## EDITORIAL

# Determinants of infant sleep: a call for precise measurement and mechanisms of influence☆

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As reported in Zandoná et al.'s interesting article,[1] prenatal medical factors such as smoking, hypertension, diabetes, and intrauterine growth restriction bore no relation with infant sleep during this early time period. In contrast, extrauterine factors such as breastfeeding, family income, mothers' education, and depressive symptoms did show some linkages. Breastfeeding was associated with more total sleep time in the infants' first month and with more interrupted sleep across the full six months. In addition, higher family income and maternal education was predictive of longer sleep latencies (although it is unclear at which ages this occurred), as was greater maternal depressive symptoms at 3 and 6 months.

These results were interesting and my comments to them center around two overarching themes. The first is the need for precise measurement in studies of infant sleep. The second is a call for the systematic examination of the mechanisms by which, in particular, extrauterine environments influence, and are possibly influenced by, infant sleep.

## Measuring infant sleep

Let me first turn to measurement concerns. Infant sleep in Zandoná et al.[1] was assessed using four questions from the Child Sleep Questionnaire: (1) What is the total duration of your child's sleep during the day?; (2) What is the total duration of your child's sleep at night?; (3) During the night, how many hours does your child sleep without waking up? (uninterrupted sleep); and (4) How long does it take for your child to fall asleep at night? (sleep latency). These questions were answered at each of three time points: 30 days, three months, and six months post-partum. Measuring child sleep in this manner raises many questions about precision, especially given that sleep assessment was entirely based on parent report of sleep across an unspecified period of time, and that the items did not provide clear behavioral anchors for parents on which to base their responses. For at least some infants, day- and nighttime sleep varies daily, and thus asking parents to provide accurate estimates of their infant's mean number of hours of sleep (through free recall across an unclear time span) could be quite challenging. As worded, the questions appeared not to provide parents with a specific time period that they could have used to make more precise estimate (*e.g.*, prefacing each question with, ''During the past week…''). There was also lack of clarity to parents about how sleep latency should be measured. To be more specific, from what point in time was sleep latency based? When the infant was laid down to sleep in their crib? From the moment room lights were turned off? From the point the bedtime routine began or ended? Without such behavioral anchors given to parents, it is difficult to interpret the sleep latency findings.

Measuring child sleep is, of course, a challenging task, and there is much to consider, including how representative the sleep window is for a given infant, how easy/difficult a system is to administer, and whether the system is objective (*i.e.*, assessed passively with a wearable device or through videosomnography) or subjective (*i.e.*, parent or caregiver report).[2] The gold standard for measuring sleep, at any age, is electroencephalography (EEG), but that is imprac-

tical when the task is to measure infant sleep in the home. More appropriate alternatives for studies of infant and child sleep in the home include questionnaires, daily diaries, and actigraphy. Child sleep questionnaires (*e.g.*, Bruni et al.[3] and Owens et al.[4]) are many, but their psychometrics are not always well-established, and it is not uncommon that individual items need to be modified to provide the reporter with sufficient behavioral anchors to respond with precision. Even with behavioral anchors in place, the biggest drawback of questionnaire and survey approaches is that they tend to be administered at a single time point and inquire about general sleep characteristics, when in fact infant sleep can vary substantially from one night to the next.[5] There is also another factor to consider in determining whether or not to use an infant sleep questionnaire, and that is that parents who do not sleep well tend to report that their children also do not sleep well.[6] Why this is the case is not clear. It may be that parents who are distressed (*e.g.*, with more depressive symptoms) do not sleep well,[7] and they in turn may be more likely than non-distressed parents to view minor postural changes and leg movements in their infants as wake-ups, when such changes are not necessarily counted as awakenings by objective assessments (*e.g.*, actigraphy[6]).

A step up from questionnaires is the daily diary approach, in which parents are asked in the morning to report on the infant's sleep the preceding night, across several consecutive days. For each administration of the diary, limiting the time window of reporting to the evening or day before lowers the parent's reliance on retrospective memory of longer time periods, and obtaining diary information across consecutive days enables the parent to provide a more precise representative measure of infant sleep. Daily diaries can also be used to capture, on a day-to-day basis, the frequency and duration of infant daytime naps, information on whether infant night awakenings were signaled (*i.e.*, crying/calling out) or not, and other information that can be examined as predictors/correlates of infant sleep. These include infant sleep locations across the night, who responds to infant night awakenings, what was done to sooth the infant back to sleep, *etc*. The advantages of a daily sleep diary are many. They are easy and inexpensive to administer. Each administration has a specified time window (*e.g.*, the previous night/previous 24 h). They can be repeated across consecutive days to obtain a more representative window of infant sleep. They enable the averaging of sleep data across days. And they enable an assessment of day-to-day volatility of infant sleep, and potential reasons for such. Indeed, we have found in our work that day-to-day variability in infant sleep is as sensitive to environmental predictors (*e.g.*, household chaos) as mean levels of infant sleep.[5]

