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ORIGINAL CONTRIBUTIONS

Lactation Mastitis: Occurrence and Medical Management among 946 Breastfeeding Women in the United States

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In 1994–1998, the authors followed 946 breastfeeding women from Michigan and Nebraska for the first 3 months postpartum or until they stopped breastfeeding to describe mastitis incidence, mastitis treatment, and any associations between mastitis occurrence and hypothesized host characteristics and behaviors. Participants were interviewed by telephone at 3, 6, 9, and 12 weeks postpartum or until they ceased breastfeeding. A total of 9.5% reported provider-diagnosed lactation mastitis at least once during the 12-week period, with 64% diagnosed via telephone. After adjustment in a logistic regression model, history of mastitis with a previous child (odds ratio (OR) = 4.0, 95% confidence interval (CI): 2.64, 6.11), cracks and nipple sores in the same week as mastitis (OR = 3.4, 95% CI: 2.04, 5.51), using an antifungal nipple cream (presumably for nipple thrush) in the same 3-week interval as mastitis (OR = 3.4, 95% CI: 1.37, 8.54), and (for women with no prior mastitis history) using a manual breast pump (OR = 3.3, 95% CI: 1.92, 5.62) strongly predicted mastitis. Feeding fewer than 10 times per day was protective regardless of whether or not feeding frequency in the same week or the week before mastitis was included in the model (for the same week: 7–9 times: OR = 0.6, 95% CI: 0.41, 1.01; ≤6 times: OR = 0.4, 95% CI: 0.19, 0.82). Duration of feeding was not associated with mastitis risk. *Am J Epidemiol* 2002;155:103–14.

breast feeding; human body; lactation; mastitis; risk factors

Editor's note: *An invited commentary on this article appears on page 115.*

Lactation mastitis is a cellulitis of the interlobular connective tissue within the mammary gland that usually occurs in the first 6 weeks postpartum (1, 2). The clinical spectrum ranges from focal inflammation with minimal systemic symptoms to abscess and septicemia. Abscesses are reported to occur in 11 percent of all affected women (2). Pain and discomfort associated with mastitis or concerns about treatment with antibiotics that pass through the breast milk may lead some women to cease breastfeeding.

The signs and symptoms include fever of 38.5°C or greater; flu-like aches and chills; and a red, tender, hot, swollen, wedge-shaped area of the breast (3). In prospective studies of breastfeeding women, the incidence of lactation mastitis per infant nursed has been reported to be as low as 2.5 percent among United States women (1), 24 percent among Finnish women (4), and 27.1 percent among Australian women (5). In a population-based study conducted in Scotland in the pre-antibiotic era, the incidence was 8.9 percent (6).

The agents most frequently cultured are *Staphylococcus aureus* or coagulase-negative staphylococci (3, 7). Several investigators (2, 3, 8) suggest a fissure in the nipple as a route of infection. Other proposed routes include through the lactiferous ducts into a lobule or by hematogenous spread (2, 3).

As there have been few formal studies of lactation mastitis, most hypothesized risk factors are based on clinical impression. Risk factors fall into two general categories:

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Abbreviations: CI, confidence interval; OR, odds ratio; RR, rate ratio.

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poor breastfeeding technique (1–3, 8, 9) and lowered immune status secondary to stress and sleep deprivation (10). Poor breastfeeding technique may lead to poor drainage of a duct, insufficient emptying of the breast, milk stasis, and cracks or fissures of the nipple. In the one study that formally examined these factors, however, they occurred relatively infrequently: Milk stasis due to weaning or missed feeding preceded nine of the 65 infections, and in eight, the nipple of the involved breast was fissured (1). The number of nipple fissures in the unaffected breast and in women without mastitis was not reported nor was the incidence of milk stasis in women without mastitis.

Increased stress and sleep deprivation, which are often complaints of new mothers, have also been reported as risk factors (3). In a retrospective study among participants at a breastfeeding conference, women with a history of mastitis associated their mastitis with fatigue, stress, a plugged duct, change in number of feedings, engorgement/stasis, an infection in the family, breast trauma, and poor diet (11). These findings are suggestive only; the study was retrospective, the occurrence of these factors among women without mastitis was not reported, and the population had a strong commitment to breastfeeding.

We followed 946 breastfeeding women for the first 3 months postpartum or until they stopped breastfeeding to describe incidence of mastitis, mastitis treatment, and any associations between mastitis occurrence and hypothesized host characteristics and behaviors.

MATERIALS AND METHODS

Study protocol

Study participants were recruited from women who gave birth at a family birthing center in Michigan and from pregnant women working at a single large company in Nebraska, which had recently implemented a breastfeeding support program for employees. Together, the two sites gave geographic, employment, and socioeconomic status diversity. Enrollment began in Michigan during July 1994, and in Nebraska in November 1994; the last interview was in March 1998. At both sites, potential participants were given information about the study during their pregnancy and a postcard to indicate refusal. The only requirement for enrollment was an intention to breastfeed. All women who did not refuse and who delivered a live infant were sent a letter describing the study and a calendar/diary designed to be used as a memory aid during study interviews. The calendar showed nursing positions and provided spaces to record information pertinent to the study. Women could participate more than once; 43 women did so. There were five sets of twins and one set of triplets.

Most potential participants were contacted by telephone at 3 weeks postpartum, and their verbal consent was obtained at the time of the interview. Participants were interviewed at 3, 6, 9 and 12 weeks postpartum or until they ceased breastfeeding. After each interview, they were sent a small incentive, such as video coupons. Fifty-six women missed the first interview and were enrolled at week 6.

Interviews were conducted by using computer-assisted technology that enforced skip patterns, checked answers for appropriate ranges, and allowed for textual comments. Interviewers received 4 hours of training, were monitored periodically for adherence to the study protocol, and were retrained annually. Each participant had the same female interviewer for all four interviews. The study protocol was approved by the institutional review boards of all participating institutions.

