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Cláudia Castro Dias & Bárbara Figueiredo

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REVIEW ARTICLE



Sleep-wake behaviour during the first 12 months of life and associated factors: a systematic review

Cláudia Castro Dias  and Bárbara Figueiredo 

School of Psychology, University of Minho, Braga, Portugal

ABSTRACT

This paper aims to provide a systematic review of the literature on the associated factors with infant sleep-wake behaviour during the first 12 months of life, namely (1) the factors positively and negatively associated with sleep-wake behaviour and (2) the factors positively and negatively affected by sleep-wake behaviour. This systematic review was based on a standard protocol constructed according with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement and included 146 papers. Two typologies of factors were found in the literature: factors positively and negatively associated with infant sleep-wake behaviour and effects of sleep-wake behaviour. Different factors were identified as being positively and negatively associated with the different sleep-wake behaviours and positively and negatively affected by the different sleep-wake behaviours during the first 12 months of life. Some inconsistent results could be explained by methodological differences between the studies.

ARTICLE HISTORY

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KEYWORDS

Sleep-wake behaviour; infant; positive factors; negative factors

Literature has been shown that infant sleep-wake behaviour is associated with several factors: infant factors, namely temperament (Kaley, Reid, & Flynn, 2012; Sorondo & Reeb-Sutherland, 2015) and parental factors, namely parental psychopathology (Sadeh, Tikotzky, & Scher, 2010). Moreover, a recent review pointed for a bidirectional association, arguing that parental factors influence and are influenced by infant sleep-wake behaviour, within the context of a transactional model (Sadeh et al., 2010). The transactional model argues that the bidirectional associations between parental factors and infant sleep-wake behaviors are complex and dynamic (Sadeh et al., 2010).

Several changes and high individual stability have been observed in infant sleep wake-behaviour during the first months (Figueiredo, Dias, Pinto, & Field, 2016), being imperative to identify the factors that could be associated with sleep-wake behaviour during the first 12 months of life. The identification of these factors could help to the prevention and early intervention on infant's sleep problems and to guide future research on infant sleep-wake behaviour.

To our knowledge, there is no systematic review in the literature identifying the factors positively and negatively associated with sleep-wake behaviour during the first 12 months of life. This paper aims to provide a systematic review of the literature on the associated factors with infant sleep-wake behaviour during the first 12 months of life, namely (1) the factors positively and negatively associated with sleep-wake behaviour and (2) the factors positively and negatively affected by sleep-wake behaviour.

Materials and methods

This systematic review was based on a standard protocol constructed according with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Moher, Liberati, Tetzlaff, & Altman, 2009).

Literature search

The authors performed a literature search to identify manuscripts referring infant sleep-wake behaviour published between June 1996 and June 2016. The search covered three databases: MEDLINE, ISI Web of Knowledge, and PsycINFO using the keywords: sleep AND infant OR baby. Considering the spoken languages by the two authors, English, Portuguese, Spanish, Italian, and French written articles were included. The first author performed the electronic search and the second author independently replicated it. To select potentially relevant papers, the two authors independently analyzed the titles and the abstracts ($n = 8610$) obtained in the electronic search and excluded the manuscripts that did not study factors associated with infant sleep-wake behaviour ($n = 8244$). The manuscripts whose abstracts assessed factors associated with infant sleep-wake behaviour ($n = 367$) were then independently analyzed for inclusion/exclusion criteria by the two authors, leading to the exclusion of 220 manuscripts. Through all the literature search process, the two authors reached consensus through discussion.

Inclusion and exclusion criteria

This systematic review included only original empirical articles addressing factors associated with sleep-wake behaviour during the first 12 months of life. The authors used the following inclusion criteria: (a) original studies; (b) assessing factors associated with sleep-wake behaviour; (c) during the first 12 months of life. Studies were excluded based on the following exclusion criteria: (a) non-original research (e.g. literature reviews, systematic reviews, or meta-analysis); (b) studies assessing infants above 12 months or studies that did not indicate infant's age; (c) sleep interventions or clinical trials; (d) case reports or single case studies.

Quality assessment

All included studies were scored for quality, based on the system of Downs and Black (Downs & Black, 1998), a Quality Index that evaluates the methodological quality of randomized and non-randomized studies. The Quality Index is comprised of 27 items that are aggregated in 5 sub-scales. Fourteen items, from the total 27, were selected to score all the studies that were included in this systematic review, with a maximum possible score of 15. Manuscripts scoring >10 in the Quality Index were considered good, those scored between seven and 10 were considered moderate, and those scoring < 7 were considered poor.

Data extraction

One author extracted the data from the studies to 2 data sheets (Tables 1 and 2) and the other author reviewed the data. The data sheets were organized according with (1) factors typology, namely: factors positively and negatively associated with infant sleep-wake behaviour and factors positively and negatively affected by infant sleep-wake behaviour and (2) the publication year.

This systematic review included the different sleep-wake behaviors studied in the literature: sleep duration (number of hours that infants spend sleeping), Wake After Sleep Onset (WASO) (number of hours that infants spend awake during the night), sleep periods (number of sleep episodes) and night wakings (number of wakings during the night), sleep latency (time infants take to fall asleep), longest

Table 1. Factors positively and negatively associated with infant sleep-wake behaviour during the first 12 months of life.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
<i>Factors positively associated with infant sleep-wake behaviour during the first 12 months of life</i>								
Blair et al. (2012)		UK	L	Birth order	11478 6 months	Q	SD (24 h)	SD (24 h) at 6 months not associated with number of siblings
Kaley et al. (2012)		UK	CS	Birth order	77 1–2 months	D	SD (24 h, day, night), NW	↑ SD (24 h, day) at 1–2 months in non-first-time infants NW not associated with birth order
Kozyrskyj, Kendall, Zubrick, Newnham, and Sly (2009)		Australia	L	Birth order	2398 12 months	Q	NW	↑ NW at 12 months associated with ↑ siblings
Santos, Mota, and Matijasevich (2008)		Brazil	L	Birth order	3907 0 and 12 months	I	NW	↑ NW at 12 months in non-first-born infants
So, Michael Adamson, and Horne (2007)		Australia	L	Birth order	20 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months	Combined measures: A and D	SD (24 h, day, night), NW	SD (24 h, day, night) and NW at 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, and 12 months not associated with birth order ↓ SD (night) at 7 months (measured by D) in non-first-born infants
Quillin (1997)		USA	CS	Birth order	44 1 month	D	SD (24 h, night), NW, SP (24 h)	SD (24 h, night), NW, and SP (24 h) at 1 months not associated with birth order
Blair et al. (2012)		UK	L	Ethnicity	11478 6 months	Q	SD (24 h)	↓ SD (24 h) at 6 months in non-white infants
Santos, Matijasevich, and Domingues (2012)		Brazil	CS	Ethnicity	885 3 months	I	NW	↑ NW at 3 months in non-white infants
Nevarez, Rifas-Shiman, Kleinman, Gillman, and Taveras (2010)		USA	L	Ethnicity	1676 6, and 12 months	Q	SD (24 h)	↓ SD (24 h) at 6 and 12 months in non-white infants
Bathory et al. (2016)		USA	CS	Parental education	557 9 months	Q	SD (day, night)	↓ SD (night) associated with ↓ parental health literacy SD (day) not associated with parental health literacy
Blair et al. (2012)		UK	L	Parental education	11478 6 months	Q	SD (24 h)	SD (24 h) at 6 months not associated with maternal education and paternal social class
Kozyrskyj et al. (2009)		Australia	L	Parental education	2398 12 months	Q	NW	NW at 12 months not associated with maternal education
Nevarez et al. (2010)		USA	L	Parental education	1676 6, and 12 months	Q	SD (24 h)	↓ SD (24 h) at 6 and 12 months associated with ↓ maternal education
Palmstierna, Sepa, and Ludvigsson (2008)		Sweden	L	Parental education	16467 12 months	Q	NW	↑ NW at 12 months associated with ↑ parental theoretical education
Orsi et al. (2015)		Brazil	L	NICU characteristic	13 0 months	P	SD (24 h, day, and night)	↑ SD (24 h and day) associated with reduced sensory and environmental stimuli SD (night) not associated with sensory and environmental stimuli
Touchette et al. (2013)		Canada	L	Genetic/ environment (twins)	995 6 months	Q	SD (day, night)	↑ SD (night) at 6 months associated with genetic influences SD (day) at 6 months associated with environmental influences
Tourula, Isola, Hassi, Bloigu, and Rintamäki (2010)		Finland	CS	Environment	34 3 months	O	SD (day)	↑ SD (day) at 3 months in outdoor environment

(Continued)

Table 1. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
Bhat et al. (2006)		UK	CS	Sleep position	24 0 months	P	SD (day), SP (day), SE	↑ SD (day), ↓ SP (day), and ↑ SE at 0 months associated with prone position
Utgun, Öndoğan, Yalaz, and Yildirim Sözmén (2015)		Turkey	CS	Clothes' fabrics	8 6–12 months	NS	SD (night)	↑ SD (night) at 6–12 months associated with wearing Ö4 fabric
Brand, Furlano, Sidler, Schulz, and Holsboer-Trachsler (2011)		Switzerland	L	Cortisol	16 2 and 3 months	A	SD (day, night), A (day, night)	↑ SD (night) and ↑ NW at 3 months associated with ↑ cortisol secretion in infants with colic
Lucas-Thompson et al. (2009)		USA	L	Cortisol	92 6 and 12 months	Q	NW	↑ NW at 6 and 12 months associated with ↑ cortisol response to stress at 6 and 12 months
Larson, White, Cochran, Donzella, and Gunnar (1998)		USA	CS	Cortisol	78 2–4 months	D	SD (night)	↑ SD (night) at 2–4 months associated with early morning peak in cortisol levels
Shinohara and Kodama (2011)		Japan	CS	Melatonin	67 3–5 months	D	SD (night), NW, SP (day), LSP (24 h)	↑ SD (night) at 3–5 months associated with ↓ morning melatonin levels at 3–5 months
Pennestri et al. (2015)		Canada	L	Attachment	138 6, 12 months	Q	SD (night), NW, SL (night), LSP (night), BT	↓ SD (night), ↑ NW and ↑ BT at 6 and 12 months in disorganized children than in secure and ambivalent children ↓ LSP (night) at 12 months in disorganized children than in secure and ambivalent children SL (night) not associated with attachment
Zentall, Braungart-Rieker, Ekas, and Lickenbrock (2012)		USA	L	Attachment	46 7, 12 months	Q	NW	↓ NW from 7 to 12 and 14 months in infants with secure attachment NW at 7 months not associated with attachment
Scher (2001a)		Israel	CS	Attachment	94 12 months	A	SD (night), NW, LSP (night), SL (night)	SD (night), NW, LSP (night), and SL (night) at 12 months not associated with attachment style
de Graag, Cox, Hasselman, Jansen, and de Weerth (2012)		The Netherlands	L	Mother–infant relationship	84 1 and 5 months	D	LSP (24 h)	↑ LSP (24 h) from 1 to 5 months associated with ↑ flexible mother–infant interactions at 5 months
Schwichtenberg, Anders, Vollbrecht, and Poehlmann (2011)		USA	L	Mother–infant relationship	134 4 and 9 months	D	SD (day), SP (day)	↑ SD (day) at 9 months associated with ↑ maternal negative affect and behaviour at 4 and 9 months ↑ SP (day) at 4 and 9 months associated with ↑ optimal maternal interactive behaviors at 24 months
Scher (2001b)		Israel	CS	Mother–infant relationship	37 12 months	A	SD (night), NW, SE, BT	↑ NW at 12 months associated with ↑ mother–infant relationship ↑ SE at 12 months associated with ↑ infant responsiveness, but not with other mother–infant interaction dimensions SD (night) and BT at 12 months not associated with mother–infant interaction
<i>Factors negatively associated with infant sleep-wake behaviour during the first 12 months of life</i>								
Saenz, Yaughner, and Alexander (2015)		USA	L	Gender	47 3–4 months	A	SD (night), SE	SD (night) and SE at 3–4 months not associated with gender
Blair et al. (2012)		UK	L	Gender	11478 6 months	Q	SD (24 h)	↓ SD (24 h) at 6 months in boys
Kaley et al. (2012)		UK	CS	Gender	77 1–2 months	D	SD (24 h, day, night), NW	↑ NW at 1–2 months in boys SD (24 h, day, night) not associated with gender

