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Nighttime Breastfeeding Behavior Is Associated with More Nocturnal Sleep among First-Time Mothers at One Month Postpartum

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Study Objective: To describe sleep duration and quality in the first month postpartum and compare the sleep of women who exclusively breastfed at night to those who used formula.

Methods: We conducted a longitudinal study in a predominantly low-income and ethnically diverse sample of 120 first-time mothers. Both objective and subjective measures of sleep were obtained using actigraphy, diary, and self-report data. Measures were collected in the last month of pregnancy and at one month postpartum. Infant feeding diaries were used to group mothers by nighttime breastfeeding behavior.

Results: Mothers who used at least some formula at night (n = 54) and those who breastfed exclusively (n = 66) had similar sleep patterns in late pregnancy. However, there was a significant group difference in nocturnal sleep at one month postpartum as measured by actigraphy. Total nighttime sleep was 386 ± 66 minutes for the exclusive breastfeeding group

and 356 ± 67 minutes for the formula group. The groups did not differ with respect to daytime sleep, wake after sleep onset (sleep fragmentation), or subjective sleep disturbance at one month postpartum.

Conclusion: Women who breastfed exclusively averaged 30 minutes more nocturnal sleep than women who used formula at night, but measures of sleep fragmentation did not differ. New mothers should be encouraged to breastfeed exclusively since breastfeeding may promote sleep during postpartum recovery. Further research is needed to better understand how infant feeding method affects maternal sleep duration and fragmentation.

Keywords: Actigraphy, sleep, maternal, breastfeeding, infant formula

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Becoming a mother for the first time is a major life-changing event for any woman. The first few months postpartum is a dynamic time as the woman is undergoing significant physiologic and psychological changes to recover from the stresses of pregnancy and childbirth while adjusting to her new role and responsibility of caring for her infant.¹ Much needed restorative sleep during this time is often interrupted with night waking, mainly for infant care and feeding.²

Although infant feeding of any type interferes with maternal sleep,³ it is a common belief that infant formula makes an infant feel fuller and thus sleep more and in turn helps the mother to sleep more as well. This may explain why formula supplementation, even of breastfed infants, remains a popular practice, especially at bedtime. As early as two days after birth, approximately 25% of breastfed infants in the United States (US) are supplemented with infant formula; the proportion increases to 37% and 44% by 3 months and 6 months, respectively.⁴

To our knowledge, there is no firm evidence indicating that formula supplementation increases infant or maternal sleep time or reduces sleep fragmentation. Only one laboratory study indicated that lactating women have more deep sleep than formula-feeding women.⁵ More documented time in deep sleep

BRIEF SUMMARY

Current Knowledge/Study Rationale: Common belief suggests that infant formula leads to better infant sleep and in turn to better maternal sleep. Prior research in a sample of socio-economically advantaged mothers indicated that breastfeeding mothers obtained more sleep at night than those using formula, and this study was conducted to determine whether a similar pattern was also evident in a sample of lower-income and ethnically diverse women.

Study Impact: This study replicates our prior findings that mothers who breastfeed exclusively obtain more sleep than mothers who use at least some formula, despite common belief to the contrary. Infant feeding type was unrelated to sleep fragmentation, and the mechanism by which feeding type influences sleep duration remains unclear.

stages among lactating women may be due to higher levels of circulating prolactin, although this has not been definitively established.⁵ Despite the need for new mothers to obtain adequate sleep, the association between maternal sleep and breastfeeding behaviors is rarely examined.

Results from two recent studies indicated no difference in maternal sleep quality or duration by feeding method. Montgomery-Downs and colleagues studied sleep with actigraphy in 80 women between 2 and 12 weeks postpartum and grouped

them by feeding method (breastfeeding, formula feeding, or both) assessed by telephone interview.⁶ Not only was there a broad range of weeks postpartum, the sample also included both primiparas and multiparas, whose sleep may differ greatly due to family sleeping arrangements.