Measuring instruments

All interviews included questions on breastfeeding habits, breast-related symptoms, and breast care, including use of breast pumps, bottle-feeding, mastitis, sleeping habits, depression, smoking and drinking habits, and household duties. Questions about the infant's birth; history of mastitis with a previous child, including date of diagnosis; other medical history; and sociodemographic information were asked at enrollment. As much as possible, subjects were asked to recall breastfeeding information on a week-by-week basis.

Case definition

Mastitis was defined by self-report of mastitis diagnosed by a health care provider. The use of a more specific definition, which included antibiotic prescription and symptoms, did not change the results, and thus, we opted to use the more sensitive definition. Because of an error in the computer-assisted interviewing program, 44 women who ceased breastfeeding sometime during the 3 weeks prior to a study interview were not asked about the occurrence of mastitis. Once the error was discovered, a validation study was conducted; this study is described in detail elsewhere (12) (Gillespie et al., University of Michigan, manuscript submitted for publication). Briefly, we recontacted all women whom the error impacted, all known mastitis cases, and a sample of the remaining participants. Recall of mastitis was found to be quite reliable and was unrelated to age, race, income, parity, history of mastitis, and study site. We detected one additional mastitis case among those in whom the error occurred. This case was included in the analysis to the extent possible.

Statistical analysis

We describe crude associations between exposures and rate of mastitis with rate ratios and cumulative incidence (risk) ratios and their approximate 95 percent confidence intervals (13). Rate ratios were calculated for time-dependent covariates, for example, breastfeeding habits, and cumulative incidence ratios for covariates that did not change, for example, marital status. Relative risks and confidence intervals were calculated using dEPID software (14). We tested differences between groups for categorical variables with chi-square tests and for continuous variables with Student's *t* tests, with a two-sided significance level of $\alpha = 0.05$.

We modeled the time to first mastitis as a function of baseline and time-varying covariates. Discrete-time survival

analysis was used, with a time-dependent logistic regression model (15) that included site and breastfeeding variables. We estimated the association between hypothesized risk factors in the week of mastitis with mastitis risk by using rate ratios. In cases in which the hypothesized risk factor could have resulted from the mastitis or early signs of mastitis (e.g., cracks and nipple sores), we also calculated (by using the same model) the association of mastitis with the hypothesized variables in the week prior to mastitis. Because women could enter the study more than once, we analyzed the data both considering all births by a single mother as independent and taking into account clustering utilizing generalized estimating equations using the SAS program, Proc Genmod (16). The results were very similar in both analyses, so we present them taking clustering into account.

RESULTS

Characteristics of the study population

A total of 1,057 women were identified for study. One hundred could not be contacted after multiple attempts because of improper contact information, no answer, no response to messages left on telephone answering machines, etc. Of those initially contacted, 11 refused, for a response rate of 99 percent. Of the 946 contacted, consenting women, 112 (11.8 percent) had already ceased breastfeeding at the time of the initial interview and provided 3-week interview data only. Of the 834 women still breastfeeding at 3 weeks, 801 (96.0 percent) completed at least one additional interview, and 658 (78.9 percent) completed all four interviews. Overall, 840 of 946 (88.8 percent) were followed for 12 weeks or until they ceased breastfeeding.

The majority (n = 711 (75.2 percent)) of study participants were enrolled from Michigan. Michigan participants tended to be slightly older, to have more education, and to have a slightly higher income than Nebraska participants (table 1). The majority of participants at both sites were White and living with their spouse or partner. Participants from Nebraska were more likely to be first-time mothers and, if they had children, to have fewer children living with them.

Mastitis incidence

During the 12-week study period, 77 women (8.1 percent) had one case of self-reported, health care provider-diagnosed mastitis; 12 (1.3 percent) had two cases, and one (0.1 percent) had three cases, for an overall incidence of first mastitis of 9.5 percent. The cumulative incidence of a first case of mastitis was 10.3 percent in Michigan and 7.2 percent in Nebraska. There was no statistically significant difference in incidence by site. Mastitis incidence was highest in the first few weeks postpartum and fell gradually thereafter (figure 1). Cracks and nipple sores occurred at a much higher frequency than mastitis, with the highest incidence in the first (36 percent) and second (14 percent) weeks postpartum. Women who reported a history of mastitis with a previous child were more likely to have mastitis with the current baby in every follow-up period (figure 2).

Mastitis diagnosis, clinical presentation, disease impact, and treatment

Women usually were diagnosed by their obstetrician/gynecologist (38 percent), but also by family practitioners (21 percent), nurses (23 percent), and others (18 percent). The majority (64 percent) were diagnosed after a telephone contact with their health care provider and did not receive a physical examination. Women diagnosed over the telephone and those diagnosed in person were similar with respect to symptoms and sociodemographic variables (data not shown).

The most common mastitis symptoms were breast tenderness (98 percent), fever (82 percent), malaise (87 percent), chills (78 percent), redness (78 percent), and a hot spot (a localized area of warmth and tenderness on the affected breast) (62 percent). Women averaged 4.9 days when they had one or more symptoms (range, 1–21 days). These symptoms were severe enough to cause the vast majority of women to restrict their activities at least somewhat (77 percent) and to spend at least 1 day in bed (72 percent). Almost half of the women changed their breastfeeding habits, either feeding more often (36 percent), less often (11 percent), feeding more often (49 percent) or less often (8 percent) on the affected breast, changing nursing holds more frequently (33 percent), trying a new nursing hold (12 percent), or making some other change (19 percent).

Most women with mastitis (88 percent) were prescribed one or more medications, either antibiotics (86 percent) and/or analgesics (17 percent); two woman reported receiving an antifungal medication, and another did not know the name of the drug prescribed. The most commonly prescribed antibiotics were cephalexin (46 percent), amoxicillin (7 percent), ampicillin (7 percent), and augmentin (7 percent). No cultures were performed. In addition, health care providers suggested applying hot compresses (83 percent), fully emptying the affected breast (65 percent), feeding more frequently (74 percent), and changing feeding positions often (48 percent). We did not ask whether women were advised to stop breastfeeding.