Santos et al. (2012)	Brazil	CS	Gender	885 3 months	I	NW	↑ NW at 3 months in boys
LampI and Johnson (2011)	USA	L	Gender	23 0–12 months	D	SD (24 h), SP (24 h), LSP (24 h)	↑ SP (24 h) and ↓ LSP (24 h) at 0–12 months in boys SD (24 h) not associated with gender
Kozyrskij et al. (2009)	Australia	L	Gender	2398 12 months	Q	NW	NW at 12 months not associated with gender
Santos et al. (2008)	Brazil	L	Gender	3907 0 and 12 months	I	NW	↑ NW at 12 months more in boys
Anuntaseree, Mo-Suwan, Vasiknanonte, Kuasirikul, and Choprapawan (2008)	Thailand	CS	Gender	3172 3 months	I	NW	↑ NW at 3 months in boys
So et al. (2007)	Australia	L	Gender	20 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months	Combined measures: A and D	SD (24 h, day, night), WASO, SP (day), LSP (night)	↓ SD (day) at 1 (measured by A and D) and 2 (measured by A) months in boys SD (day) at 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months not associated with gender SD (24 h, night), WASO, and LSP (night) at 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 months not associated with gender
Thomas and Foreman (2005)	USA	CS	Gender	37 1–2 months	D	SD (24 h), SP (24 h), LSP (24 h)	↓ SD (24 h) at 1–2 months in boys SP (24 h), LSP (24 h) at 1–2 months not associated with gender
Goodlin-Jones, Burnham, Gaylor, and Anders (2001)	USA	CS	Gender	80 3, 6, 9, or 12 months	V	NW, LSP (night)	↑ LSP (night) in girls NW not associated with gender
Bach, Telliez, Leke, and Libert (2000)	France	CS	Gender	38 1 month	EEG	SD (24 h), LSP (24 h)	↓ SD (24 h), and ↓ LSP (24 h) at 1 month in boys
Blair et al. (2012)	UK	L	Parents' socio- demographic factors	11478 6 months	Q	SD (24 h)	↓ SD (24 h) at 6 months in infants of older mothers
Kozyrskij et al. (2009)	Australia	L	Parents' socio- demographic factors	2398 12 months	Q	NW	↑ NW at 12 months in infants of mothers older than 20 years NW at 12 months not associated with maternal marital status
Nevarez et al. (2010)	USA	L	Parents' socio- demographic factors	1676 6, and 12 months	Q	SD (24 h)	↓ SD (24 h) at 6 and 12 months associated with infants of single/divorced parents
Palmstierna et al. (2008)	Sweden	L	Parents' socio- demographic factors	16467 12 months	Q	NW	↑ NW at 12 months associated with non-Swedish parents and marginally associated with single parent at birth
Tomalski et al. (2013)	UK	CS	Socio-economic factors	45 6–9 months	Q	SD (24 h, day, night), WASO, NW	SD (24 h, day, night), WASO, and NW not associated with income
Nevarez et al. (2010)	USA	L	Socio-economic factors	1676 6 and 12 months	Q	SD (24 h)	↓ SD (24 h) at 6 and 12 months associated with ↓ household incomes, and ↑ household members
Kozyrskij et al. (2009)	Australia	L	Socio-economic factors	2398 12 months	Q	NW	NW at 12 months not associated with financial problems and income
Santos et al. (2008)	Brazil	L	Socio-economic factors	3907 0 and 12 months	I	NW	↑ NW at 12 months in infants whose mothers were employed during pregnancy

(Continued)

Table 1. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
Fouts, Roopnarine, and Lamb (2007)		USA	CS	Socio-economic factors	62 3–4 months	O	SD (day), SP (day), LSP (day)	↑ SP (day) and ↓ LSP (day) at 3–4 months in infants from ↓ socioeconomic status SD (day) at 3–4 months not associated with socioeconomic status
Cohen, Atun-Einy, and Scher (2012)		Israel	CS	Environment	34 7 months	A	SD (night), WASO, NW, BT, WT	↑ BT at 7 months in winter months SD (night), WASO, and NW and WT at 7 months not associated with seasonal effects
Bottino et al. (2012)		USA	CS	Environment	1226 12 months	Q	SD (24 h)	↓ SD (24-hour) at 12 months associated with ↑ urban environments
Harrison (2004)		UK	L	Environment	66 1, 2, 3 months	Combined measures: D and A	SD (night)	↓ SD (night) at 1 month associated with ↓ exposure to light during the afternoon
Kozyrskij et al. (2009)		Australia	L	Environment	2398 12 months	Q	NW	↑ NW at 12 months associated with mothers not smoking at 12 months NW at 12 months not associated with exposure to stressful events
Santos et al. (2012)		Brazil	CS	Gestational exposure	885 3 months	I	NW	NW at 3 months not associated with gestational exposure to caffeine ↑ NW at 3 months in infants exposed to smoke and alcohol during pregnancy
Kozyrskij et al. (2009)		Australia	L	Gestational exposure	2398 12 months	Q	NW	↑ NW at 12 months associated with ↑ stressful events during early pregnancy and no exposure to smoke during pregnancy
Lehnkering, Korte, and Siegmund (2009)		Germany	CS	Gestational exposure	22 0 months	Combined measures: A and D	SD (24 h)	SD (24 h) at 0 months not associated with gestational exposure to smoke
Hanft, Burnham, Goodlin-Jones, and Anders (2006)		USA	L	Gestational exposure	34 1, 3, 6, 9, and 12 months	V	SD (night), WASO, NW, LSP (night)	↓ SD (night) at 3, 6, and 12 months and ↓ LSP (night) at 6 months in infants exposed to substances during pregnancy WASO and NW at 1, 3, 6, 9, and 12 months, SD (night) at 1 and 9 months and LSP (night) at 1, 3, 9, and 12 months not associated with gestational exposure to substances
Korte, Hoehn, and Siegmund (2004)		Germany	L	Delivery mode	57 0 months	A	SD (24 h, day, night), SP (day)	SD (24 h, day, night) at 0 months not associated with delivery mode ↑ SP (day) at 0 months in infants born by planned C-section
Huang, Paiva, Hsu, Kuo, and Guilleminault (2014)		China	CS	Gestational age	191 6 months	Q	SD (day, night) NW	↑ SD (day, night) and ↑ NW at 6 months in preterm infants
Guyer et al. (2015)		Switzerland	L	Gestational age	48 1, 3, and 6 months	D	SD (24 h, day, night), LSP (night)	↑ SD (night) and ↑ LSP (night) at 1, 3, and 6 months in premature infants SD (24 h, day) at 1, 3, and 6 months not associated with gestational age
Asaka and Takada (2010)		Japan	CS	Gestational age	28 12 months	A	SD (24 h, day, night), WASO, NW	↓ SD (night) at 12 months in preterm infants SD (24 h, day), WASO, and NW at 12 months not associated with gestational age

Kozyrskyj et al. (2009)	Australia	L	Gestational age	2398 12 months	Q	NW	↓ NW at 12 months in preterm infants
Volkovich, Ben-Zion, Karny, Meiri, and Tikotzky (2015)	Israel	L	Feeding method	153 3 and 6 months	Combined measures: A and D	NW	↑ NW at 3 and 6 months associated with breastfeeding at 3 months
Brown and Harries (2015)	UK	CS	Feeding method	715 6–12 months	Q	NW	NW at 6–12 months not associated with feeding method
Huang et al. (2016)	China	L	Feeding method	524 1, 3, 5, and 8 months	D	SD (24 h, day, night), NW, SP (day), LSP (night)	↓ SD (24 h, day) in the first 8 months in exclusively and partially breastfed infants ↑ NW in the first 8 months in exclusively and partially breastfed infants than in exclusively formula fed SD (night), SP (day) and LSP (night) not associated with feeding method
Tikotzky et al. (2015)	Israel	L	Feeding method	57 3 and 6 months	Combined measures: A, D, and Q	NW	↑ NW at 6 months associated with breastfeeding at 3 and 6 months
Hughes, Gallagher, and Hannigan (2015)	Ireland	CS	Feeding method	11134 9 months	Q	SD (night), NW	↓ SD (night) and ↑ NW at 9 months associated with ↑ breastfeeding rates
Hysing et al. (2014)	Norway	L	Feeding method	55831 6 months	Q	NW	↑ NW at 6 months associated with breastfeeding
Galbally, Lewis, McEgan, Scalzo, and Islam (2013)	Australia	CS	Feeding method	4507 3–19 months	Q	NW	↑ NW at 3–19 months associated with breastfeeding at 6 months
Mindell, Du Mond, Tanenbaum, and Gunn (2012)	USA	L	Feeding method	92 3, 6, 12 months	Q	SD (night), NW, SP (day), LSP (24 h), SL (night)	↑ NW and ↑ SP (day) at 3–12 months associated with breastfeeding SD (night), LSP (24 h), and SL (night) at 3–12 months not associated with feeding method
Ramamurthy et al. (2012)	Asia Pacific Region	CS	Feeding method	4602 0–12 months	Q	SD (24 h, day, night), NW, SP (day), SL (night), LSP (night), BT, WT	↑ SD (24-hour, day), ↑ NW, ↓ LSP (night), ↑ SP (day), and ↑ BT from 0 to 6 months in breastfed infants ↑ NW, and ↓ LSP (night) from 6 to 12 months in breastfed infants SD (night) and WT not associated with breastfeeding
Demirci, Braxter, and Chasens (2012)	USA	CS	Feeding method	77 6–11 months	Q	SD (24 h, day, night), SL (night)	SD (24 h, day, night) and SL (night) at 6–11 months not associated with feeding method
Kaley et al. (2012)	UK	CS	Feeding method	77 1–2 months	D	SD (24 h, day, night), NW	↑ NW at 1–2 months in breastfed infants SD (24 h, day, night) at 1–2 months not associated with feeding method
Engler, Hadash, Shehadeh, and Pillar (2012)	Israel	CS	Feeding method	94 2–4 months	Q	SD (night), NW, SL (night)	↑ NW and marginally ↑ SD (night) at 2–4 months associated with breastfeeding SL (night) not associated with feeding method
Lamp and Johnson (2011)	USA	L	Feeding method	23 0–12 months	D	SD (24 h), SP (24 h), LSP (24 h)	↑ SP (24 h) and ↓ LSP (24 h) at 0–12 months associated with breastfeeding SD (24 h) not associated with feeding method
Nevarez et al. (2010)	USA	L	Feeding method	1676 6, and 12 months	Q	SD (24 h)	SD (24 h) at 6 and 12 months not associated with feeding method at 6 months
Kozyrskyj et al. (2009)	Australia	L	Feeding method	2398 12 months	Q	NW	↑ NW at 12 months associated with ↑ exclusive breastfeeding duration