In our prior study, most mothers (96%) were breastfeeding at 4 weeks; differences in sleep duration could not be analyzed with such a small group of formula feeding mothers.³ However, in a subsequent analysis of the same sample at 12 weeks postpartum, 67% remained exclusively breastfeeding, and mothers and their partners slept an average of 40 to 45 minutes longer than parents who used formula supplementation at night.⁷ Our previous sample was relatively older and more educated than the general population of first-time parents in the US; thus findings may not be generalizable to most new parents.

Therefore, the purpose of this study was to replicate our prior study's findings in a new sample of predominantly low-income and ethnically diverse first-time mothers. We compared the sleep of women who exclusively breastfed at night ($n = 66$) to those who used at least some formula at night ($n = 52$) in the first month postpartum. We tested three null hypotheses: (1) no group difference in sociodemographic characteristics; (2) no group difference in objective sleep duration or fragmentation as measured by wrist actigraphy; and (3) no group difference in perception of sleep disturbance.

METHODS

Participants and Design

This study was approved by the Committee on Human Research at the University of California, San Francisco. As part of a randomized clinical trial aimed at minimizing sleep disruption and stress for new mothers, pregnant women in their third trimester were recruited from free childbirth preparation classes and prenatal clinics serving primarily low-income women.⁸ Inclusion criteria were (1) English-speaking women expecting their first child, (2) ≥ 18 years of age, (3) not working the night shift, (4) not taking medications that alter sleep, and (5) no history of diagnosed sleep disorder or affective disorder. Intention to breastfeed was not an inclusion criterion.

After eligible women consented and baseline measures of sleep were collected in the last month of pregnancy, women were randomly assigned to an experimental group and given a modified sleep hygiene kit to help them feel more prepared for infant care during the night and more competent in their new role. The control group received nutritional information and comparable time with the researcher. Breastfeeding information was not a component of either group's intervention content. Follow-up assessments of sleep and well-being occurred at 1, 2, and 3 months postpartum. Each assessment took place in the participant's home. This analysis focused on the 1-month postpartum data because that time point is a critical time for lactation establishment.¹

Measures

Breastfeeding Behaviors

Breastfeeding behaviors were ascertained from the sleep and infant feeding diary completed by the mother over 3

consecutive days and nights. To facilitate the mother's diary completion, each day was divided into 12-h time periods from 09:00 to 20:59 for daytime recording and from 21:00 to 08:59 for nighttime recording. Each hour was further divided into 15-min sections. For each feeding session, mothers were instructed to mark start times and type of feeding. For descriptive purposes, type of infant feeding was initially classified in categories congruent with standard definitions: (a) *Exclusive breastfeeding* = 100% breastfeeding or breast milk feeding; (b) *partial breastfeeding* = any combination of breastfeeding or breast milk feeding, and formula supplementation; and (c) *formula-feeding* = 100% formula feeding.⁹

To analyze the effect of infant feeding method on maternal sleep at night (from 21:00 to 08:59), breastfeeding behavior was then categorized as either (1) *exclusive breastfeeding (EBF)* = 100% breastfeeding or breast milk feeding on all 3 nights, or (2) *formula* = giving any formula at night on any of the 3 nights. These 2 categories of feeding were specific to nighttime breastfeeding behavior. Thus, at any time during the 72 h, women in the formula group could also have breastfed or given breast milk in addition to formula.

Sociodemographic Characteristics

Data on age, race, marital or relationship status, education, monthly household income, and employment status or working for pay outside the home were obtained when women were screened for eligibility during their third trimester. Women enrolled in the study were asked about their breastfeeding intention (yes/no) and, if yes, how long they planned to breastfeed (months). At one month postpartum, participants were asked again about their employment status. To assess support women received or perceived at this time, they were also asked whether they had help with the baby each night during the 72-h study period.