Associations of risk factors with cumulative incidence of mastitis and cracks and nipple sores

The overall cumulative incidence (risk) of mastitis among those who had never breastfed previously was 7.3 percent compared with 10.8 percent among those who had breastfed previously. For women with a history of mastitis, the risk was 23.9 percent compared with 8.3 percent among first-time mothers (rate ratio (RR) = 2.9, 95 percent confidence interval (CI): 1.79, 4.69) (table 2). Women with a history of mastitis were also more likely to report cracks and nipple sores (RR = 1.3, 95 percent CI: 1.04, 1.50). Neither the cumulative incidence of mastitis nor that of cracks and nipple sores was associated with age, income, returning to work, or participating in a breastfeeding support group (table 2). Women who reported having outside help were less likely to report cracks or nipple sores (odds ratio (OR) = 0.8, 95 percent CI: 0.71, 0.97), but having outside help was not associated with mastitis.

TABLE 1. Demographic characteristics of 946 breastfeeding women who participated in a prospective cohort study of lactation mastitis, Michigan and Nebraska, 1994–1998*

Characteristics	Nebraska		Michigan	
	No.	%	No.	%
Overall	235	25	711	75
Age (years)				
18–19	2	1	10	1
20–24	17	7	49	7
25–29	90	40	218	31
30–34	91	40	257	37
35–39	25	11	139	20
≥40	2	1	32	5
Race				
White	211	90	637	90
Black	14	6	45	6
Other	9	4	26	4
Marital status				
Married	221	94	683	96
Living with partner	2	1	9	1
Separated	11	5	17	2
Hours worked outside the home when pregnant				
None	1	0	252	36
<20	2	1	91	13
21–39	39	17	145	21
≥40	192	82	214	30
Education				
Less than high school	67	29	108	15
High school diploma	54	23	162	23
College degree	91	39	330	47
Professional or graduate training	23	10	110	16
Total family income (dollars)				
<$25,000	33	14	78	12
$25,000–$49,999	88	38	235	35
$50,000–$99,999	103	45	319	47
≥$100,000	6	3	48	7
Parity (no. of livebirths)				
1	103	44	201	28
2	84	36	239	34
3	35	15	164	23
4	8	3	64	9
≥5	4	2	42	6

* The two sites were significantly different with respect to age, working during pregnancy, education of the respondent, parity ($p < 0.01$), and income ($p = 0.05$). Numbers may not total 946 because of missing values.

Associations of breastfeeding and other health behaviors with rate of mastitis

Women with previous mastitis compared with those without this history had significantly more weeks with nipple cracks or sores, more weeks with 10 or more feedings per day, and more weeks with feedings of 10 minutes or less; used fewer positions; and were less likely to pump, bottle-feed, wash their breasts either before or after feeding, and use nursing bras. Because of the strong association of mastitis with mastitis history, we present associations separately by mastitis history.

Cracks and nipple sores that occurred during the same week as mastitis were associated with an almost sixfold increase in mastitis rate for women with no history of mastitis and a threefold increase in mastitis rate for women with such a history (table 3). Women without cracks and nipple sores in the same week as mastitis had similar rates of mastitis in the right (8.8/1,000 person-weeks) as in the left (8.5/1,000 person-weeks) breast and lower rates of mastitis

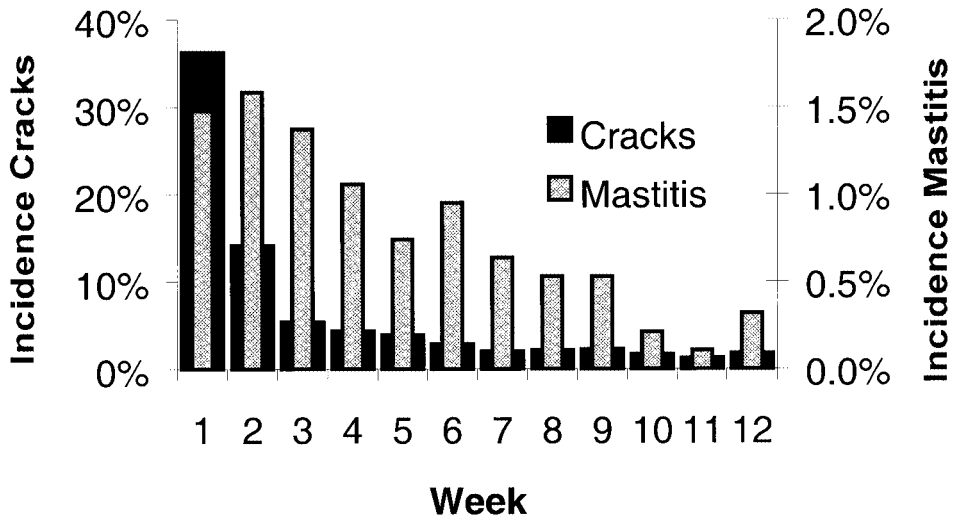

FIGURE 1. Incidence of mastitis and nipple cracks or sores by week postpartum, Michigan and Nebraska, 1994–1998.

in both breasts at the same time (1.5/1,000 person-weeks). Women with cracks and nipple sores in one breast in the same week as mastitis had higher rates of mastitis in the breast with cracks or nipple sores (48.9/1,000 person-weeks) than in the breast without them (13.3/1,000 person-weeks). Women with cracks or nipple sores in both breasts in the same week as mastitis experienced the highest mastitis rate (88.7/1,000 person-weeks).