(Continued)



Table 1. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
Anuntaseree et al. (2008)		Thailand	CS	Feeding method	3172 3 months	I	NW	↑ NW at 3 months associated with exclusive breastfeeding
Mindell, Meltzer, Carskadon, and Chervin (2009)		USA	CS	Feeding method	1473 0–11 months	I	SD (night), NW, SL (night)	↑ NW at 0–11 months associated with breastfeeding SD (night) and SL (night) not associated with feeding method
Schwichtenberg and Poehlmann (2009)		USA	CS	Feeding method	128 4 months	D	SD (night), NW	↓ SD (night) and ↑ NW at 4 months in breastfed preterm infants
DeLeon and Karraker (2007)		USA	CS	Feeding method	41 9 months	D	SD (24 h, day, night), WASO, NW, SP (day)	↓ SD (night), ↑ WASO and ↑ NW at 9 months associated with breastfeeding SD (24 h, day), and SP (day) not associated with feeding method
Cubero et al. (2005)		Spain	CS	Feeding method	16 3 months	A	SD (night), SL (night), SE	↑ SD (night) and ↑ SE at 3 months associated with breastfeeding SL (night) not associated with feeding method
Morgan, Lucas, and Fewtrell (2004)		UK	L	Feeding method	1694 6, 9 months	Q	SD (night)	↓ SD (night) at 9 months associated with ↑ breastfed duration in term infants SD (night) at 9 months not associated with breastfeeding duration in term infants
Quillin and Glenn (2004)		USA	CS	Feeding method	33 1 month	D	SD (24 h, night), NW, SP (24 h)	↓ SD (24 h) at 1 month associated with breastfeeding SD (night), NW and SP (24 h) not associated with feeding method
Ball (2003)		UK	L	Feeding method	253 1, 3 months	D	NW	↑ NW at 1 and 3 months associated with breastfeeding
Lee (2000)		Korea	CS	Feeding method	188 0–4 months	D	SD (24 h), LSP (night)	↑ SD (24 h) and ↓ LSP (night) at 0–4 months associated with breastfeeding
Thomas (2000)		USA	CS	Feeding method	37 1 month	D	SD (24 h, day, night), WASO	SD (24 h, day, night), and WASO not associated with feeding method in preterm infants
Wolke, Söhne, Riegel, Ohrt, and Österlund (1998)		Finland/ Germany	L	Feeding method	5969 5 months	I	NW	↑ NW at 5 months associated with breastfeeding
Quillin (1997)		USA	CS	Feeding method	44 1 month	D	SD (night), NW, SP (24 h)	↓ SD (night) and ↑ NW at 1 month in breastfed infants SP (24 h) at 1 month not associated with feeding method
Brown and Harries (2015)		UK	CS	Diet	715 6–12 months	Q	NW	NW at 6–12 months not associated with milk feeds, age of introduction of solids, number of complementary meals per day, and daytime feeds.
Nevarez et al. (2010)		USA	L	Diet	1676 6, and 12 months	Q	SD (24 h)	↓ SD (24 h) at 12 months associated with introduction of solids <4 months
Thomas and Foreman (2005)		USA	CS	Diet	37 1–2 months	D	SD (24 h), SP (24 h), LSP (24 h)	↓ SD (24 h), ↑ SP (24 h), and ↓ SD (24 h) associated with ↑ infant feedings
Telliez, Bach, Leke, Chardon, and Libert (2002)		France	CS	Diet	17 1 month	P	SD (day)	↑ SD (day) in the medium-chain triacylglycerol diet group
Philbrook and Teti (2016)		USA	L	Bedtime routines	109 1, 3 and 6 months	V	SD (night)	↓ SD (night) from 1 to 6 months associated with ↓ arousing activities

Vijakhana, Wilaisakditipakorn, Ruedeekhajorn, Pruksananonda, and Chonchaiya (2015)	Thailand	L	Bedtime routines	208 6 and 12 months	D	SD (night)	↓ SD (night) at 12 months associated with ↑ evening media exposure at 6 and 12 months
Cespedes et al. (2014)	USA	L	Bedtime routines	1864 6, 12 months	Q	SD (24 h)	↓ SD (24 h) at 6 and 12 months associated with ↑ TV viewing
Nevarez et al. (2010)	USA	L	Bedtime routines	1676 6, and 12 months	Q	SD (24 h)	↓ SD (24 h) at 12 months associated with infant TV/video viewing
Mindell et al. (2009)	USA	CS	Bedtime routines	1473 0–11 months	I	SD (night), NW, SL (night)	↓ SD (night) at 0–11 months associated with no bedtime routine, late bedtimes, and no reading at bedtime ↑ NW at 0–11 months associated with late bedtimes, and no reading at bedtime but not with no bedtime routine ↑ SL (night) at 0–11 months associated with late bedtimes, but not with no bedtime routine and reading at bedtime
Philbrook and Teti (2016)	USA	L	Parental bedtime involvement	109 1, 3 and 6 months	V	SD (night)	↓ SD (night) from 1 to 6 months associated with close contact with the mother at bedtime, ↓ mother emotional availability, ↓ nursing at bedtime
Ramamurthy et al. (2012)	Asia Pacific Region	CS	Parental bedtime involvement	4602 0–12 months	Q	SD (24 h, day, night), NW, SP (day), SL (night), LSP (night), BT, WT	↑ NW and ↓ LSP in infants fed back to sleep SD (24 h, day, night), SP (day), SL (night), BT, and WT not associated with fed back to sleep
Mindell et al. (2009)	USA	CS	Parental bedtime involvement	1473 0–11 months	I	SD (night), NW, SL (night)	↓ SD (night) and ↑ NW at 0–11 months associated with put in crib asleep, parent present at bedtime ↑ SL (night) at 0–11 months associated with put in crib asleep
Tikotzky and Sadeh (2009)	Israel	L	Parental bedtime involvement	85 1, 6 and 12 months	Combined measures: A, D, and Q	NW	↑ NW (measured by A, D, Q) at 6 and 12 months associated with maternal cognitions at pregnancy, 6 and 12 months emphasizing the infant's distress and need for help at night, and ↑ parental involvement at bedtime at 6 months
Anuntaseree et al. (2008)	Thailand	CS	Parental bedtime involvement	3172 3 months	I	NW	↑ NW at 3 months associated with use of a swinging or rocking cradle, falling asleep while feeding
DeLeon and Karraker (2007)	USA	CS	Parental bedtime involvement	41 9 months	D	SD (24 h, day, night), WASO, NW, SP (day)	↓ SD (night) and ↑ WASO at 9 months associated with putting the infant to bed asleep SD (24 h, day), NW, SP (day) not associated with putting the infant to bed asleep
Touchette et al. (2005)	Canada	L	Parental bedtime involvement	1741 5 months	Q	SD (night)	↓ SD (night) at 5 months associated with feeding after awakenings, rocking to sleep, and brought to parent's bed after awakenings
Goodlin-Jones et al. (2001)	USA	CS	Parental bedtime involvement	80 3, 6, 9, or 12 months	V	NW, LSP (night)	↑ NW and ↓ LSP (night) associated with non-self-soothing style
Philbrook and Teti (2016)	USA	L	Sleep arrangements	109 1, 3 and 6 months	V	SD (night)	↓ SD (night) from 1 to 6 months associated with co-sleeping
Volkovich et al. (2015)	Israel	L	Sleep arrangements	153 3 and 6 months	Combined measures: A and D	SD (day, night), NW, LSP (night)	↑ NW (measured by D) associated with co-sleeping infants at 3 and 6 months SD (night), NW, LSP (night) (measured by A), and SD (day) (measured by D) not associated with sleep arrangements

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Table 1. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
Huang et al. (2016)		China	L	Sleep arrangements	524 1, 3, 5, and 8 months	D	SD (24 h, day, night), NW, SP (day), LSP (night)	↑ SD (24 h, day) in the first 8 months associated with room-sharing ↑ SD (night) in the first 8 months associated with independent sleeping NW, SP (day), LSP (night) not associated with sleep arrangements
Bruni et al. (2014)		Italy	L	Sleep arrangements	704 1, 3, 6, 9, and 12 months	I	SD (24 h, day, night), NW	↑ SD (night) at 3, 6, 9, and 12 months associated with bed-sharing ↑ SD (night) at 3 months, ↑ SD (24 h, day) at 3 and 6 months, and ↑ SD (day) at 12 months in infants associated with independent sleeping
Möllborg, Wennergren, Norvenius, and Alm (2011)		Sweden	CS	Sleep arrangements	5605 6 months	Q	NW	↑ NW at 6 months associated with bed sharing
Santos et al. (2008)		Brazil	L	Sleep arrangements	3907 0 and 12 months	I	NW	↑ NW at 12 months associated with co-sleeping
DeLeon and Karraker (2007)		USA	CS	Sleep arrangements	41 9 months	D	SD (24 h, day, night), WASO, NW, SP (day)	↓ SD (night), ↑ WASO and ↑ NW at 9 months associated with co-sleeping SD (24 h, day), and SP (day) not associated with sleep arrangements
Baddock, Galland, Bolton, Williams, and Taylor (2006)		New Zealand	CS	Sleep arrangements	80 0–6 months	V	SD (night)	SD (night) at 0–6 months not associated with sleep arrangements
Touchette et al. (2005)		Canada	L	Sleep arrangements	1741 5 months	Q	SD (night)	↓ SD (night) at 5 months associated with co-sleeping
Jenni, Fuhrer, Iglowstein, Molinari, and Largo (2005)		Switzerland	L	Sleep arrangements	493 1, 3, 6, 9, 12 months	I	SD (night), NW	↓ SD (night) and ↑ NW at 6, 9, and 12 months associated with bed sharing
Mao, Burnham, Goodlin-Jones, Gaylor, and Anders (2004)		USA	CS	Sleep arrangements	18 3, 6, 9, 12 months	V	NW	↑ NW at 6, 9, and 12 months associated with co-sleeping
Lukowski, Liu, Peirano, Odio, and Bauer (2015)		China	CS	Disposable diaper use	82 6 months	D	NW	↑ NW at 6 months in infants associated with cloth diapers use
Thomas and Spieker (2016)		USA	CS	Parental mental health	46 8 months	Q	SD (24 h)	SD (24 h) at 8 months not associated with maternal fatigue or depression.
Sorondo and Reeb-Sutherland (2015)		USA	L	Parental mental health	40 5, 9, and 12 months	Q	SD (day, night), WASO, NW, SL (night)	↑ SD (day) at 5 months and ↓ SD (day) at 9 and 12 months associated with ↑ maternal stress at 5 months SD (night), WASO, NW, and SL (night) at 5, 9, and 12 months not associated with maternal stress at 5 months
Hughes et al. (2015)		Ireland	CS	Parental mental health	11134 9 months	Q	SD (night), NW	↓ SD (night) and ↑ NW at 9 months associated with ↑ maternal stress and depressive symptoms and ↓ self-reported health
Loutzenhiser, McAuslan, and Sharpe (2015)		Canada	L	Parental mental health	108 1, 3, 6 months	D	SD (night)	↓ SD (night) at 1 month associated with ↑ maternal fatigue