Objective Measures of Sleep

To estimate day and night sleep time, each participant was asked to wear a wrist actigraph (Ambulatory Monitoring, Inc., Ardsley, NY) for 72 h at each assessment point. This device weighs about 2 ounces and provides continuous motion activity data using a battery-operated wristwatch-size microprocessor that senses motion with a piezoelectric linear accelerometer. An amplifier setting of 18 (filter 2.0-3.0 Hz) was used, along with zero-crossing mode and 30-sec epochs. Although polysomnography is considered the gold standard for measuring sleep stages, it is cumbersome, more invasive, and cannot run continuously for 72 h to get an estimate of both daytime and nighttime sleep in the home environment. Assessment of sleep in healthy young adults showed strong correlations between polysomnographic measures and actigraphy measures ($r = 0.93$ to 0.99)¹⁰⁻¹² and 88% agreement between the 2 methodologies.¹³

Actigraphy data were analyzed using Action4 software (Ambulatory Monitoring, Inc., Ardsley, NY). The autoscoring program for sleep uses activity counts to determine sleep and wake episodes on the basis of the criteria of Webster et al.: after 4 min scored as wake, the next 1 min of sleep is scored as wake, and ≤ 6 min of sleep surrounded by 10 min of wake before and after is scored as wake.¹⁴ Three sleep-related variables from the autoscoring program were included as outcomes for this study:

(1) *total sleep time at night (TST-night)* or average minutes of sleep between 21:00 and 08:59 over 3 nights, (2) *total sleep time during the day (TST-day)* or average minutes of sleep between 09:00 and 20:59 over 3 days, and (3) *wake after sleep onset (WASO)*, calculated by dividing the minutes awake by minutes in bed after falling asleep and presented as a percentage.³ TST-night and TST-day were subsequently summed to obtain an estimate of average sleep duration over 24 h (TST-24). To facilitate interpretation of maternal sleep from the actigraphy data, mothers completed a 72-h sleep diary with information about bed times, wake times, naps, and sleep locations. The use of standard 12-h blocks (09:00 to 20:59 and 21:00 to 08:59) to calculate estimates of TST was to minimize threats to validity from inconsistency in interrater scoring procedures related to unpredictable or polyphasic sleep patterns typical in the early postpartum period. If the 12-h blocks split a sleep period (e.g., the woman was still sleeping at 09:00 and the diary indicated a later wake time), they were adjusted to incorporate the entirety of that sleep period within the nocturnal block.

Subjective Measures of Sleep

Mothers also completed the 21-item General Sleep Disturbance Scale (GSDS)¹⁵ at each time point. The GSDS is used to assess frequency of specific sleep problems experienced during the past week. Each item is rated on a scale of 0 (*no days*) to 7 (*every day*); the total score ranges between 0 and 147, with higher scores indicative of more frequent sleep disturbance. The GSDS was originally developed and tested in a sample of shift-working nurses¹⁵ and further tested in other samples of pregnant and postpartum women.^{3,7,16} Cronbach α reliability coefficients for this sample were 0.80 at the last month of pregnancy and 0.77 at one month postpartum.

Data Analysis

Actigraphy, diary, and self-report (GSDS) data were processed and reduced to descriptive means and standard deviations (SD). Preliminary analyses were performed to ensure no violation of normality, linearity, and homoscedasticity assumptions. Women were grouped by feeding behavior at night for analysis. Women in the EBF group exclusively breastfed or fed breast milk to the infant ($n = 66$), and they were compared to women in the formula group ($n = 54$) who used any amount of formula at night on any of the 3 nights of actigraphy monitoring.

To evaluate potential demographic factors associated with breastfeeding, continuous variables were tested with independent group t -tests, and categorical variables were tested with χ^2 tests. Repeated measures analysis of variance (RMANOVA) was used to test for mean group differences in sleep variables in the last month of pregnancy and at one month postpartum. The design had 1 between-subjects factor with 2 levels (EBF and formula) and 1 within-subjects factor (time) with 2 levels (last month of pregnancy and 1 month postpartum). This design allowed for testing of the main effect of group, the main effect of time, and the interaction of group by time. Post hoc testing of significant interactions was conducted to identify group differences at each of the 2 time points. Demographic variables that differed by feeding type were included in the RMANOVA as covariates. Associations between actigraphy measures of sleep and perception of sleep disturbance were measured using

Pearson correlation coefficients. Data were analyzed using a two-tailed statistical significance level of $\alpha = 0.05$ with 95% confidence intervals (95% CI) using SPSS version 18.0 software for Windows.

