity, social interaction and exercise), whilst in close proximity to their infant (Whittingham & Douglas, 2014). One evidence-based example is the Neuroprotective Developmental Care (NDC) approach, developed by Douglas et al. in Australia (Crawford et al., 2022). This provides a uniquely holistic approach to supporting families in the perinatal period, acknowledging the interrelatedness of infant feeding, sleep, cry-fuss behaviours, and maternal mood. In practice, assessment, planning and intervention are integrated across the five domains of infant health, maternal health, sleep, sensory experiences, and feeding (Crawford et al., 2022).

Feeding

A further mechanism by which maternal circadian rhythm can influence that of the infant is via breast milk. Numerous benefits of breastfeeding have been established, but the influence of feeding method on the development of an infant's circadian rest-activity rhythm has only recently been examined in small samples (Caba-Flores et al., 2022). Results suggest that breastfed infants develop a more regular circadian rest-activity rhythm, and obtain this earlier, than mixed breast/bottle fed infants (Kikuchi et al., 2020), and have better sleep parameters (Abdul Jafar et al., 2021). In addition, mixed-feeding mothers' nocturnal sleep was more disturbed than that of exclusively breastfeeding mothers (Kikuchi et al., 2020). Melatonin concentration in breast milk varies in a circadian pattern, with higher melatonin concentrations in nighttime breast milk (Italianer et al., 2020), making it known as a 'chrononutrient' (Gombert & Codoñer-Franch, 2021). It therefore appears that, before the infant's circadian rhythm is yet functioning, melatonin consumption in breast milk can help circadian stimulation (Gombert & Codoñer-Franch, 2021). It can be hypothesised that a robust maternal circadian rhythm could confer advantages to the infant via optimal melatonin transfer during breastfeeding, including at night, if this is possible for the mother with adequate support.

In addition to infant feeding, maternal diet is also likely to affect circadian rhythm. This occurs through meal timings, a well-known circadian cue (Pickel & Sung, 2020), but perhaps also through the influence of diet on the gut microbiota, which is being found in new research to have circadian rhythm-altering properties (Bishehsari et al., 2020). Indeed, breastfeeding has been found to confer advantages for the infant microbiota (Fitzstevens et al., 2017). The intersection of microbiome research with infant circadian rhythm maturation is another rich field for exploration which is beyond the scope of this review.

Parent-infant proximity

Anthropologists in this field have observed how, in the majority of world cultures, mothers and caregivers carry their infants during the day and sleep in close proximity to them at night (Rudzik & Ball, 2021). It has been observed that increased maternal presence and physical contact, including at night, provide beneficial regulatory effects on infant circadian rhythm entrainment (Tsai et al., 2011). Infants remaining close to caregivers during daytime naps, as well as reducing the risk of Sudden Infant Death Syndrome (SIDS), allows infants to be exposed to important daytime circadian cues of light, noise and activity (Douglas et al., 2015). This further helps them to differentiate nighttime and daytime sleep. Bedsharing and co-sleeping (parents sleeping close to their infants) may facilitate maximum responsiveness (comforting and feeding) with minimal nighttime activity and light stimulation. However, dominant Western models of infant care often emphasise separation of the mother and infant at night (Rudzik & Ball, 2021). Ensuring that non-Western discourses of sleep are given prominence may help to understand the benefits conferred by

Table 1 Postnatal circadian rhythm-informed recommendations for practice

Recommendation domain	Example actions
Light exposure	Evidence suggests that maximising light exposure during the day and minimising light exposure at night facilitates circadian synchronicity of the mother-infant dyad (e.g., spending time outdoors during the day, minimising smartphone use at night)
Feeding	Feeding can be an important circadian entrainer, including at night. Breast milk may pose additional circadian-related advantages, information which may be useful to parents when making feeding decisions
Activity	Parent-infant proximity may facilitate healthy newborn circadian entrainment, by exposing infants to activity during the day, and maintaining quiet responsiveness at night

mother-infant proximity in other sociocultural contexts (Ball et al., 2019), not least those of a circadian rhythm-promoting nature.

Implications for clinical practice and future research

Public health advice

Table 1 summarises possible recommendations for parents, informed by the limited evidence of the importance of circadian rhythm at this time.

Targeted treatment for PND

Current treatments for PND do not take into account the underlying importance of disrupted circadian rhythm. Paying attention to this potentially critical component in the development of PND invites targeted chronotherapeutic strategies which are likely to help both the mother and the infant. An example requiring further research is the use of light, which is the principal environmental determinant of circadian rhythm (Küller, 2002; Wirz-Justice et al., 2011). This could be natural sunlight from spending time outdoors, or via bright light therapy (BLT) (Wirz-Justice & Benedetti, 2019). Bright light exposure has been found to shift circadian phase and thereby improve sleep in a variety of settings, including when changing time zones (Blume et al., 2019). There also is evidence for, and consensus on, the use of BLT in treating non-seasonal depression (Wirz-Justice et al., 2005). In the context of major depression, a systematic review and meta-analysis provides evidence for the efficacy of BLT in augmenting antidepressants and possibly speeding the response (Penders et al., 2016; Geoffroy et al., 2019). It has been argued that BLT is thus a useful candidate for treating PND, where a quicker response is particularly important for the mental health of the mother and infant.