Brand, Furlano, Sidler, Schulz, and Holsboer-Trachsler (2014)	Switzerland	L	Parental mental health	24 2 and 3 months	Combined measures: A and D	SD (day, night), NW, SP (day)	↑ NW, SP (day) and ↓ SD (day) at 2 months associated with ↑ family strain at 3 months and maternal depression symptoms at 2 and 3 months ↓ SD (night) at 2 months associated with ↑ maternal depression symptoms at 2 months ↓ SD (night) at 3 months associated with ↑ maternal depression symptoms at 3 months
Piteo et al. (2013)	Australia	CS	Parental mental health	111 12 months	Q	SD (day, night), NW	↓ SD (day, night) and ↑ NW at 12 months associated with ↑ family dysfunction ↓ SD (night) and ↑ NW at 12 months associated with ↑ postnatal depression
Goldberg et al. (2013)	USA	L	Parental mental health	179 6 and 12 months	Q	NW, WASO	↑ NW and ↑ WASO at 6 and 12 months associated with ↑ maternal depressive symptoms at 6 and 12 months
Gress-Smith, Luecken, Lemery-Chalfant, and Howe (2012)	USA	L	Parental mental health	132 5 and 9 months	Q	NW	↑ NW at 9 months associated with ↑ maternal depressive symptoms at 5 months
Sinai and Tikotzky (2012)	Israel	CS	Parental mental health	50 4–5 months	D	SD (day), WASO (night), NW	↓ SD (day), ↑ WASO associated with ↑ parenting stress in families whose mothers in maternity leave NW not associated with parenting stress in families whose mothers in maternity leave
Mao, Zhu, and Su (2011)	China	CS	Parental mental health	420 1–2 months	Q	SD (24 h)	↓ SD (24 h) at 1–2 months associated with ↑ maternal postpartum depression
Nevarez et al. (2010)	USA	L	Parental mental health	1676 6, and 12 months	Q	SD (24 h)	↓ SD (24 h) at 12 months associated with ↑ maternal antenatal depression
Armitage et al. (2009)	USA	L	Parental mental health	18 0 and 6 months	A	SD (24 h, day, night), NW, SP (day), SL (night)	↓ SD (night), ↑ SP (day), ↑ NW, ↑ SL (night) at 0 and 6 months in associated with maternal history of depression SD (24 h, day) not associated with maternal history of depression
Baird, Hill, Kendrick, and Inskip (2009)	UK	L	Parental mental health	874 6 and 12 months	Q	NW	↑ NW at 6 and 12 months associated with maternal pre-conception psychological distress
Karraker and Young (2007)	USA	CS	Parental mental health	1275 6 months	I	NW	↑ NW at 6 months associated with ↑ maternal depression symptoms at 6 months
O'Connor et al. (2007)	UK	L	Parental mental health	11490 6 months	Q	SD (24 h), NW	SD (24 h), and NW at 6 months not associated with prenatal maternal anxiety and depression ↓ SD (24 h) associated with maternal depression at 8 weeks and 8 months and anxiety at 8 weeks ↑ NW associated with maternal depression and anxiety at 8 months
Warren, Howe, Simmens, and Dahl (2006)	USA	L	Parental mental health	1222 6 months	Q	NW	↑ NW at 6 months associated with ↑ maternal depression symptoms at 1, 6, 15, 24 and 36 months
Dennis and Ross (2005)	Canada	L	Parental mental health	505 1–2 months	Q	NW, LSP (day)	↑ NW at 1 and 2 months associated with ↑ maternal postpartum depression at 1 and 2 months LSP (day) at 1 and 2 months not associated with maternal postpartum depression at 1 and 2 months
Thomas and Spieker (2016)	USA	CS	Parental sleep	46 8 months	Q	SD (24 h)	↓ SD (24 h) at 8 months moderately associated with ↓ maternal sleep and ↑ maternal wake disturbance

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Table 1. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
Sharkey, Iko, Machan, Thompson-Westra, and Pearlstein (2016)		USA	L	Parental sleep	31 0, 1, and 4 months	D	SD (24 h), SP (24 h), LSP (24 h), BT	↓ LSP (24 h) at 0 months associated with ↓ maternal SD and ↓ maternal SE at 0 months ↓ SP (24 h) at 0 months associated with ↑ maternal SE at 0 months SD (24 h), SP (24 h), LSP (24 h), BT at 1 and 4 months not associated with maternal sleep
Tikotzky et al. (2015)		Israel	L	Parental sleep	57 3 and 6 months	Combined measures: A, D, and Q	NW, SE	↑ NW and ↑ SE at 3 and 6 months associated with ↑ maternal NW and ↑ SE at 3 and 6 months
Brand et al. (2014)		Switzerland	L	Parental sleep	24 2 and 3 months	Combined measures: A and D	SD (day, night), NW, SP (day)	↑ NW and SP (day) and ↓ SD (day) at 2 months associated with ↑ maternal insomnia at 2 and 3 months ↓ SD (night) at 2 months associated with ↑ maternal insomnia at 2 months ↑ SP (day) at 3 months associated with ↑ maternal insomnia at 3 months
Demirci et al. (2012)		USA	CS	Parental sleep	77 6–11 months	Q	SD (night)	↓ SD (night) at 6–11 months associated with ↓ maternal SD
Sinai and Tikotzky (2012)		Israel	CS	Parental sleep	50 4–5 months	D	SD (day), WASO, NW	↑ NW and ↑ NA associated with ↑ NW and ↑ WASO of mothers and fathers SD (day) at 4–5 months not associated with parental sleep
Thomas and Foreman (2005)		USA	CS	Parental sleep	37 1–2 months	D	SD (24 h) LSP (24 h)	↓ LSP (24 h) associated with ↓ maternal LSP (24 h) and ↓ SP (24 h)
Tikotzky et al. (2015)		Israel	L	Parental involvement	57 3 and 6 months	Combined measures: A, D, and Q	SD (night), NW, SE	SD (24 h) at 1–2 months not associated with maternal sleep ↑ NW at 6 months (measured by A and D) associated with ↓ involvement of fathers in infant care at 3 and 6 months ↑ NW at 3 months (measured by D) associated with ↓ involvement of fathers in infant care at 6 months SD (night) and SE at 3 and 6 months not associated with parental involvement
Zaidman-Zait and Hall (2015)		Canada	L	Parental involvement	1487 5 months	Q	NW	↑ NW at 5 months associated with ↓ maternal parenting impact and self-efficacy scores and ↓ paternal parenting impact and ↑ overprotectiveness scores
Bordeleau, Bernier, and Carrier (2012)		Canada	L	Parental involvement	55 12 months	D	SD (24 h, night)	SD (24 h, night) at 12 months not associated with maternal sensitivity at 12 months
Tikotzky, Sadeh, et al. (2010)		Israel	L	Parental involvement	56 1 and 6 months	Combined measures: A and D	SD (night), NW, BT	↓ SD (night) and ↓ NW at 6 months associated with ↑ paternal involvement in overall infant care at 1 and 6 months ↑ BT at 6 months associated with ↑ paternal involvement in overall infant care at 6 months, but not at 1 month
Scher and Blumberg (1999)		Israel	L	Parental involvement	81 6 and 12 months	Q	NW	↑ NW at 12 months associated with a facilitator care-giving orientation

Atun-Einy and Scher (2016)	Israel	L	Motor development	20 7, 8, 9, 10, 11 months	A	NW, SE	NW not associated with the emergence of pulling-to-stand ↑ NW and ↓ SE associated with crawling onset in infants with early crawling
Mindell and Lee (2015)	Brazil	CS	Motor development	1351 3–13 months	Q	SD (night), SL (night), NW, SP (day), BT, WT	SD (night), SL (night), NW, SP (day), BT, and WT at 3–13 months not associated with fine and gross motor skills scores
Scher and Cohen (2015)	Israel	L	Motor development	28 5, 6, 7, 8, 9, 10, and 11 months	A	NW	↑ NW associated with crawling onset in infants with early crawling
Gibson, Elder, and Gander (2012)	New Zealand	CS	Motor development	52 12 months	A	SD (24 h, night), SE	SD (24 h, night) and SE at 12 months not associated with motor development
Scher (2005a)	Israel	CS	Motor development	59 8 months	Combined measures: A and Q	SD (night), NW, LSP (night), SE, BT	↑ NW at 8 months associated with crawling SD (night), LSP (night), SE, and BT at 8 months not associated with motor development
Scher and Cohen (2005)	Israel	CS	Motor development	107 5–8 months	Q	NW	↑ NW at 5–8 months associated with crawling
Küpers et al. (2015)	Netherlands	L	Physical growth	2475 1, 6, and 12 months	NS	SD (24 h)	↑ SD (24 h) at 4 months associated with ↓ weight gain for age
Hiscock, Scalzo, Canterford, and Wake (2011)	Australia	L	Physical growth	3857 0–12 months	D	SD (24 h)	SD (24 h) at 0–12 months not associated with body mass index at 0–12 months and later
LampI and Johnson (2011)	USA	L	Physical growth	23 0–12 months	D	SD (24 h), SP (24 h), LSP (24 h)	↑ SD (24 h) and SP (24 h) in the first 12 months associated with episodic growth in length LSP (24 h) not associated with episodic growth in length
Tikotzky, De Marcas, et al. (2010)	Israel	CS	Physical growth	96 6 months	Combined measures: A and Q	SD (day, night), NW, SE	↓ SD (night) (measured by Q) and ↓ SE at 6 months associated with ↑ weight-to-length ratio and ↑ weight above weight expected for length ↑ SE at 6 months associated with ↑ length NW (measured by A and Q), SD (night) (measured by A), and SD (day) (measured by Q) at 6 months not associated with physical growth
Kirjavainen et al. (2001)	Finland	L	Colic	31 1, 2, 6, 7 months	Combined measures: D and P	SD (24 h, night), NW	↓ SD (24 h, night) at 1 month in infants with colic ↓ NW at 7 months in infants with colic SD (24 h, night) at 2, 6, and 7 months not associated with colic
White, Gunnar, Larson, Donzella, and Barr (2000)	USA	CS	Colic	40 2 months	D	SD (24 h, day, night)	↓ SD (24 h) at 2 months associated with colic
Anuntaseree et al. (2012)	Thailand	CS	Health problems	4085 12 months	I	SD (day, night), NW, SP (day), SL (night)	↓ SL (night) and ↓ SD (night) at 12 months in infants associated with atopic dermatitis SD (day), NW and SP (day) not associated with atopic dermatitis
Pellegrini-Belinchón et al. (2012)	Spain	CS	Health problems	750 12 months	Q	NW	↑ NW at 12 months associated with wheezing
Kozyrskij et al. (2009)	Australia	L	Health problems	2398 12 months	Q	NW	NW at 12 months not associated with asthma at 6 years