RESULTS

Of the 198 women screened, 152 women were eligible, willing to participate, and enrolled in the study. There were no differences in sociodemographic characteristics (age, race, marital status, education, income, or employment status) between women who were not eligible and those who were eligible for the study. Of the 152 women, 126 women had sleep measures and breastfeeding diary data at one month postpartum. Of the 26 women who were excluded due to missing data, 15 did not participate in the one month postpartum assessment, 5 had actigraph device failure, 5 did not complete the feeding diary, and 1 did not complete the GSDS. Because this report focuses on sleep and feeding of mothers of normal full-term infants, an additional 6 women with infants who had extended length of stay in hospital (> 7 days) due to complications after birth were excluded from analysis. The final sample consisted of 120 first-time mothers.

Breastfeeding Behavior

Across the 3 days and nights of diary measures at one month postpartum, breastfeeding behavior was classified using standard definitions.⁹ About half (52%, $n = 62$) were exclusive breastfeeding, 28% ($n = 34$) were partial breastfeeding, and 20% ($n = 24$) were exclusive formula-feeding. For analysis of nighttime feeding, 55% ($n = 66$) were categorized as EBF for all 3 nights, 24% ($n = 29$) were partial breastfeeding, and 21% ($n = 25$) were exclusive formula-feeding. The partial breastfeeding and exclusive formula-feeding women did not differ on demographic variables or sleep outcomes, and these women were grouped together for subsequent analyses. In addition, 28% ($n = 27$) of the 95 women using breast milk reported giving it to their infant in a bottle at least once over the 3 nights, and bottle-feeding breast milk was more common (62%) in the partial breastfeeding group than in the EBF (14%) group ($\chi^2(1) = 23.2$, $p < 0.001$). Because there were no significant differences on demographic variables or sleep outcomes between mothers giving breast milk from a bottle or from the breast, the EBF group included both types of breast milk feeding.

Sociodemographic Characteristics

Table 1 provides sample characteristics for the 2 feeding groups. Participants ranged in age from 18 to 41, and the mean age of 26.5 years is similar to the mean age of 25 years among first-time mothers in the United States.¹⁷ On average, the EBF group was 3 years older than the formula group. The feeding groups also differed by race; two-thirds of the African American women and roughly half of women of Asian, Latina, or mixed/other race used formula at night, while nearly 80% of Caucasian women were exclusively breastfeeding at night. Most women in the sample (68%) indicated they were single or unmarried. Although there was no difference in marital status by feeding type, women in the EBF group were more likely to be in a relationship than women in the formula group. The

Table 1—Sample characteristics by type of infant feeding at night

Variable	EBF ^a at night (n = 66)	Formula ^b at night (n = 54)	Test Statistic
Age in years (mean ± SD)	27.9 ± 6.1	24.9 ± 6.7	$t_{118} = 2.58, p = 0.011$
Race			$\chi^2(4) = 10.8, p = 0.029^c$
African American (13%)	5 (33%)	10 (67%)	
Asian (32%)	19 (49%)	20 (51%)	
Caucasian (24%)	23 (79%)	6 (21%)	
Latina (22%)	14 (54%)	12 (46%)	
Mixed/Other (9%)	5 (45%)	6 (55%)	
Currently married	20 (30%)	18 (33%)	NS
Currently in relationship	59 (89%)	40 (74%)	$\chi^2(1) = 4.83, p = 0.028$
Education: completed college	27 (41%)	16 (30%)	NS
Household income < \$2,000/month ^d	41 (65%)	34 (71%)	NS
Working at 36 weeks pregnant	14 (21%)	4 (7%)	$\chi^2(1) = 4.44, p = 0.035$
Working at 1 month postpartum	0	4 (7%)	$\chi^2(1) = 5.06, p = 0.025$
Intention to BF	66 (100%)	50 (93%)	$\chi^2(1) = 5.06, p = 0.025$
Duration in months (mean ± SD)	8.8 ± 3.8	8.2 ± 4.9	NS
Help with infant care every night	13 (20%)	19 (35%)	$\chi^2(1) = 5.40, p = 0.056$
Assigned to intervention group	41 (62%)	40 (74%)	NS