Cracks and nipple sores may be treated with ointments; however, there was little association with any ointment use during the same week as mastitis. There was a twofold increase (RR = 2.0, 95 percent CI: 1.00, 4.17) for any ointment use in the week before mastitis among women with no history of mastitis. Using an antifungal ointment during the same week as mastitis, but not during the previous week, was statistically significantly associated with mastitis among women with no mastitis history (RR = 6.8, 95 percent CI: 2.13, 21.78). We do not know whether the antifungal creams were self- or physician-prescribed.

Average frequency of feeding per day, but not duration of feeding, was associated with mastitis rate; this was true whether or not the feeding habits were in the same week or

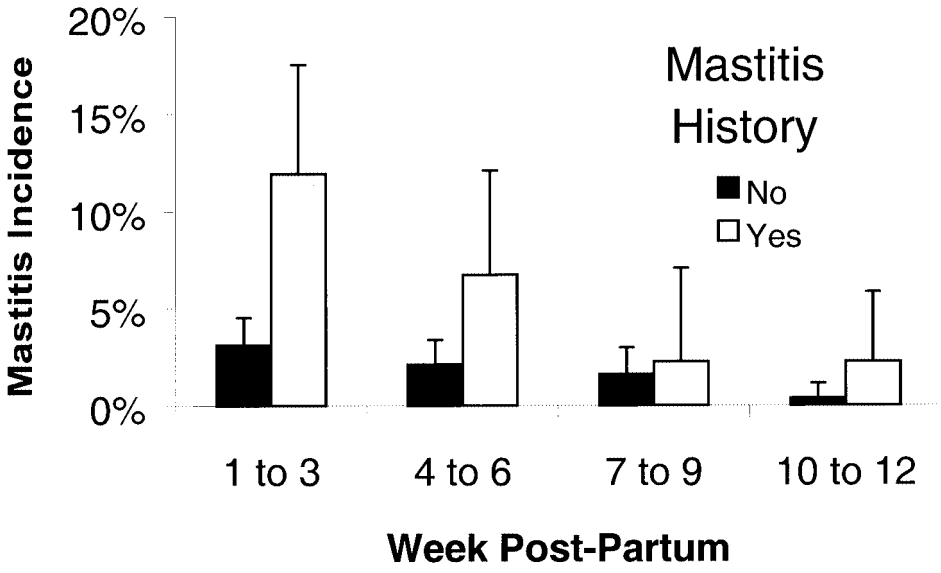

FIGURE 2. Mastitis incidence, with the upper limits of the 95% confidence intervals shown by "whisker," by 3-week postpartum interval and mastitis history, Michigan and Nebraska, 1994–1998.

TABLE 2. Relative risk (cumulative incidence ratio) of lactation mastitis and cracks and nipple sores by mastitis history and sociodemographic characteristics for 946 breastfeeding women who participated in a prospective cohort study of lactation mastitis, Michigan and Nebraska, 1994–1998

Predictor	Mastitis		Cracks and nipple sores	
	RR*	95% CI*	RR	95% CI
Mastitis history				
First-time mother (*n* = 303)	Reference		Reference	
Parity >1, never breastfed before (*n* = 51)	0.2	0.03, 1.72	0.5	0.30, 0.83
Breastfed before, no mastitis (*n* = 458)	0.9	0.51, 1.40	0.9	0.77, 1.05
Mastitis in the past (*n* = 134)	2.9	1.79, 4.69	1.3	1.04, 1.50
Site				
Nebraska (*n* = 235)	0.7	0.42, 1.17	0.8	0.64, 0.93
Michigan (*n* = 711)	Reference		Reference	
Age (years) (missing for 14 women)				
18–24 (*n* = 78)	Reference		Reference	
25–29 (*n* = 308)	1.6	0.63, 3.91	0.7	0.55, 0.91
30–34 (*n* = 348)	1.4	0.58, 3.56	0.9	0.70, 1.11
≥35 (*n* = 198)	1.7	0.68, 4.42	1.0	0.76, 1.25
Income (dollars) (missing for 36 women)				
<$25,000 (*n* = 111)	Reference		Reference	
$25,000–$49,999 (*n* = 323)	1.0	0.50, 1.98	1.1	0.88, 1.47
$50,000–$99,999 (*n* = 422)	0.9	0.47, 1.80	1.1	0.87, 1.43
≥$100,000 (*n* = 54)	1.4	0.58, 3.57	1.0	0.67, 1.47
Marital status (missing for 3 women)				
Not married (*n* = 39)	No mastitis in those not married		0.7	0.46, 1.14
Married (*n* = 904)	Reference		Reference	
Ethnicity (missing for 4 women)				
Non-White (*n* = 94)	0.8	0.37, 1.62	0.7	0.50, 0.92
White (*n* = 848)	Reference		Reference	

Table continues

the week before mastitis. Women without a history of mastitis who fed six or fewer times a day had a rate of mastitis five times lower than those who fed 10 or more times a day (same week as mastitis: RR = 0.2, 95 percent CI: 0.06, 0.46; week before mastitis: RR = 0.2, 95 percent CI: 0.07, 0.55); for women with a history of mastitis, the rate was 2.5 times lower (same week as mastitis: RR = 0.4, 95 percent CI: 0.15, 1.11; week before mastitis: RR = 0.4, 95 percent CI: 0.14, 1.19) (figure 3).

Breast pain when latching on, nursing, not nursing, or all the time also were associated with an increased rate of mastitis; however, if lagged by 1 week, they were not associated, suggesting that the breast pain may have been a symptom of mastitis rather than a risk factor of acquisition. Similarly, women who reported using more nursing positions had a higher rate of mastitis among those with a history of mastitis, but an increased number of positions likely reflects a response to nipple cracks or sores, breast pain, or mastitis. This variable could not be lagged because it was not asked on a week-by-week basis.