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Table 1. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
McKay and Angulo-Barroso (2006)		USA	L	Health problems	16 3, 4, 5, and 6 months	A	SD (24 h)	↓ SD (24 h) at 3 months associated with Down Syndrome
Wolke et al. (1998)		Finland/ Germany	L	Health problems	5969 5 months	I	NW	↓ NW at 5 months associated with admission to special care units
Ghaem et al. (1998)		Australia	CS	Health problems	102 0–3 and 3–12 months	Q	SD (day), NW	↑ NW at 3–12 months associated with gastro-esophageal reflux disease SD (day) at 3–12 months not associated with gastro-esophageal reflux disease
Konrad, Herbert, Schneider, and Seehagen (2016)		UK	CS	Mental development	48 6 and 12 months	Combined measures: A and D (combined)	SD (24 h, day, night), WASO, NW, SP (day)	↑ WASO and NW at 6 months infants (but not at 12 months) associated with ↓ imitation score SP (day), SD (24 h, day, night) not associated with imitation score
Mindell and Lee (2015)		Brazil	CS	Mental development	1351 3–13 months	Q	SD (night), SL (night), NW, SP (day), BT, WT	SD (night), SL (night), NW, SP (day), BT, and WT at 3–13 months not associated with problem solving, communication, and personal-social skills scores
Lukowski and Milojevich (2013)		USA	CS	Mental development	21 10 months	Q	SD (day, night), NW	↑ SD (day) at 10 months associated with ↑ encoding ↓ NW and ↑ SD (day) at 10 months associated with ↑ generalization SD (day, night) and NW not associated with delayed recall
Gibson, Elder, et al. (2012)		New Zealand	CS	Mental development	52 12 months	A	SE	↑ SE at 12 months associated with ↑ problem solving
Scher (2005b)		Israel	CS	Mental development	50 10 months	Combined measures: A and Q	SD (24 h), NW, SE	↓ NW and ↑ SE at 10 months (measured by A) associated with ↑ mental developmental index SD (24 h) and NW (measured by Q) not associated with mental development index
Shibagaki, Sawata, and Tachibana (2004)		Japan	CS	Mental development	27 4–12 months	P	SD (night), WASO	↓ WASO associated with ↑ developmental quotient in infants with developmental disabilities SD (night) not associated with developmental quotient
Gertner et al. (2002)		Israel	L	Mental development	34 0 and 6 months	A	SD (24 h, day, night)	↑ SD (24 h, night) at 0 months associated with ↓ mental developmental scores at 6 months SD (day) at 0 months not associated with mental developmental scores at 6 months
McGeorge, Milne, Cotton, and Whelan (2015)		Australia	CS	Social emotional problems	55 4–7 months	D	SD (24 h)	↓ SD (24 h) at 4–7 months associated with ↑ sensory sensitivity and sensation avoiding
Humphreys et al. (2014)		UK	L	Social emotional problems	14062 6 months	Q	SD (24 h), NW	SD (24 h) and NW at 6 months not associated with autism
Landau et al. (2010)		Israel	CS	Social emotional problems	44 1–2 months	Combined measures: A and D	SD (24 h, day, night), NW, SP (day)	SD (24 h, day, night), NW, and SP (day) not associated with Attention Deficit Hyperactivity Disorder ↑ stability in SD (day) and SP (day) associated with ↓ risk for Attention Deficit Hyperactivity Disorder

Scher (2008)	Israel	CS	Social emotional problems	52 10 months	Combined measures: A and Q	NW, SE	↑ NW (measured by A, but not measured by Q) and ↓ SE at 10 months associated with ↑ maternal separation anxiety at 10 months
Spruyt et al. (2008)	Belgium	L	Social emotional problems	20 3, 6, 11, and 12 months	Combined measures: A and D	SD (day)	↑ SD (day) at 12 months associated with ↓ emotion regulation and ↓ total behaviour development score
DeLeon and Karraker (2007)	USA	CS	Social emotional problems	41 9 months	D	SD (24 h, day, night), WASO, NW, SP (day)	↓ SD (24 h, night), ↑ WASO, ↑ NW, ↑ SP (day) at 9 months associated with ↑ separation distress SD (night) not associated with separation distress
Scher and Blumberg (1999)	Israel	L	Social emotional problems	81 6 and 12 months	Q	NW	↑ NW at 12 months associated with ↑ maternal separation anxiety
Mindell and Lee (2015)	Brazil	CS	Temperament	1351 3–13 months	Q	SD (night), SL (night), NW, SP (day), BT, WT	↑ NW and ↓ SP (day) associated with ↓ bedtime, morning, and daytime mood ↑ BT and ↓ SD (night) associated with ↓ daytime mood ↓ SD (night) and ↑ WT associated with ↓ morning mood SL not associated with mood BT not associated with bedtime and morning mood WT not associated with bedtime and daytime mood SD (night) not associated with bedtime mood
Sorondo and Reeb-Sutherland (2015)	USA	L	Temperament	40 5, 9, and 12 months	Q	SD (day, night), WASO, NW, SL (night)	↑ SL (night) at 5 months and ↑ WASO at 5, 9, and 12 months associated with negative reactivity at 5 months SD (day, night) and NW at 5, 9, and 12 months not associated with negative reactivity
Kaley et al. (2012)	UK	CS	Temperament	77 1–2 months	D	SD (24 h, day, night), NW	↑ SD (day) at 1–2 months associated with positive temperament ↓ SD (24 h, day, night) at 1–2 months correlated with temperament dimensions (activity, approach, intensity, and distractibility) NW at 1–2 months not associated with temperament dimensions
Gibson, Gander, and Elder (2012)	New Zealand	CS	Temperament	52 12 months	A	SD (night), SL (night), BT, WT	↓ SL (night) at 12 months in infants more alert during the day ↑ SD (night) and ↑ WT at 12 months in infants in good mood in the morning ↓ WT at 12 months in infants rated as tired at bedtime SD (night), BT, and WT at 12 months not associated with daytime alertness SL (night) and BT at 12 months not associated with morning mood SD (night), SL (night), and BT at 12 months not associated with tired at bedtime SD (night), SL (night), BT and WT at 12 months not associated with bedtime mood and bedtime problems
Spruyt et al. (2008)	Belgium	L	Temperament	20 3, 6, 11, and 12 months	Combined measures: A and D	SD (24 h, day, night)	↑ SD (24 h) at 3 months associated with ↑ approachability ↑ SD (24 h) at 6 months associated with ↑ rhythmicity and ↓ distractibility ↑ SD (24 h) at 12 months associated with ↑ rhythmicity and ↓ persistence

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Table 1. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
Palmstierna et al. (2008)		Sweden	L	Temperament	16467 12 months	Q	NW	↑ SD (day) at 12 months associated with perceived negative mood ↑ SD (night) at 3, 6 and 11 months associated with ↑ approachability ↑ NW at 12 months associated with difficult temperament
Bayer, Hiscock, Hampton, and Wake (2007)		Australia	CS	Temperament	692 3–6 months	Q	NW	↑ NW at 3–6 months associated with difficult temperament
Touchette et al. (2005)		Canada	L	Temperament	1741 5 months	Q	SD (night)	↓ SD (night) at 5 months associated with difficult temperament
Scher (2001a)		Israel	CS	Temperament	94 12 months	A	SD (night), NW, LSP (night), SL (night), SE	↑ SE at 12 months associated with ↑ fussiness SD (night), NW, LSP (night), and SL (night) at 12 months not associated with fussiness
Scher, Tirosh, and Lavie (1998)		Israel	CS	Temperament	30 12 months	A	SD (night), NW, SE, BT	↑ SD (night), ↑ NW, ↓ SE, and ↓ BT at 12 months associated with ↑ rhythmicity ↓ BT at 12 months associated with positive mood SD, NW, SE, BT at 12 months not associated with other dimensions of temperament
Gibson, Gander, et al. (2012)		New Zealand	CS	Sleep problems	52 12 months	A	SD (24 h, day, night), SL (night), SP (24 h), SE, BT, WT	↓ SD (24 h, night) and ↑ SP (24 h) at 12 months in infants rated with sleep problems SD (day), SL (night), SE, BT, and WT at 12 months not associated with sleep problems
Bayer et al. (2007)		Australia	CS	Sleep problems	692 3–6 months	Q	NW	↑ NW at 3–6 months associated with maternal report of sleep problem
Hiscock and Wake (2001)		Australia	CS	Sleep problems	738 7–9 months	Q	NW, SP (day), SL, BT, WT	↑ NW, ↓ SP (day) and ↑ SL at 7–9 months in infants reported by mothers as presenting a sleep problem ↑ BT and ↓ WT marginally associated with maternal reports of sleep problems
St James-Roberts and Peachey (2011)		UK/ Denmark	L	Crying	610 233 1 and 3 months	Q	NW	↑ NW at 3 months associated with prolonged crying at 1 month in one study but not in another
DeLeon and Karraker (2007)		USA	CS	Crying	41 9 months	D	SD (24 h, day, night), WASO, NW, SP (day)	↓ SD (night), ↑ WASO, ↑ NW at 9 months associated with ↑ daytime crying SD (24 h, day), and SP (day) at 9 months not associated with daytime crying
Harrison (2004)		UK	L	Crying	66 1, 2, 3 months	D	SD (24 h, night)	SD (24 h, night) not associated with crying ↓ SD (24 h, night) at 1 month, but not at 2 and 3 months associated with ↑ evening crying
Lee (2000)		Korea	CS	Crying	188 0–4 months	D	SD (24 h)	↓ SD (24 h) at 0–4 months associated with ↑ cry duration

St James-Roberts, Conroy, and Hurry (1997)	UK	CS	Crying	132 1 month	D	SD (24 h, day, night), WASO	↓ SD (24 h, day) at 1 months in persistent than in moderate criers SD (night) and WASO at 1 month not associated with crying
<i>Non-associated factors</i>							
Agarwal, Gupta, Pushkarna, and Bhargava (2000)	India	CS	Massage and use of oil	125 1 month	D	SD (24 h, day, night), NW, SP (24 h, day)	SD (24 h, day, night), NW and SP (24-h, day) at 1 month not associated with massage and use of oil
Johnson, McMahon, and Gibson (2014)	Australia	L	Conception mode	134 7 months	D	SD (24 h)	SD (24 h) at 7 months not associated with conception mode
Butler, Moore, and Mindell (2016)	USA	CS	Sleep aid	104 0–11 months	Q	SD (day, night), NW, SP (day), LSP (night), BT, WT	↑ NW at 0–11 months associated with pacifier use and ↑ LSP (night) at 0–11 months associated with finger suck ↑ SD (day) at 0–11 months associated with non-suck and pacifier use SD (night) and SP (day), BT and WT at 0–11 months not associated with sleep aid
Odoi, Andrew, Wong, Yiallourou, and Horne (2014)	Australia	L	Sleep aid	30 0–1, 2–3, 5–6 months	P	SD (day), SP (day)	SD (day) and SP (day) at 0–1, 2–3, and 5–6 months not associated with sleep aid
Burnham, Goodlin-Jones, Gaylor, and Anders (2002)	USA	L	Sleep aid	80 1, 3, 6, 9, and 12 months	V	SD (night), NW, LSP (night)	SD (night), NW, and LSP (night) not associated with sleep aid
Ball (2007)	UK	CS	Sleep arrangements (twins)	24 1–3 months	V	SD (night), NW	SD (night) and NW at 1–3 months not associated with sleep arrangements in twin infants

Design: CS Cross-sectional; L Longitudinal.