EBF, exclusive breastfeeding; NS, not significant. ^aThe EBF group included 9 women whose infants received at least some breast milk from a bottle at night, the remaining 57 were exclusively breastfed at night. ^bThe formula group included 25 mothers who only used formula during the night and 29 who used formula to supplement BF at night. Of the 29 whose infants had at least some breast milk at night, 18 used a bottle at least some of the time. ^cCaucasian women were more likely than women of other races to be in the EBF group. ^d9 women either declined to report or did not know their household income; n = 111 for income.

sample was predominantly low-income.¹⁸ There were no group differences in income or education. About 21% of the EBF group worked for pay during the third trimester, but none of these women had returned to work by one month postpartum. These rates differed significantly from the formula group in which only 4 women (7%) worked during pregnancy and at one month postpartum.

There was a significant difference in the prenatal intention to breastfeed between the 2 feeding groups. All 4 participants who stated no intention to breastfeed were African American women in the formula group. Of the 116 women who intended to breastfeed, the planned duration did not differ between the feeding groups. Women in the formula group were somewhat more likely than EBF women to report having help on all 3 nights of the monitoring period, although this difference did not reach statistical significance ($p = 0.056$). Intervention assignment in the larger clinical trial (sleep hygiene intervention vs. nutrition control) was unrelated to type of feeding or to maternal sleep outcomes at one month postpartum.

Sleep Outcomes

Comparisons of sleep outcomes by time and by type of feeding group are presented in **Table 2**. There were no differences between groups in the last month of pregnancy. At one month postpartum, TST-night was lower for both groups but decreased more in the formula group (62 min, 95% CI: 39, 85) than in the EBF group (21 min, 95% CI: 0.1, 42), resulting in a significant interaction between time and group (**Figure 1**). In post hoc testing of the interaction, the feeding groups did not differ in late pregnancy, but at one month postpartum, EBF mothers obtained significantly more nocturnal sleep than

formula feeding mothers. To ensure that these results were not unduly influenced by the grouping of exclusive and supplemental formula feeding mothers, separate post hoc tests were done to compare each formula group to the EBF group. Although the supplemental (356 ± 63 min) and exclusive (356 ± 73 min) formula groups obtained similar amounts of nocturnal sleep, only the supplemental group differed significantly from the EBF group ($t_{91} = 2.03, p = 0.045$); the analysis of the exclusive formula group did not reach statistical significance ($t_{89} = 1.87, p = 0.064$), likely due to the slightly smaller sample size and greater variance in this group. TST-day (actigraphy) did not differ by time or feeding group, and TST-24 patterns were similar to those observed for TST-night. However, the post hoc analysis comparing TST-24 for EBF and formula-feeding mothers was not statistically significant in the slightly smaller and more varied sample for the TST-24 analysis ($n = 113$).

The time spent awake after initially falling asleep (WASO) was also higher at one month postpartum compared to the third trimester, but did not differ by feeding group. Perception of sleep disturbance (GSDS score) differed significantly by time, as women in both feeding groups perceived more sleep disturbance at one month postpartum than the last month of pregnancy. The relationship between perceived sleep disturbance (GSDS scores) during the past week, and actigraphy WASO for 72 h was weak at the third trimester time point ($r = 0.12$) as well as at one month postpartum ($r = 0.15$).