Among women with no history of mastitis, use of a breast pump, particularly a manual pump, resulted in an increased rate of mastitis. A history of using a breast pump for the previous week was also associated with mastitis, but the rate ratio was reduced and was no longer statistically significant; for other breast pumps, use of a pump during the previous week also noticeably reduced the association. For women with a history of mastitis, using a pump had no association with mastitis rate, with the point estimates for manual pumping suggesting a protective effect for both the same and the previous week. Other breastfeeding behaviors, including bottle-feeding, engorgement, washing breasts before or after feeding, using nursing pads, and wearing a nursing bra had little association with mastitis rate; none of the observed associations were statistically significant. Women who reported taking daytime naps had higher rates of mastitis, but, again, this result could be an effect rather than a cause of mastitis. When information from the previous week was used, there was still a modest increase in the rate for women with no history of mastitis, but it was no longer statistically significant.

TABLE 2. Continued

Predictor	Mastitis		Cracks and nipple sores	
	RR	95% CI	RR	95% CI
Education (missing for 1 woman)				
Less than high school (n = 175)	Reference		Reference	
High school diploma (n = 216)	1.2	0.60, 2.22	1.2	0.93, 1.54
College degree (n = 421)	1.2	0.65, 2.08	1.4	1.09, 1.70
Professional or graduate degree (n = 133)	1.6	0.82, 3.12	1.4	1.08, 1.81
Children living at home (missing for 3 women)				
1 (n = 293)	Reference		Reference	
2 (n = 330)	1.1	0.69, 1.87	1.0	0.83, 1.16
3 (n = 198)	1.3	0.76, 2.24	0.9	0.72, 1.09
4 (n = 75)	0.9	0.40, 2.20	1.0	0.75, 1.29
≥5 (n = 47)	1.0	0.36, 2.74	0.9	0.59, 1.24
Smoking during any week (missing for 1 woman)				
Yes (n = 61)	No mastitis in smokers		1.1	0.84, 1.42
No (n = 884)	Reference		Reference	
Drinking during any week (missing for 82 women)				
Yes (n = 442)	1.1	0.74, 1.61	1.0	0.86, 1.12
No (n = 422)	Reference		Reference	
Return to work by week 12				
Yes (n = 60)	0.7	0.28, 1.90	1.0	0.74, 1.32
No (n = 886)	Reference		Reference	
Breastfeeding support group (missing for 83 women)				
Yes (n = 96)	1.4	0.78, 2.33	1.0	0.81, 1.24
No (n = 767)	Reference		Reference	
Outside help in any wave (missing for 1 woman)				
Yes (n = 633)	1.2	0.79, 1.87	0.8	0.71, 0.97
No (n = 312)	Reference		Reference	

* RR, relative risk; CI, confidence interval.

Discrete survival regression analysis

To explore further the relations between variables identified in the bivariate and stratified analyses, we fit a time-dependent logistic regression model (table 4), including mastitis history, weeks since birth, and the following variables measured in the same week as mastitis: nipple sores or cracks, antifungal nipple cream, frequency of feeding, and use of a manual breast pump. Duration of feeding and daytime naps were not associated with risk of mastitis after adjustment for other variables and, thus, were not included in the model. After adjustment for covariates and clustering between responses for women who participated more than once, mastitis history, cracks and nipple sores in the same week as mastitis, and use of antifungal nipple cream in the same 3-week interval as mastitis remained positively associated with mastitis, increasing risk more than threefold. Those who fed fewer than 10 times per day in the same week as mastitis were at significantly decreased risk of mastitis, with those feeding fewer than six times per day having a risk 2.5 times lower than women feeding 10 or more times a day. Use of a manual breast pump in women without mastitis history was also significantly associated with mastitis rate. The interaction with mastitis history ($p = 0.02$) indicates that those with mastitis history do not share the increased risk with manual breast pump use: Using a manual breast pump increased risk of mastitis 2.1 times (95 percent CI: 1.09, 3.86) among women with no mastitis history, but had no association with mastitis among women who had experienced mastitis with a previous baby. When the model was fit using covariates from the previous week, the results were similar, although cracks and nipple sores were only marginally statistically significant ($p = 0.06$). The interaction between mastitis history and use of a manual breast

TABLE 3. Unadjusted rate ratios for the association of breastfeeding and other health behaviors with lactation mastitis by history of mastitis, Michigan and Nebraska, 1994–1998

Characteristic	No previous mastitis				Mastitis history			
	Person-weeks exposed	Mastitis rate/1,000	RR*	95% CI*	Person-weeks exposed	Mastitis rate/1,000	RR	95% CI
Nipple cracks or sores†								
Same week as mastitis								
Yes	591	30.5	5.6	3.21, 9.77	146	54.8	3.1	1.38, 6.84
No	7,353	5.4			1,345	17.8		
Week before mastitis								
Yes	849	20.0	3.5	1.99, 6.18	204	24.5	1.2	0.46, 3.14
No	7,000	5.7			1,280	20.3		
Any ointment use								
Yes	545	11.0	1.6	0.67, 3.64	87	23.0	1.1	0.26, 4.50
No	7,384	7.0			1,404	21.4		
Antifungal ointment								
Yes	63	47.6	6.8	2.13, 21.78	12	83.3	4.0	0.54, 29.12
No	7,866	7.0			1,479	21.0		
Frequency of feeding (times/day)								
Same week as mastitis								
<6	1,937	2.1	0.2	0.06, 0.46	339	14.7	0.4	0.15, 1.11
7–9	3,189	7.2	0.6	0.32, 0.98	654	15.3	0.4	0.20, 0.94
≥10	2,183	12.8			476	35.7		
Week before mastitis								
<6	1,694	2.4	0.2	0.07, 0.55	292	13.7	0.4	0.14, 1.19
7–9	3,211	6.5	0.53	0.03, 0.93	642	14.0	0.4	0.19, 0.92
≥10	2,440	12.3			530	34.0		
Duration of feeding (minutes)†								
Same week as mastitis								
<10	1, 037	5.8			284	31.7		
11–20	3,605	8.0	1.4	0.58, 3.35	825	17.0	0.5	0.23, 1.24
21–30	1,836	7.1	1.2	0.47, 3.22	281	24.9	0.8	0.29, 2.11
≥31	850	9.4	1.6	0.56, 4.69	78	25.6	0.8	0.17, 3.74
Week before mastitis								
<10	1,051	7.6			285	31.6		
11–20	3,586	7.0	0.9	0.41, 2.03	809	18.5	0.6	0.26, 1.34
21–30	1,831	7.1	0.9	0.39, 2.25	279	17.9	0.6	0.19, 1.69
≥31	896	11.2	1.5	0.58, 3.71	90	22.2	0.7	0.15, 3.26
Pain when latching on								
Yes	3,084	12.6	3.2	1.86, 5.58	588	35.7	2.9	1.41, 6.08
No	4,845	3.9			903	12.2		
Pain when nursing								
Yes	2,979	14.4	4.8	2.65, 8.57	597	36.9	3.3	1.56, 6.96
No	4,950	3.0			894	11.2		
Pain when not nursing								
Yes	1,938	17.0	4.1	2.43, 6.86	372	43.0	3.0	1.50, 6.01
No	5,991	4.2			1,119	14.2		
Pain all the time								
Yes	381	21.0	3.2	1.50, 6.67	126	71.4	4.2	1.96, 2.91
	7,548	6.6			1,365	1.7		