Another growing field of research is the link between the natural environment and human health, and into developing so-called nature-based interventions (Harper et al., 2021). These interventions may encourage greater 'nature connectedness', which is associated with higher mental and physical wellbeing, by spending time outside in the natural world (Pritchard et al., 2019). Mothers and infants being supported to spend more time together outdoors could confer advantages not only in terms of light exposure, but also by providing opportunities for physical activity (Fullam et al., 2021), social contact (Fullam et al., 2021), rich daytime sensory stimulation which is important for infant development (Lickliter, 2011), and opportunities to diversify commensal microbiota (Robinson & Jorgensen, 2020).

Conclusion

We have argued for the importance of recognising how the onset or perpetuation of PND may in part reflect circadian rhythm disruption within the mother-infant dyad. We presented the hypothesis that, by optimising circadian rhythmicity in the postnatal period, the risk of PND could be reduced, as well as the risk of other adverse health consequences caused by circadian desynchronisation in both mother and infant. This could inform health professionals' recommendations to new parents, by including those promoting circadian health. However, several limitations exist in the current evidence base, including a detailed knowledge of which circadian parameters are affected in both healthy and depressed postnatal women. Interventions promoting optimal postnatal light exposure, activity and social cues for the mother-infant dyad merit further research, given that they may represent culturally-appropriate, non-stigmatising and low-cost approaches to supporting postnatal maternal and infant wellbeing.

Appendix

Table 2

Table 2 Example search strategy

Strategy	Database	Search term	Results
2	PsycINFO	exp "HUMAN BIOLOGICAL RHYTHMS"/	7436
3	PsycINFO	CHRONOTYPE/	620
4	PsycINFO	(circadian rhythm*).ti,ab	8945
5	PsycINFO	(body clock*).ti,ab	743
6	PsycINFO	(biological rhythm*).ti,ab	1930
7	PsycINFO	(sleep*wake).ti,ab	1015
8	PsycINFO	(circadian disturbance*).ti,ab	1210
9	PsycINFO	(2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8)	15,351
10	PsycINFO	MOTHERS/	44,891
11	PsycINFO	"POSTNATAL PERIOD"/	5103
12	PsycINFO	(mother* OR maternal).ti,ab	152,143
13	PsycINFO	(post*natal).ti,ab	20,604
14	PsycINFO	(post*partum).ti,ab	12,441
15	PsycINFO	(10 OR 11 OR 12 OR 13 OR 14)	174,809
16	PsycINFO	(9 AND 15)	432
17	Medline	(circadian rhythm*).ti,ab	33,293
18	Medline	(body clock*).ti,ab	2767
19	Medline	(biological rhythm*).ti,ab	5771
20	Medline	(sleep*wake).ti,ab	1826
21	Medline	(circadian disturbance*).ti,ab	2649
22	Medline	(17 OR 18 OR 19 OR 20 OR 21)	39,152
23	Medline	(mother* OR maternal).ti,ab	411,179
24	Medline	(post*natal).ti,ab	109,614
25	Medline	(post*partum).ti,ab	57,197
26	Medline	(23 OR 24 OR 25)	533,741
27	Medline	(22 AND 26)	904
28	CINAHL	exp "BIOLOGICAL CLOCKS"/	586
29	CINAHL	exp "CIRCADIAN RHYTHM"/	7020
30	CINAHL	"SLEEP DISORDERS, CIRCADIAN RHYTHM"/	702
31	CINAHL	"CHRONOBIOLOGY DISORDERS"/	295
32	CINAHL	(circadian rhythm*).ti,ab	2770
33	CINAHL	(body clock*).ti,ab	373
34	CINAHL	(biological rhythm*).ti,ab	467
35	CINAHL	(sleep*wake).ti,ab	11
36	CINAHL	(circadian disturbance*).ti,ab	489
37	CINAHL	(28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36)	9464
38	CINAHL	MOTHERS/	31,370
39	CINAHL	"MOTHER-INFANT RELATIONS"/	3137
40	CINAHL	exp "POSTNATAL PERIOD"/	14,049
41	CINAHL	PUERPERIUM/	555
42	CINAHL	(mother* OR maternal).ti,ab	140,927
43	CINAHL	(post*natal).ti,ab	17,029
44	CINAHL	(post*partum).ti,ab	23,084
45	CINAHL	(38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44)	175,003
46	CINAHL	(37 AND 45)	195
47	EMBASE	"CIRCADIAN RHYTHM"/	89,247
48	EMBASE	PHOTOPERIODICITY/	10,836
49	EMBASE	"BIOLOGICAL RHYTHM"/	6983
50	EMBASE	(circadian rhythm*).ti,ab	33,999

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