To account for the potential effects of sociodemographic differences on the sleep outcomes, variables in **Table 1** that differed between the groups were included as covariates in the RMANOVA. Due to the relatively small sample, each covariate was evaluated in a separate analysis. The significant time by

Table 2—Repeated measures analysis of sleep quantity and quality parameters by time and group

Variable	EBF ^a at night	Formula ^b at night	Significant Effects
TST-night (minutes)	n = 66	n = 52	Time: $F_{1,116} = 28.4, p < 0.001, \eta^2 = 0.197$
Last month of pregnancy	407 ± 85	418 ± 88	T×G: $F_{1,116} = 6.80, p = 0.010, \eta^2 = 0.055$
1 month postpartum	386 ± 66	356 ± 67	Postpartum post hoc: $t_{116} = 2.44, p = 0.016, \eta^2 = 0.049$
TST-day (minutes)	n = 63	n = 51	none
Last month of pregnancy	79 ± 61	86 ± 60	
1 month postpartum	90 ± 64	90 ± 73	
TST-24 hours (minutes)	n = 63	n = 50	Time: $F_{1,111} = 10.5, p = 0.002, \eta^2 = 0.086$
Last month of pregnancy	490 ± 101	506 ± 105	T×G: $F_{1,111} = 4.89, p = 0.031, \eta^2 = 0.041$
1 month postpartum	479 ± 98	452 ± 77	
WASO (%)	n = 66	n = 53	Time: $F_{1,117} = 33.9, p < 0.001, \eta^2 = 0.225$
Last month of pregnancy	21.1 ± 11.6	20.3 ± 13.5	
1 month postpartum	26.7 ± 9.8	28.7 ± 10.3	
GSDS Total Score	n = 66	n = 54	Time: $F_{1,118} = 12.8, p < 0.001, \eta^2 = 0.098$
Last month of pregnancy	46.5 ± 15.6	42.9 ± 16.9	
1 month postpartum	49.7 ± 15.5	51.1 ± 15.4	

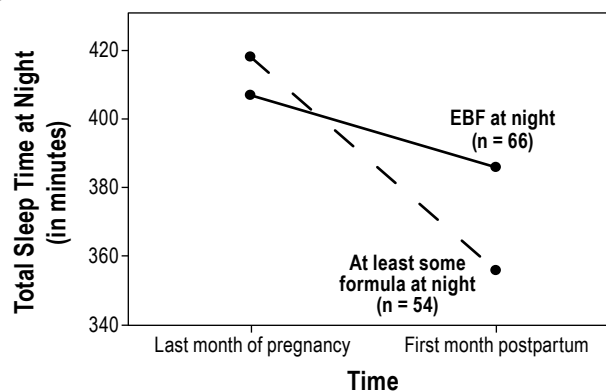
EBF, exclusive breastfeeding; TST, total sleep time; T×G, interaction effect of time and group; GSDS, General Sleep Disturbance Scale; WASO, wake after sleep onset. ^aThe EBF group included 9 women whose infants received at least some breast milk from a bottle at night; the remaining 57 exclusively breastfed at night. ^bThe formula group included 25 mothers who used formula exclusively at night and 29 who used formula to supplement breast milk at night. Of the 29 women whose infants had at least some breast milk at night, 18 used a bottle at least some of the time.

group interactions for TST-night and TST-24 remained significant even when the following covariates were included in the models: maternal age, Caucasian race, relationship status, work status in pregnancy or postpartum, intention to breastfeed, or having help with infant care at night. Intervention assignment (sleep hygiene intervention vs. nutrition control) was also evaluated as a possible covariate, and its inclusion had no impact on the significant time by group interactions for TST-night and TST-24.