Table continues

pump was also no longer statistically significant. In both models, the time variables showed mastitis rates to be significantly higher in weeks 1–6 relative to weeks 10–12.

DISCUSSION

In this prospective cohort study of 946 breastfeeding women followed for the first 3 months postpartum, 9.5 percent of the population self-reported health care provider-diagnosed lactation mastitis at least once. The strongest risk factors were history of mastitis with a previous child, cracks and nipple sores in the same week, using an antifungal nipple cream (presumably for nipple thrush) in the same week, feeding the baby more frequently and, for women with no prior mastitis history, using a manual breast pump in the same week. The incidence was essentially the same by sociodemographic variables, study site, sleeping habits, and breastfeeding practices other than frequency of feeding. This result is in contrast to a study in southwest Finland that found an increased incidence among women aged 21–35 years relative to younger and older women (4).

TABLE 3. Continued

Characteristic	No previous mastitis				Mastitis history			
	Person-weeks exposed	Mastitis rate/1,000	RR	95% CI	Person-weeks exposed	Mastitis rate/1,000	RR	95% CI
Any breast pain in the week before mastitis								
Yes	1,540	8.4	1.2	0.65, 2.25	277	18.1	0.8	0.32, 3.18
No	6,305	7.0			1,205	21.6		
No. of positions used†								
1	2,022	5.4			288	6.9		
2	3,678	6.0	1.1	0.52, 2.22	690	15.9	2.3	0.51, 10.36
≥3	4,433	5.6	1.0	0.51, 2.11	516	36.8	5.3	1.24, 22.76
Pumping‡								
Same week as mastitis								
Any	3,346	10.8	2.2	1.32, 3.81	478	20.9	1.0	0.46, 2.03
Electric pump	1,948	9.2	1.9	1.03, 3.59	198	25.3	1.2	0.44, 3.07
Manual pump	956	15.7	3.3	1.70, 6.30	195	15.4	0.7	0.21, 2.37
By hand	722	8.3	1.7	0.70, 4.27	126	15.9	0.7	0.17, 3.11
No pumping	4,583	4.8	Reference		1,013	21.7		
Week before mastitis								
Any	3,265	7.7	1.1	0.65, 1.85	469	21.3	1.0	0.46, 2.19
Electric pump	1,850	6.5	0.9	0.48, 1.81	187	21.4	1.0	0.35, 3.01
Manual pump	949	11.6	1.7	0.84, 3.30	187	16.0	0.8	0.23, 2.60
By hand	750	5.3	0.8	0.27, 2.16	134	22.4	1.1	0.32, 3.63
No pumping	4,587	7.0			1,015	20.7		
Bottle fed								
Yes	3,273	6.7	0.9	0.51, 1.48	445	18.0	0.8	0.35, 1.74
No	4,653	7.7			1,046	22.9		
Engorgement								
Yes	564	12.4	1.8	0.81, 3.94	89	22.5	1.0	0.25, 4.26
No	7,350	6.9			1,402	21.4		
Washed nipples before feeding								
Yes	198	15.2	2.1	0.67, 6.81	15	0§	1.5	0.09, 24.72
No	7,731	7.1			1,476	21.7		
Washed nipples after feeding								
Yes	152	13.2	1.8	0.45, 7.49	14	0§	1.6	0.10, 26.50
No	7,777	7.2			1,477	21.7		
Used nursing pads								
Yes	4,767	8.6	1.7	0.87, 3.16	927	22.7	1.1	0.51, 2.19
No	2,319	5.2			513	21.4		
Wore a nursing bra								
Yes	6,396	7.8	1.6	0.70, 3.80	1,272	22.8	1.4	0.42, 4.52
Some	276	7.2	1.5	0.31, 7.52	39	0.0	0.7	0.03, 12.55
No	1,257	4.8			180	16.7		
Took daytime naps								
Same week as mastitis								
Yes	4,358	9.4	1.8	1.01, 3.13	771	23.3	1.2	0.75, 1.90
No	3,214	5.3			713	19.6		
Week before mastitis								
Yes	4,681	8.5	1.4	0.82, 2.54	833	22.8	1.2	0.59, 2.52
No	2,862	5.9			644	18.6		

* RR, relative risk; CI, confidence interval.
† Rate ratios for no previous mastitis and mastitis history were significantly different for nipple cracks and sores, feeding for 11–20 minutes, and number of positions used.
‡ Categories are not mutually exclusive. All comparisons are to no pumping.
§ For tables with zero cells, odds ratios were calculated by adding 1/2 to all cells.