Sleep measures: A Actigraphy; D Diary; EEG Electro encephalography I Interview; MMS Motility Monitor System; NS Not Specified; O Observation; P Polysomnography; Q Questionnaire; V Video recording.

Sleep-wake behaviour: BT Bedtime; LSP Longest sleep period; SL Sleep latency; NW Night wakings; SD Sleep duration; SE Sleep efficiency; SP Sleep periods; WT Wake Time; WASO Wake After Sleep Onset.

Table 2. Factors positively and negatively affected by sleep-wake behaviour during the first 12 months of life.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
<i>Positive factors</i>								
McDaniel and Teti (2012)		USA	L	Co-parenting	150 1 and 3 months	D	NW	↑ NW at 1 and 3 months indirectly predicted ↓ co-parenting quality
<i>Negative factors</i>								
Tikotzky et al. (2015)		Israel	L	Parental bedtime involvement	57 3 and 6 months	Combined measures: A, D, and Q	SD (night), NW, SE	SD (night), and SE at 3 and 6 months and NW at 3 months not associated with nighttime paternal involvement at 6 months
Johnson et al. (2014)		Australia	L	Parental bedtime involvement	134 7 months	D	SD (24 h)	↓ SD (24 h) at 7 months associated with ↑ maternal bedtime involvement at 18 months
Tikotzky and Shaashua (2012)		Israel	L	Parental bedtime involvement	71 12 months	A	NW	↑ NW at 12 months associated with ↑ parental bedtime involvement at 4 years
Sharkey et al. (2016)		USA	L	Parental mental health	31 0, 1, and 4 months	D	SD (24 h), SP (24 h)	↑ SP (24 h) at 0 and 1 month associated with ↑ maternal depressive symptoms ↓ SD (24 h) at 0 and 1 month associated with ↑ maternal stressors at 4 months
McDaniel and Teti (2012)		USA	L	Parental mental health	150 1 and 3 months	D	NW	↑ NW at 1 and 3 months indirectly predicted ↑ maternal depression
Klingenberg et al. (2013)		Denmark	L	Physical growth	311 9 months	Q	SD (24 h, night)	SD (24 h, night) at 9 months not associated with adiposity indicators at 36 months
Gillman et al. (2008)		USA	L	Physical growth	1100 6 and 12 months	Q	SD (24 h)	↓ SD (24 h) at 6 and 12 months associated with ↑ risk of overweight at 3 years
Dionne et al. (2011)		Canada	L	Mental development	1029 6 months	I	LSP (day, night)	↑ LSP (day) at 6 months associated with ↓ language outcome at 18, 30 and 60 months LSP (night) at 6 months not associated with language outcome at 18, 30 and 60 months
Bernier, Carlson, Bordeleau, and Carrier (2010)		Canada	L	Mental development	60 12 months	D	SD (24 h), NW, SE	↑ SE at 12 months associated with ↑ performance on executive tasks at 26 months (but not at 18 months) SD (24 h) and NW at 12 months not associated performance on executive tasks at 18 and 26 months
Bouvette-Turcot et al. (2015)		Canada	L	Social emotional problems	209 6 and 12 months	Q	SD (24 h)	↓ SD (24 h) from 6 to 36 months associated with negative emotionality/behavioural dysregulation at 36 months in infants with 5-HTTLPR allele
Sadeh et al. (2015)		Israel	L	Social emotional problems	43 12 months	A	SD (night), NW, SE	↑ NW and ↓ SE at 12 months associated with ↑ attention regulation and behaviour problems at 3–4 years SD (night) at 12 months not associated with attention regulation and behaviour problems at 3–4 years

(Continued)

Table 2. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
Saenz et al. (2015)		USA	L	Social emotional problems	47 3–4 months	A	SD (night), SE	↓ SD (night) at 3–4 months associated with ↑ externalizing problems and autism spectrum disorder behaviors at 18–24 months in girls SD (night) at 3–4 months not associated with internalizing and dysregulation problems SE 3–4 months not associated with social emotional problems
Scott et al. (2013)		UK	L	Social emotional problems	8195 6 months	Q	SD (night), NW	↓ SD (night) at 6 months associated with attention deficit hyperactivity disorder NW at 6 months not associated with attention deficit hyperactivity disorder
Bordeleau et al. (2012)		Canada	L	Social emotional problems	55 12 months	D	SD (24 h, night)	SD (24 h, night) at 12 months not associated with externalizing and internalizing symptoms at 4 years
Jansen et al. (2011)		The Netherlands	L	Social emotional problems	4782 2 months	Q	SD (24 h), NW	↑ NW at 2 months associated with ↑ anxiety and depression at 3 years SD (24 h) at 2 months not associated with anxiety and depression at 3 years
Novosad, Freudigman, and Thoman (1999)		USA	CS	Temperament	41 0 and 8 months	MMS	LSP (24 h)	↑ LSP (24 h) at 0 months associated with ↓ adaptable temperament at 8 months
Hysing et al. (2014)		Norway	L	Sleep problems	55831 6 months	Q	SD (night), NW	↓ SD (night) at 6 months associated with ↓ SD (night) at 18 months ↑ NW at 6 months associated with ↑ NW at 18 months
Byars, Yolton, Rausch, Lanphear, and Beebe (2012)		USA	L	Sleep problems	359 6, 12 months	Q	SD (24 h, day), SL (night), SP (day)	↓ SD (24 h), ↑ SL (night) at 6 and 12 months associated with ↑ sleep problems SD (day) at 6 and 12 months not associated with sleep problems ↓ SD (24 h), ↑ SL (night) at 24 and 36 months ↑ SP (day) at 6 months associated with ↑ SP (day) at 12 months, but not at 24 and 36 months
Tikotzky and Shaashua (2012)		Israel	L	Sleep problems	71 12 months	Combined measures: A, D, and Q	NW, SE	↑ NW at 12 months associated with ↑ NW, ↓ SE, and ↓ SD (night) at 4 years ↑ SE at 12 months associated with ↑ NW (measured by Q) at 4 years SE at 12 months not associated with NW (measured by A), SE, and SD (night) at 4 years

(Continued)

Table 2. Continued.

First author	Year of publication	Country	Design	Associated factor	N Age (months)	Sleep measure	Sleep-wake behaviour	Main result
Palmstierna et al. (2008)		Sweden	L	Sleep problems	16467 12 months	Q	NW	↑ NW at 12 months associated with ↑ NW at 3 and 5 years and with ↓ perceived sleep quality at 12 months, 3 and 5 years
Schwichtenberg, Shah, and Poehlmann (2013)		USA	L	Attachment	171 4, 9 months	D	SD (day, night), NW, SP (day)	↑ SD (day) from 4 to 9 months predicted secure attachment at 16 months SD (night) and NW not associated with attachment
Beijers, Jansen, Riksen-Walraven, and de Weerth (2011)		The Netherlands	L	Attachment	193 0–6 and 12 months	D	NW	↑ NW at 0–6 months associated with insecure-resistant attachment at 12 months ↓ NW at 6 months associated with avoidant attachment at 12 months No associations between NW at 12 months and attachment

Design: CS Cross-sectional; L Longitudinal.

Sleep measures: A Actigraphy; D Diary; EEG Electro encephalography I Interview; MMS Motility Monitor System; NS Not Specified; O Observation; P Polysmonogrpahy; Q Questionnaire; V Video recording.

Sleep-wake behaviour: BT Bedtime; LSP Longest sleep period; SL Sleep latency; NW Night wakings; SD Sleep duration; SE Sleep efficiency; SP Sleep periods; WT Wake Time; WASO Wake After Sleep Onset.

sleep period (time of the longest sleep episode), bedtime/sleep onset time (hour of sleep start during the night), wake time (waking time in the morning), and sleep efficiency (percentage of sleep during the night from bedtime to wake time).

Results

Databases search

After the elimination of duplicates, 8610 relevant papers were identified in the literature search. The examination of titles and abstracts lead to the exclusion of 8244 non-relevant papers and the remaining 366 papers were examined for inclusion/exclusion criteria. Two hundred and twenty papers met one or more exclusion criteria and were excluded. This systematic review included 146 papers. [Figure 1](#) presents a flow diagram of the search.

Articles reviewed

Studies performed in 25 countries were included. Most of the studies were performed in the United States ($n = 42$), Israel ($n = 22$), UK ($n = 15$), Australia ($n = 11$), or Canada ($n = 10$) and about half of the studies presented a longitudinal design ($n = 76$). Infant sleep-wake behaviour's measures included questionnaire ($n = 53$), diary ($n = 33$), actigraphy ($n = 17$), interview ($n = 10$), video recording ($n = 7$), polysomnography ($n = 5$), observation by experimented researchers ($n = 2$), electroencephalography ($n = 1$), motility monitoring system ($n = 1$), combined measures ($n = 15$; 8 studies used actigraphy and sleep diary; 4 studies used actigraphy and questionnaire; 2 studies used actigraphy, sleep diary and questionnaire; and 1 study used sleep diary and polysomnography), and 2 studies did not specify sleep-wake behaviour measures. About half of the studies were scored as good ($n = 76$), and the other half as moderate quality ($n = 70$) in the Quality Index.

Factors positively and negatively associated with sleep-wake behaviour

The following factors emerged as positively associated with sleep-wake behaviour during the first 12 months of life: being a first-time infant in 4/6 studies, Caucasian ethnicity in 3/3 studies, higher parental educational/health literacy level in 3/5 studies, lower sensory and environmental stimuli in 1/1 study, better genetic/environmental influences in 1/1 study, outdoor environment in 1/1 study,

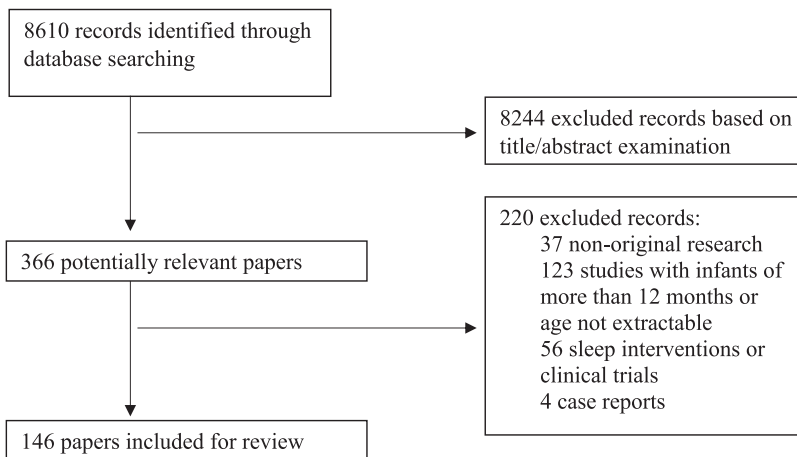


Figure 1 . Search strategy flow chart.

sleeping in prone position in 1/1 study, wearing Ö4 fabric in 1/1 study, regulated cortisol and melatonin levels in 4/4 studies, infant secure attachment patterns in 2/3 studies, and better mother-infant relationship in 3/3 studies (see [Table 1](#)).