Inclusion of covariates did not change the results for TST-day or WASO. However, in analyses of perceived sleep disturbance, controlling for maternal age, partner status, or postpartum work status, resulted in a significant interaction for time by feeding group ($F_{1,117} = 4.26, p = 0.041$ with age, $F_{1,117} = 4.22, p = 0.042$ with partner status, and $F_{1,117} = 4.69, p = 0.032$ with postpartum work status). After controlling for maternal age, GSDS scores for the EBF group increased by an average of 2.4 points (from 46.8 ± 16.4 to 49.3 ± 15.6), indicating worse sleep postpartum, while the formula group increased by 9.1 points (from 42.5 ± 16.4 to 51.6 ± 15.6). Similarly, when controlling for partner status, GSDS scores for the EBF group increased by an average of 4.0 points (from 45.5 ± 16.1 to 49.5 ± 15.8), while the formula group increased by 10.6 points (from 40.2 ± 17.4 to 50.8 ± 17.1). Lastly, when accounting for the effect of postpartum work status, GSDS scores in the EBF group still increased by an estimated 3.2 points from pregnancy to postpartum (from 46.5 ± 16.1 to 49.7 ± 15.4), while the formula group increased an estimated 9.9 points (from 42.0 ± 16.7 to 51.9 ± 16.0).

DISCUSSION

In this study of first-time mothers, objective nocturnal sleep time at one month postpartum was significantly greater for

Figure 1—Total sleep time at night over time and by feeding group

EBF, exclusive breastfeeding.

women who exclusively breastfed compared to women who used formula at night. These results support our previous findings in a sample of more affluent first-time mothers as well as the fathers at three months postpartum.⁷ Since the greatest decline in EBF occurs during the first month,¹⁹ the association between nocturnal sleep and feeding behavior during this period is key to breastfeeding promotion. The first month after childbirth is a critical time for postpartum recovery as well as lactation establishment. Less sleep at night during this time not only affects a mother's physical and emotional health but may also interfere with her milk supply, given the caloric demands for lactation and the potential association between deep sleep and prolactin levels.⁵

It is often assumed that new mothers get less sleep because of their added roles and responsibilities. While both groups of mothers slept less at night in the first month postpartum compared to their last month of pregnancy, this is an expected

part of new parenthood. Yet our results indicate that sleep loss, specifically between 21:00 and 08:59, for mothers who used formula at night (62 min) was nearly three times the amount of sleep loss experienced by women in the EBF group (21 min). Although the feeding groups did not differ significantly with respect to WASO or time spent in bed (data not shown), the differences were in the expected directions, and thus group differences in nocturnal sleep duration might reflect the cumulative effect of subtle changes in these variables. Further study is needed to more fully understand the observed relationship between feeding method and nocturnal sleep duration.

Exclusive breastfeeding mothers in our sample obtained more nocturnal sleep by objective estimates with actigraphy, but there was little difference in their self-reported perception of disturbed sleep until maternal age and work status were controlled in the analysis. Since the correlation between subjective and objective sleep disturbance in this sample was weak at both time points, future research with this population should include both objective and self-report measures on a nightly basis to better understand this phenomenon.

Sociodemographic characteristics in our current sample are more representative of the population of first-time mothers in the US than the sample in our previous study.⁷ The higher EBF rate at one month postpartum for the previous sample (82%) compared to this current sample (52%) is congruent with current US breastfeeding data documenting better breastfeeding outcomes with higher socioeconomic status compared to low-income and ethnically diverse samples.⁴ Consistent with another study that reported younger women having shorter breastfeeding duration and more supplementation compared to older women,²⁰ the women in our study who used formula at night were an average of 3 years younger than women who exclusively breastfed at night. Being employed and having a non-flexible work schedule may be a factor affecting breastfeeding outcomes^{21,22} and should also be explored in future studies, since employment was associated with nighttime formula use at one month postpartum.