The incidence of mastitis reported here is approximately half that reported from prospective cohorts in Australia (27 percent, 95 percent CI: 22, 32 percent, $n = 306$ (5)), New South Wales (20 percent, 95 percent CI: 18, 22 percent, $n = 1,075$ (17)), or southwest Finland (24 percent, 95 percent CI: 21, 27 percent, $n = 664$) (4)), but was more than three times the incidence reported in a United States cohort (2.5 percent, 95 percent CI: 1.8–3.0 percent, $n = 2,534$) (1) . This may be explained by differences in case definition, population, temporal variation, selection biases, or other unmeasured factors. Nevertheless, there is general agreement that mastitis is a common bacterial infection among breastfeeding women.

One of the enduring myths of mastitis risk is that it results from inexperience with breastfeeding. However, in our study,

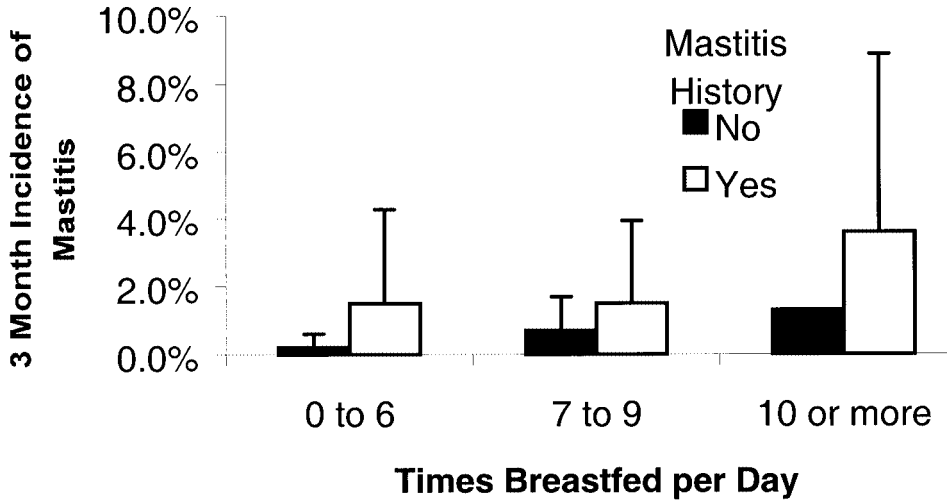

FIGURE 3. Three-month incidence of mastitis, with the upper limits of the 95 percent confidence intervals shown by "whisker," by average number of feedings per day and mastitis history, Michigan and Nebraska, 1994–1998.

TABLE 4. Odds ratios and 95 percent confidence intervals for the associations of breastfeeding practices and other health behaviors with lactation mastitis: results from a time-dependent logistic regression model using characteristics from the same week as mastitis and from the week before mastitis* for 946 breastfeeding women who participated in a prospective cohort study of lactation mastitis, Michigan and Nebraska, 1994–1998

Week of time-dependent covariates	OR†	95% CI†	*p* value
Covariates from the same week as mastitis			
Mastitis history	4.0	2.64, 6.11	0.0000
Nipple cracks or sores	3.4	2.04, 5.51	0.0000
Antifungal nipple cream	3.4	1.37, 8.54	0.009
Feed (times/day)			
<6	0.4	0.19, 0.82	0.01
7–9	0.6	0.41, 1.01	0.06
≥10	Reference		
Using a manual breast pump			
No mastitis history	3.3	1.92, 5.62	0.0000
Mastitis history	0.9	0.21, 4.04	
Manual breast pump* mastitis history (weeks)			0.02
1–3	3.3	1.41, 7.74	0.006
4–6	3.0	1.31, 6.89	0.009
7–9	2.4	1.02, 5.73	0.05
10–12	Reference		
Covariates from the week before mastitis			
Mastitis history	3.3	2.12, 5.16	0.0000
Nipple cracks or sores	1.7	0.96, 2.86	0.07
Antifungal nipple cream‡	3.4	1.06, 10.80	0.04
Feed (times/day)			
<6	0.4	0.20, 0.89	0.02
7–9	0.6	0.40, 0.99	0.05
≥10	Reference		
Using a manual breast pump			
No mastitis history	2.1	1.09, 3.86	0.03
Mastitis history	0.5	0.12, 1.65	0.23
Manual breast pump* mastitis history (weeks)			
1–3	3.7	1.53, 8.96	0.004
4–6	3.0	1.22, 7.23	0.02
7–9	2.3	0.93, 5.86	0.07
10–12	Reference		

* Adjusted for clustering between the 43 women who participated twice, using generalized estimating equations.
† OR, odds ratio; CI, confidence interval.
‡ This variable was not lagged, as measured in 3-week intervals.

women with a history of mastitis—by definition, previous breastfeeders—had a greater risk. Adjustment for the observed breastfeeding practices did not remove the significant effect of mastitis history. Standard breastfeeding literature recommends frequent, short feedings to build milk supply (18). While each additional 10 minutes per feeding increased risk of developing nipple fissures, cracks, or sores, longer feedings were not associated with increased incidence of mastitis. More frequent, rather than longer, feedings were associated with nipple fissures, cracks, or sores and mastitis incidence. Nipple trauma may result from latching the baby onto and removing the baby from the nipple. It is also possible that the act of latching on or removing the baby from the nipple results in increased exposure to potential mastitis pathogens on the mother's hands. Interestingly, washing the nipple either before or after feeding was not associated with mastitis incidence. We did not evaluate hand-washing practices. Nipple cracks and sores have been identified previously as mastitis risk factors (1, 4); cracks and sores enhance the entry of bacteria into breast tissue. Nipple cracks and sores were reported by more than one third of all participants in the first week postpartum.