On the other hand, the following factors emerged as negatively associated with sleep-wake behaviour during the first 12 months of life: male gender in 10/12 studies, older maternal age in 2/2 studies, single/divorced parents in 2/2 studies, non-native parents in 1/1 study, lower socio-economic status in 3/5 studies, winter months in 1/1 study, urban environments in 1/1 study, less exposure to light in 1/1 study, and more exposure to maternal smoking in 1/1 study, gestational exposure to smoke, alcohol, substances, namely alcohol, tobacco, cocaine, marijuana, and methamphetamine, and stressful events in 3/4 studies, planned C-section in 1/1 study, and preterm delivery in 4/4 studies, breastfeeding in 22/27 studies, earlier introduction of solids, higher number of feedings, and diet components in 3/4 studies, later bedtimes, less bedtime activities, and television and media exposure in 5/5 studies, more parental bedtime involvement (characterized by parental presence at bedtime, nursing or rocking at bedtime, putting the infant in crib asleep, or feeding back to sleep) in 8/8 studies, bed-sharing or co-sleeping in 10/11 studies, cloth diapers in 1/1 study, maternal depression, stress, or fatigue and family dysfunction and stress in 17/18 studies, worse parental sleep in 7/7 studies, lower parental involvement in 4/5 studies, emergence of crawling in 4/6 studies, weight gain in 3/4 studies, colic in 2/2 studies, health problems in 5/6 studies, lower scores in mental development tasks in 6/7 studies, social and emotional problems in 6/7 studies, difficult temperament in 10/10 studies, sleep problems in 3/3 studies, and crying in 5/5 studies (see [Table 1](#)).

Massage and use of oil, conception mode, sleep aid, and sleep arrangements in twins were not associated with infant sleep-wake behaviour (see [Table 1](#)).

Factors positively and negatively affected by sleep-wake behaviour

Sleep-wake behaviour during the first 12 months of life was shown to positively affect co-parenting quality in 1/1 study and negatively affect parental bedtime involvement in 2/3 studies, maternal mental health in 2/2 studies, obesity in 1/2 study, performance in mental tasks in 2/2 studies, social emotional problems in 5/6 studies, temperament in 1/1 study, sleep problems in 4/4 studies, and attachment in 2/2 studies (see [Table 2](#)).

Discussion

This study aimed to provide a systematic review of the literature on associated factors with sleep-wake behaviour during the first 12 months of life. This systematic review considered different sleep-wake behaviours and included studies performed over the last 20 years in 25 different countries.

Factors positively and negatively associated with sleep-wake behaviour

The most consistent factors found in literature as being positively associated with the different sleep-wake behaviours during the first 12 months of life were: being a first-time infant, Caucasian ethnicity, the regulation of the HPA axis, secure attachment pattern and a positive mother-infant relationship. The other factors were either poorly explored or provided inconsistent results across the different studies.

Being a first-time infant was associated with longer sleep duration and less night wakings (Kozyrskij et al., 2009; Santos et al., 2008; So et al., 2007). Results from studies with the smallest samples either suggested no differences in the different sleep-wake behaviours that were analyzed (Kaley et al., 2012; Quillin, 1997; So et al., 2007) or a tendency for longer sleep duration in non-first-time infants (Kaley et al., 2012). When the number of siblings was assessed, different results were found, namely more night wakings in infants with more siblings in one study (Kozyrskij et al.,

2009) and no differences in another study (Blair et al., 2012). Studies addressing birth order also differed regarding the time of sleep-wake behaviour assessment. While during the first months, results were not consistent (Kaley et al., 2012; Quillin, 1997; So et al., 2007), in the second half of the first year, non-first-time infants were shown to present less sleep duration during the night (So et al., 2007), and more night wakings (Kozyrskyj et al., 2009; Santos et al., 2008). As the most important changes in sleep-wake behaviour occur during the first 3 months (Burnham et al., 2002; Henderson, France, & Blampied, 2011), differences in birth order may not be easily seen in the first months.

Caucasian ethnicity was consistently associated with longer sleep duration during the 24-hour period and more night wakings when compared with non-caucasian ethnicity (Blair et al., 2012; Nevarez et al., 2010; Santos et al., 2012). This result is consistent with previous research showing cultural differences in sleep-wake behaviours between Caucasian and Asian infants (Mindell, Sadeh, Wiegand, How, & Goh, 2010).

Although some inconsistent results, a secure attachment was associated with more regulated sleep-wake behaviour, characterized by more sleep duration during the night, less night wakings, and a longer longest sleep period in 2 studies (Pennestri et al., 2015; Zentall et al., 2012). This may be explained by the fact that secure infants are more able to deal with the mother separation during the night and rely on mother's availability, presenting a more regulated sleep-wake behaviour during the night (Zentall et al., 2012). Regarding mother-infant interaction, different results have been found. A positive mother-infant relationship was associated with a higher increase in the longest sleep periods (de Graag et al., 2012) and with more night wakings, but not with sleep duration during the night and bedtime (Scher, 2001b). Researchers studying preterm infants showed the importance of sleep-wake behaviors during the day in association with the mother-infant relationship (Schwichtenberg et al., 2011).

Although few studies addressed infant hormonal factors, results suggested a trend for an association between a regulation of the HPA axis and less night wakings (Lucas-Thompson et al., 2009) and more sleep during the night (Lucas-Thompson et al., 2009). Results from a recent study were controversial, however, this study was conducted with infants with colic (Brand et al., 2011), and colic were shown to be associated with infant sleep-wake behaviour in previous research (Kirjavainen et al., 2001; White et al., 2000). Furthermore, lower morning melatonin levels were also associated with increased sleep duration during the night in one study (Shinohara & Kodama, 2011).

The most consistent factors negatively associated with different sleep-wake behaviours during the first 12 months of life were: male gender, breastfeeding, bedtime routines, bed-sharing, parental mental health, parental sleep, and infant social-emotional and sleep problems. Other factors were also negatively associated with sleep-wake behaviour, namely lower socio-economic status, preterm birth, crawling onset, difficult temperament, and crying. However, considering the paucity of studies or the inconsistent results, more research is needed.

Male gender was consistently associated with shorter sleep duration, more night wakings, less sleep efficiency, and shorter longest sleep periods during the first 12 months of life. Interestingly, results from studies performed in Australia suggested no gender differences in the different sleep-wake behaviours that were analyzed (Kozyrskyj et al., 2009; So et al., 2007), which can underlie some cultural characteristics. Non-Australian studies, whose results showed no gender differences in the different infant sleep-wake behaviours, were conducted with small samples and most of them assessed age ranges rather than specific ages (Goodlin-Jones et al., 2001; Kaley et al., 2012; Lampl & Johnson, 2011; Saenz et al., 2015; Thomas & Foreman, 2005). Considering that infant sleep-wake behaviour during the first months is marked by both individual and developmental changes (Figueiredo et al., 2016), the use of small sample sizes or age ranges could difficult the assessment of gender differences (Weinraub et al., 2012).

Breastfeeding was consistently associated with more night wakings (Anuntaseree et al., 2008; Ball, 2003; DeLeon & Karraker, 2007; Engler et al., 2012; Galbally et al., 2013; Huang et al., 2016; Hughes et al., 2015; Hysing et al., 2014; Kaley et al., 2012; Kozyrskyj et al., 2009; Mindell et al., 2009, 2012; Ramamurthy et al., 2012; Schwichtenberg & Poehlmann, 2009; Tikotzky et al., 2015; Wolke et al., 1998). This

is congruent with previous literature showing that the quick digestion of breast milk could lead to a more fragmented sleep in breastfed infants (Burness, 1979). However, it is not clear the association between feeding method and other sleep-wake behaviours, namely sleep duration, sleep periods or longest sleep period (Cubero et al., 2005; DeLeon & Karraker, 2007; Demirci et al., 2012; Engler et al., 2012; Huang et al., 2016; Hughes et al., 2015; Kaley et al., 2012; Lampl & Johnson, 2011; Lee, 2000; Mindell et al., 2012; Morgan et al., 2004; Nevarez et al., 2010; Quillin & Glenn, 2004; Ramamurthy et al., 2012; Schwichtenberg & Poehlmann, 2009; Thomas, 2000).

Less arousing activities, no reading, late bedtime, no bedtime routine, and television and media exposure before bedtime were associated with shorter sleep duration during the night and more night wakings (Cespedes et al., 2014; Mindell et al., 2009; Nevarez et al., 2010; Philbrook & Teti, 2016; Vijakkhana et al., 2015). This is congruent with findings that show that sleep hygiene is associated with infant sleep-wake behaviour (Mindell et al., 2009). Furthermore, higher parental bedtime involvement, characterized by parental presence at bedtime, nursing or rocking at bedtime, putting the infant in crib asleep, or feeding back to sleep were also associated with shorter sleep duration and longest sleep periods, more sleep latency during the night and more night wakings (Anuntaseree et al., 2008; DeLeon & Karraker, 2007; Goodlin-Jones et al., 2001; Huang et al., 2016; Mindell et al., 2009; Philbrook & Teti, 2016; Ramamurthy et al., 2012; Tikotzky & Sadeh, 2009; Touchette et al., 2005). These findings may be explained within the context of the transactional model that argues that parental behaviours are the most immediate and direct factor influencing infant sleep-wake behaviours (Sadeh et al., 2010). The level of parental involvement at bedtime is crucial to the development of the infant's abilities of self-soothing and self-regulation (Sadeh et al., 2010). In the presence of a low parental involvement at bedtime, the infant is taught to self-soothe and self-regulate its sleep-wake behaviors, while in the presence of high parental involvement at bedtime, the infant is not able to develop these skills (Sadeh et al., 2010).