Social support has been associated with breastfeeding behaviors in low-income and culturally diverse populations.^{23,24} Social support is a broad term that may include support from any person in the professional and social network of a lactating woman. Women in partnered relationships were significantly more likely to still be exclusively breastfeeding at one month postpartum. Another aspect of social support we examined was whether women reported that they had help with their infant's care during the night. Women who had help during the night were somewhat more likely to supplement their baby during the night, although the difference did not reach statistical significance. Perhaps the help was intended to allow new mothers more sleep, but findings demonstrate the contrary, since women who breastfed exclusively not only had less help, but also had more total sleep time compared to women who gave their infant at least some formula at night.

The exclusive breastfeeding rate in our sample was 52%, which is higher than the current national rate of 46%.⁴ Formula supplementation in the early postpartum period can lead to early breastfeeding cessation,²⁵⁻²⁸ with short- and long-term health, economic, and ecologic consequences. The early introduction of formula may increase risk of childhood asthma and obesity²⁹

as well as infection and illnesses.³⁰⁻³¹ All of these issues have an impact on higher health care costs, lost work days for parents, and lost productivity for industry and society.³⁰ Furthermore, exposure to the bisphenol A (BPA) found in most plastic baby bottles, causes irreversible neurological damage in animal studies.³² Yet these known health, economic, and ecologic consequences are not enough to deter women from using formula supplementation.

The most common reasons reported by women who stop breastfeeding and use formula are nipple and/or breast pain and insufficient milk supply.³³⁻³⁵ Milk production in the first few months postpartum relies on adequate synthesis and release of prolactin, particularly during deep sleep.⁵ Further study is needed to determine whether sleep loss at night interferes with prolactin release and milk supply. However, based on findings from this study at one month postpartum and our findings in the previous sample of older first-time mothers at three months postpartum, lactation consultants and other healthcare professionals can suggest to first-time mothers that they are likely to get more sleep at night when they breastfeed exclusively. This may be an additional incentive to deter women from supplementing with formula.

The findings of this study should be considered in light of several limitations. First, actigraphy has poor specificity for sleep and may have misidentified low-activity wake as sleep. In addition, it is unknown whether the specificity of actigraphy differs by feeding group, and it is possible that sleep may have been overrepresented among EBF mothers because they have less wrist activity than formula feeding mothers. Another potential limitation of this study is the way in which the women were categorized according to nighttime feeding behaviors. From the standardized schema and framework suggested for breastfeeding behavior,⁹ EBF means 100% breast milk and no other liquid or food for an infant. In this regard, women in the EBF group were either breastfeeding exclusively or giving 100% breast milk. Controversy may arise with the way breast milk was given, at breast or by bottle using pumped milk. The majority (84%) of women in the EBF group breastfed at breast, and only a small minority (14%) reported using a bottle to give their infant breast milk at night. Although the sample sizes were small, comparisons between the women who used a bottle for breast milk and those who did not showed that their nocturnal sleep was not significantly different. It was also possible that some of the bottle feedings were provided by somebody other than the mother; detailed information about who provided each feeding was not collected. Given that help with feedings would likely have resulted in more sleep among the formula feeding mothers, this possibility is not considered a serious threat to the validity of our findings but should be examined in future studies.

Another limitation relates to cause and effect, given the study design. It remains unknown whether women were using formula at night because they were experiencing postpartum sleep loss, or whether formula use at night resulted in sleep loss. In fact, both sleep loss and breastfeeding behavior could be affected by other factors such as maternal depression, anxiety, and stress, maternal perception of inadequate support, or infant temperament, or infant's sleep and sleeping location. Future research should also address factors related to the characteristics of the

infant in order to illuminate the relationship between mother's sleep and breastfeeding behavior.

In conclusion, if more infants are exclusively breastfed at one month, *Healthy People 2020* objective of 46% exclusive breastfeeding through 3 months of age³⁶ has more likelihood of success. The one-month time point is critical for postpartum recovery as well as lactation establishment. Adequate sleep is intricately involved in both processes, and findings from this study suggest another perspective for healthcare providers as well as consumers to look at exclusive breastfeeding behavior as an incentive for new mothers who are concerned about getting sufficient amounts of sleep at night.

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