The observed threefold increase in mastitis incidence with mastitis history is similar to the threefold increase found among 664 women in southwest Finland who were also followed for 12 weeks. Women with a history of mastitis may have a breastfeeding style that puts them at greater risk of mastitis; indeed, they had significantly different breastfeeding practices than do women without mastitis history. Alternatively, the increase in risk with mastitis history may reflect persistent colonization with a potential pathogen. Breast anatomy may also predispose to mastitis or skin type prone to nipple cracks or sores. Siblings may nurse with similar frequency either due to genetic predisposition or to learned behaviors on the part of the mother.

Mastitis caused considerable pain, worry, days in bed, and physician visits. Further, mastitis can lead to early weaning (5, 19). It was frequently diagnosed and treated over the telephone. As antibiotic resistance is an increasing concern, better algorithms to distinguish between milk stasis and mastitis without the benefit of physical examination are required. Moreover, the field would benefit from controlled studies of mastitis treatment; such studies are virtually nonexistent in the general medical literature.

Our sample size was large, with very stable estimates. We had frequent, regular contact (every 3 weeks) with study participants to assess breastfeeding practices and health behaviors. We had a high initial response (99 percent) and follow-up rate (89 percent). Study participants were recruited from two sites. While Michigan women had much higher rates of breastfeeding and tended to breastfeed longer, there was no difference in mastitis incidence rate or the incidence of nipple cracks, fissures, or sores by site. Although the women in our study are not representative of all breastfeeding women because they are primarily White and middle class, the associations should be broadly generalizable, especially since we did not find any difference between sites in mastitis incidence or any associations with sociodemographic characteristics.

Mastitis is a multiagent syndrome. To the best of our knowledge, the role of specific agents has yet to be described. The most common etiologic agents, *S. aureus*, *Staphylococcus epidermidis*, and *Streptococcus* species, inhabit either the skin or nasopharynx but are not uniformly present among all persons. For example, an estimated 20 percent of the general population are chronic carriers of *S. aureus* (20). Given that risk of mastitis is independent of sociodemographic variables and site, that mastitis history is a strong predictor, and that nipple sores occur frequently in the absence of infection, agent characteristics must be an important determinant of mastitis risk. Unfortunately, this study was not designed to examine the etiologic agents. Published articles on the bacteria-causing lactation mastitis are few, and most are at least 10 years old. The frequency of these bacteria in mothers' milk and on their breasts and in the nasopharynx among women with and those without mastitis deserves attention.

Mastitis is common but poorly understood. Our study highlights how little is known about the epidemiology and pathogenesis of this common condition. The popularly reported risk factors explain very little. Future studies should describe the role of nasal and skin flora on mastitis risk.

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REFERENCES

1. Marshall BR, Heppa JK, Zirbel CC. Sporadic puerperal mastitis: an infection that need not interrupt lactation. JAMA 1975; 233:1377–9.
2. Devereux WP. Acute puerperal mastitis: evaluation of its management. Am J Obstet Gynecol 1970;108:78–81.
3. Lawrence RA. Breastfeeding: a guide for the medical profession. St Louis, MO: C. V. Mosby, 1989.
4. Jonsson S, Pulkkinen MO. Mastitis today: incidence, prevention and treatment. Ann Chir Gynaecol Suppl 1994;208:84–7.
5. Fetherston C. Characteristics of lactation mastitis in a Western Australian cohort. Breastfeed Rev 1997;52:5–11.
6. Fulton AA. Incidence of puerperal and lactational mastitis in an industrial town of some 43,000 inhabitants. Br Med J 1945; May 19:693–6.
7. Matheson I, Aursnes I, Horgen M, et al. Bacteriological findings and clinical symptoms in relation to clinical outcome in puerperal mastitis. Acta Obstet Gynecol Scand 1988;67:723–6.
8. Niebyl JR, Spence MR, Parmley TH. Sporadic nonepidemic puerperal mastitis. J Reprod Med 1978;20:97–100.
9. Thomsen AC, Espersen T, Maigaard S. Course and treatment of milk stasis, noninfectious inflammation of the breast, and infectious mastitis in nursing women. Am J Obstet Gynecol 1984;149:492–5.
10. Dilts CL. Nursing management of mastitis due to breastfeeding. J Obstet Gynecol Neonatal Nurs 1985;14:286–8.
11. Riordan JM, Nichols FH. A descriptive study of lactation mastitis in long-term breastfeeding women. J Human Lact 1990; 6:53–8.

12. d'Arcy H, Gillespie B, Foxman B. Respiratory symptoms in mothers of young children: Association with outside child-care. Pediatrics 2000;106:1013–16.
13. Rothman KJ, Greenland S. Modern epidemiology. Second ed. Philadelphia, PA: Lippincott-Raven, 1998.
14. Sullivan KM, Foster DA. dEPID A Program for stratified and standardized analysis. Version 2.1. October 30 (shareware), 1987.
15. Allison PD. Logistic regression using the SAS System. Cary, NC: SAS Institute, Inc, 1999.
16. SAS Institute, Inc. SAS/STAT user's guide. Version 8. Cary, NC: SAS Institute Inc, 1999.
17. Kinlay JR. O'Connell DL. Kinlay S. Incidence of mastitis in breastfeeding women during the six months after delivery: a prospective cohort study. Med J Aust 1998;169:310–12.
18. Klaus MH. The frequency of suckling. A neglected but essential ingredient of breast-feeding. Obstet Gynecol Clin North Am 1987;14:623–33.
19. Schwartz K, d'Arcy HJ, Gillespie B, et al. Factors associated with weaning in the first three months post-partum. (In press).
20. Kluytmans J, van Belkum A, Verbrugh H. Nasal carriage of *Staphylococcus aureus*: epidemiology, underlying mechanisms, and associated risks. Clin Microbiol Rev 1997;10: 505–20.