Sleep arrangements (characterized by bed-sharing or co-sleeping) were consistently associated with shorter sleep duration during the night and more night wakings (Bruni et al., 2014; DeLeon & Karraker, 2007; Guyer et al., 2015; Jenni et al., 2005; Mao et al., 2004; Möllborg et al., 2011; Philbrook & Teti, 2016; Santos et al., 2008; Touchette et al., 2005). Bed-sharing/co-sleeping promotes higher physical contact with the parents and that could interfere with the infant's ability of self-comforting, causing more difficulties in the ability of the infant to return to sleep after night wakings (Green, Groves, & Tegano, 2004; Morrell & Steele, 2003). Moreover, previous research also showed an association between co-sleeping/bed-sharing and infant's dysregulation, breastfeeding and putting the infant in bed asleep, arguing that co-sleeping/bed-sharing could be used as a parent's strategy to deal with the infant's characteristics and the feeding method (DeLeon & Karraker, 2007). Only 1 study showed no associations between sleep arrangements and infant sleep-wake behaviour (Baddock et al., 2006). However, this study analyzed differences between bed-sharing and cot-sleeping, being cot-sleeping defined as sleeping in a cot, that is usually adjacent to the parent's bed (Baddock et al., 2006). Furthermore, this study was performed in New Zealand, where the lowest bed-sharing rates were shown (Mindell et al., 2009). No association between sleep arrangements and sleep-wake behaviour, when measured by actigraphy, was found in another study (Volkovich et al., 2015). However, the analyses of this study were controlled for feeding method, which has been shown to be associated with sleep arrangements in previous research (DeLeon & Karraker, 2007). Interestingly, although a recent study, performed in China, found more sleep duration during the night in independent sleeping infants, no association was shown between sleep arrangements and night wakings (Huang et al., 2016).

Parental mental health, especially maternal depression and fatigue and family dysfunction and stress have been associated with shorter sleep duration (day, night and 24-hour period) and longest sleep period (night), and more night wakings and WASO (Armitage et al., 2009; Baird et al., 2009; Brand et al., 2014; Dennis & Ross, 2005; Goldberg et al., 2013; Gress-Smith et al., 2012; Hughes et al., 2015; Karraker & Young, 2007; Loutzenhiser et al., 2015; Mao et al., 2011; Nevarez et al., 2010; O'Connor et al., 2007; Piteo et al., 2013; Saenz et al., 2015; Sinai & Tikotzky, 2012;

Sorondo & Reeb-Sutherland, 2015; Warren et al., 2006). Depressed mothers may be less able to deal with family actives, namely infant sleep-wake behaviour (Piteo et al., 2013). However, the results of 6 studies indicated no association between parental mental health and the different infant sleep-wake behaviours that were analyzed (Armitage et al., 2009; Dennis & Ross, 2005; O'Connor et al., 2007; Sinai & Tikotzky, 2012; Sorondo & Reeb-Sutherland, 2015; Thomas & Spieker, 2016). Five of these studies used measures based on parental reports (Dennis & Ross, 2005; O'Connor et al., 2007; Sinai & Tikotzky, 2012; Sorondo & Reeb-Sutherland, 2015; Thomas & Spieker, 2016). Curiously, maternal mental health was not associated with infant sleep-wake behaviour during the day in the only study that used actigraphy (Armitage et al., 2009).

Parental sleep was also associated with infant sleep-wake behaviour, namely sleep duration, sleep periods, longest sleep period, night wakings, sleep efficiency and bedtimes (Brand et al., 2014; Demirci et al., 2012; Sharkey et al., 2016; Sinai & Tikotzky, 2012; Thomas & Foreman, 2005; Thomas & Spieker, 2016; Tikotzky et al., 2015). Parents, especially mothers, presenting poor sleep could be either more stressed during the day or more actively involved in infants' soothing after a night waking which may interfere with infant's ability of self-soothing (Tikotzky & Sadeh, 2010; Tikotzky et al., 2015). Parental sleep was not associated with the different infant sleep-wake behaviours that were analyzed in 3 other studies (Sharkey et al., 2016; Sinai & Tikotzky, 2012; Thomas & Foreman, 2005). These studies were performed with small samples and 1 of them comprised a sample with a history of major depressive disorder (Sharkey et al., 2016). Furthermore, these authors found no association between parental sleep and infant sleep-wake behaviour during the day and the 24-hour period, which may suggest that parental sleep is more associated with infant sleep-wake behaviour during the night.

The presence of social and emotional problems (DeLeon & Karraker, 2007; Landau et al., 2010; McGeorge et al., 2015; Scher, 2008; Scher & Blumberg, 1999; Spruyt et al., 2008), with exception of autism (Humphreys et al., 2014), was also associated with worse sleep-wake behaviour.

More night wakings, sleep periods and sleep latency and shorter sleep duration (night and 24-hour period) were associated with sleep problems (Gibson, Gander, et al., 2012; Hiscock & Wake, 2001; Scher et al., 1998). In fact, literature has been suggesting that some sleep-wake behaviours, especially night wakings and short sleep duration, are already considered as sleep problems during the first 12 months and remain a concern for parents further in infant development (Bayer et al., 2007).

Lower socio-economic status, larger households, and maternal employment were associated with shorter sleep duration and longest sleep period, and more night wakings and sleep periods (Fouts et al., 2007; Nevarez et al., 2010; Santos et al., 2008). Considering the paucity of studies and that different parent's socio-demographic and socio-economic factors were assessed, these variables need a more extensive study to a better understanding of their association with sleep-wake behaviour during the first 12 months.

Although, during the first 6 months, preterm infants sleep more (day, and night), in longer periods (night), and present more night wakings (Guyer et al., 2015; Huang et al., 2014) at 12 months, results are not consistent across the reviewed studies (Asaka & Takada, 2010; Kozyrskij et al., 2009). Preterm infants achieve the 24-hour sleep-wake rhythms earlier than term infants (Guyer et al., 2015), and thus the differences between term and preterm infants could be more evident during the first 6 months. However, more research is warranted to better understand the association between gestational age and sleep-wake behaviour during the first 12 months of life.

Although no association was found between motor development and infant-sleep wake behaviour in 2 studies (Gibson, Elder, et al., 2012; Mindell & Lee, 2015), more night wakings were reported in the emergence of crawling (Atun-Einy & Scher, 2016; Scher & Cohen, 2005), especially in infants with early crawling (Scher, 2005a; Scher & Cohen, 2015). At crawling onset, mothers may be more involved in infant's bedtime or increase their perception of involvement in infant sleep-wake behaviour during the night, which may increase infant's night wakings (Scher & Cohen, 2005).

Results also suggest a trend for an association between easy temperament and less night wakings (Bayer et al., 2007; Mindell & Lee, 2015; Palmstierna et al., 2008; Scher et al., 1998), less WASO (Sorondo & Reeb-Sutherland, 2015), less sleep latency (Gibson, Gander, et al., 2012; Sorondo & Reeb-Sutherland, 2015), longer sleep duration (day, night, and 24-hour) (Gibson, Gander, et al., 2012; Kaley et al., 2012; Mindell & Lee, 2015; Scher et al., 1998; Spruyt et al., 2008; Touchette et al., 2005), less sleep periods (Mindell & Lee, 2015), more sleep efficiency (Scher, 2001a; Scher et al., 1998), earlier bedtime (Scher et al., 1998) and later wake time (Gibson, Gander, et al., 2012; Mindell & Lee, 2015). Previous authors hypothesized that these associations may be influenced by parents' perceptions (Mindell & Lee, 2015; Spruyt et al., 2008). Moreover, temperament dimensions were not associated with the different infant sleep-wake behaviors that were analyzed (Gibson, Gander, et al., 2012; Kaley et al., 2012; Mindell & Lee, 2015; Scher, 2001a). However, these results seem to suggest that infants with a more difficult temperament and negative mood present worse sleep-wake behaviours.

Although there is a tendency for an association between crying and less sleep duration and more fragmented sleep (DeLeon & Karraker, 2007; Harrison, 2004; Lee, 2000; St James-Roberts et al., 1997; St James-Roberts & Peachey, 2011), this association is not congruent across the different studies. Studies addressing this association used parent's reports to assess both crying and infant-sleep wake behaviour, which may underlie some biased perceptions. Further studies should address this association using actigraphy.

Factors positively and negatively affected by sleep-wake behaviour

Effects of sleep-wake behaviour were less studied, but worse sleep-wake behaviour were shown to predict later social-emotional (Bernier et al., 2010; Bordeleau et al., 2012; Bouvette-Turcot et al., 2015; Sadeh et al., 2015; Saenz et al., 2015), and sleep problems (Byars et al., 2012; Hysing et al., 2014; Palmstierna et al., 2008; Tikotzky & Shaashua, 2012).

More night wakings, shorter sleep duration (night and 24-hour period) and less sleep efficiency early in infancy were shown in infants with social and emotional problems, namely attention and emotional regulation and attention deficit hyperactivity disorder (Sadeh et al., 2015; Scott et al., 2013), externalizing problems (Saenz et al., 2015), autism disorder (Saenz et al., 2015), and anxiety and depression symptoms (Jansen et al., 2011). This may indicate that early sleep-wake behaviour is associated with brain maturation (Saenz et al., 2015). Authors of a recent study stated the importance of differential susceptibility in the association between sleep duration and later emotional development, reporting that this association is only present in infants with 5-HTTLPR allele (Bouvette-Turcot et al., 2015). Sleep-wake behaviour was not associated with externalizing problems in 1 study, whose results suggested, however, that sleep duration during the night moderated the association between maternal sensitivity and internalizing/externalizing symptoms (Bordeleau et al., 2012).

Shorter sleep duration, more night wakings, sleep periods and sleep latency were associated with later sleep problems (Byars et al., 2012; Hysing et al., 2014; Palmstierna et al., 2008; Tikotzky & Shaashua, 2012). This is consistent with the results of a previous study, pointing for the individual stability in infant sleep-wake behaviour over the first 6 months (Figueiredo et al., 2016).

Conclusions

This systematic review provided information regarding factors associated with the different sleep-wake behaviour during the first 12 months of life. Different factors were identified as being positively and negatively associated with different sleep-wake behaviors, namely infant factors, parental and environmental factors. Factors positively and negatively affected by different sleep-wake behaviours during the first 12 months of life were also presented in this systematic review. Moreover, the bidirectional nature of different factors was shown. For example, infant social-emotional and sleep

problems were shown to be negatively associated with some infant sleep-wake behaviours and were also found to be negatively affected by other infant sleep-wake behaviours.

Methodological differences between the studies seemed to underlie some different results between them, namely: (1) the use of different sleep-wake measures; (2) the study of infants with different ages or age-ranges; (3) the study of samples with different characteristics; (4) the use of different definitions of the studied variables; and (5) the study of different sleep-wake behaviours.

Infant sleep-wake behaviour presents significant developmental changes and individual differences during the first months (Figueiredo et al., 2016), being imperative the assessment of infants in specific ages and the use of large and representative samples. Infant sleep-wake behaviour presents cultural differences (Mindell et al., 2010) and incongruent results were also identified in studies performed in specific countries (e.g. Baddock et al., 2006; Kozyrskyj et al., 2009; So et al., 2007). Considering the homogeneity of some studies' samples, it could be difficult to generalize some results (Field, 2017).

Despite these differences, this systematic review identified several factors associated with the different sleep-wake behaviours during the first 12 months of life.

Disclosure statement

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Notes on contributors

Cláudia Castro Dias is a PhD student at the School of Psychology University of Minho, Braga, Portugal.

Bárbara Figueiredo, PhD, is Professor at the School of Psychology, University of Minho, Braga, Portugal.

ORCID

Cláudia Castro Dias  <http://orcid.org/0000-0002-5511-457X>

Bárbara Figueiredo  <http://orcid.org/0000-0002-8209-7445>

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