A final recommendation to consider for use in home-based studies of infant sleep is actigraphy, or the passive wearing of activity monitors to obtain a record of activity and rest periods for several consecutive days. Actigraphs come with software that provides central tendency and variability statistics across a specified time period. Teti et al. have placed actiwatches on infants' calves using a soft sock and Velcro[6] for seven consecutive days to obtain a running day-to-day record of infant nighttime and daytime sleep. The disadvantages of actigraphy are that it is expensive, and when used with infants and young children it requires monitoring to ensure that the device does not

fall off the participant. But its advantages are many. They yield information on sleep start and end times, latency to sleep (marking the time infant is put to bed), sleep duration, and indicators of sleep quality including sleep fragmentation, waking after sleep onset, sleep efficiency, and other quality indicators. I have argued[6] that approaches to infant sleep assessment that combine daily diaries with daily actigraphy may be ideal, because each is a daily data collection across consecutive days and each yields information on infant sleep that complements the other. One is a purely objective assessment, and one is parent perception. Both are useful in their own right and provide unique information about infant sleep.

## Environmental mechanisms predictive of infant sleep

In addition to focusing on intrauterine factors, Zandoná et al.[1] examined several environmental influences on infant sleep in the first six months. I was pleased to see this, because the study of environmental influences on infant development and infant sleep has been developing rapidly in the past decade. Infant sleep is being viewed as imbedded in a broad ecological network, ranging from distal (*e.g.*, culture, socioeconomic status) to proximal (*e.g.*, parent-infant interactions at bedtime) influences.[8,9] To be sure, infant sleep has been associated with macro-environmental factors. For example, socioeconomic risk has been repeatedly associated with poor child sleep (*e.g.*, El-Sheikh et al.[10]). In the present study, higher socioeconomic risk was linked with infant sleep latencies. I would argue, however, that researchers need to move beyond establishing ''main effect'' linkages between environmental markers and infant sleep to examine the proximal mechanisms linking these markers with sleep. Why, for example, is socioeconomic risk linked with poor child sleep? Putative answers to these questions may come from other studies linking quality of parental behavior, particularly at bedtime,[11,12] with better quality sleep across the night, and from studies linking household chaos and disorganization to poorer infant and child sleep.[5] In light of evidence that poor parenting quality and household chaos are also associated with socioeconomic risk,[13,14] it is reasonable to propose that these proximal, family-based processes at least partially account for and mediate the impact of macro-environmental factors, such as socioeconomic risk, on poor child sleep. Although I would expect these linkages are fundamental and culture-free, it is important to note that they derive primarily from U.S. samples. It is paramount to replicate and extend these findings to Latin American samples. It is also important for researchers to examine how bio-ecological theory[8] and the ecological/transactional model of sleep[9] can particularly inform and be adapted to the study of infant and child sleep in Latin America.

Similarly, while Zandoná et al.[1] found that higher levels of maternal depressive symptoms were associated with longer infant sleep latencies, the mechanisms linking mothers' depressive symptoms with infant sleep were not explored. An important question to be asked first is, what is the direction of influence here? The present study appeared to be framed such that maternal depressive symptoms were

viewed to be causal to longer infant sleep latencies. Perhaps that is the case, but no evidence for that causal linkage was presented, and I would argue that the reverse could be occurring: infants who chronically take longer to fall asleep can lead to higher levels of maternal distress (*i.e.*, higher levels of depressive and anxiety symptoms). Teti and Crosby[7] found that both directions of influence were plausible. In one pathway, mothers with higher depressive symptoms were found to spend more time with their infants during the night, and that in turn was predictive of more frequent infant nighttime awakenings. In another, infants who awakened more frequently during the night predicted greater maternal presence with infants at night, and in turn, higher maternal depressive symptoms. I would argue that these bidirectional influences are critically important for pediatricians to understand, given that these physicians are frequently the first in line for parents who face sleeping problems in their infants.

I would like to thank the *Jornal de Pediatria* for the opportunity to share my views and perspective about the study of infant sleep, to emphasize the importance of precise measurement and the need to identify mechanisms of influence. I look forward to seeing further development of this work in Latin America.

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## Conflicts of interest

The author declares no conflicts of interest.

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