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Symptoms Associated With Infant Teething: A Prospective Study

Michael L. Macknin, MD*; Marion Piedmonte, MA‡; Jonathan Jacobs, MD*; and Christine Skibinski, MS‡

ABSTRACT. *Context.* **Studies of infant teething have been retrospective, small, or conducted on institutionalized infants.**

Objectives. **To conduct a large, prospective study of healthy infants to determine which symptoms may be attributed to teething and to attempt to predict tooth emergence from an infant's symptoms.**

Design. **Prospective cohort.**

Setting. **Clinic-based pediatric group practice.**

Patients. **One hundred twenty-five consecutive well children of consenting Cleveland Clinic employees.**

Outcome Measures. **Parents daily recorded 2 tympanic temperatures, presence or absence of 18 symptoms, and all tooth eruptions in their infants, from the 4-month well-child visit until the child turned 1 year old.**

Results. **Daily symptom data were available for 19 422 child-days and 475 tooth eruptions. Symptoms were only significantly more frequent in the 4 days before a tooth emergence, the day of the emergence, and 3 days after it, so this 8-day window was defined as the teething period. Increased biting, drooling, gum-rubbing, sucking, irritability, wakefulness, ear-rubbing, facial rash, decreased appetite for solid foods, and mild temperature elevation were all statistically associated with teething. Congestion, sleep disturbance, stool looseness, increased stool number, decreased appetite for liquids, cough, rashes other than facial rashes, fever over 102°F, and vomiting were not significantly associated with tooth emergence. Although many symptoms were associated with teething, no symptom occurred in >35% of teething infants, and no symptom occurred >20% more often in teething than in nonteething infants. No teething child had a fever of 104°F and none had a life-threatening illness.**

Conclusions. **Many mild symptoms previously thought to be associated with teething were found in this study to be temporally associated with teething. However, no symptom cluster could reliably predict the imminent emergence of a tooth. Before caregivers attribute any infants' signs or symptoms of a potentially serious illness to teething, other possible causes must be ruled out.** *Pediatrics* **2000;105:747–752;** ***teething, tooth eruption, teeth, deciduous dentition.***

The effect of teething on infant health has been debated for at least 5000 years, and traditional beliefs on the issue have still not been entirely supplanted by scientific findings. Sumerians believed teething and worm infestation were associated. Hindu writings, as well as work by Aristotle, Homer, Celsus, and others, describe associations between teething and illness. Many of these authors implicated tooth emergence in childhood mortality.[1]

The belief that teething led to childhood mortality, seizures, diarrhea, fever, or other serious conditions was criticized as early as the 17th century by Francois Ranchin.[2] Yet in 1839, 5016 deaths in England and Wales were attributed to teething.[3] Illingworth[4] wrote in 1975 that "teething produces nothing but teeth." However, as recently as 1979, parents and physicians were identifying teething as a cause of presenting symptoms in children admitted to the hospital. A study of 50 of these children showed that in 48 cases, medical evaluation found other causes for the symptoms, ranging from upper respiratory infection to bacterial meningitis.[5]

Most medical professionals now agree that teething does not cause life-threatening illness, but they disagree about which symptoms may be associated with tooth eruption. In a prospective study, Jaber et al[6] found that body temperature increased .6°C during teething. In several studies with widely varying designs, other researchers have identified drooling, appetite disturbance, sleep disturbances, restlessness, coughing, rash, and diarrhea as symptoms associated with teething.[7–10] However, previous studies all had at least 1 or more significant design limitations, such as a small sample size, retrospective design, or a sample that included institutionalized children. To clarify which symptoms may be associated with teething, we designed a more powerful and generalizable prospective study of >100 general pediatric outpatients. We examined temperature and 18 other symptoms previously described in the pediatric literature as possibly associated with tooth eruption. Our goal was to help infants' caregivers to make decisions about which symptoms may be attributed to teething and to attempt to predict tooth emergence from an infant's symptoms.

METHODS

Subjects

We studied infants without chronic diseases who were seen at our clinic-based group pediatric practice for their 4-month well-child visits. We decided to study only children with at least 1 parent employed at the Cleveland Clinic Foundation, because we wanted to be able to contact parents regularly to encourage them to continue the onerous data collection procedure. Between August 5, 1994 and February 1, 1996, ~500 qualifying families with eligible infants were invited to participate. However, we told parents that the study was extremely difficult to complete so that only highly motivated families would enroll, and as a result, only ~1 in 4 eligible families consented to participate. We thus enrolled 125 infants ranging in age from 3 months old to 5.6 months old.

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Study Methods

All parents agreed to participate in an 8-month study beginning at the time of their child's 4-month well-child visit. To mask the purpose of the study from the parents, we described the study as one of normal infant behavior. Parents were given a Thermoscan (Thermoscan Inc, San Diego, CA) ear thermometer. Parents were shown by a pediatric nurse or pediatrician how to use the Thermoscan properly, and parents measured temperatures using proper technique under observation in the office. We provided Fahrenheit thermometers and reported results in Fahrenheit because we believed the parents were more familiar with Fahrenheit than Celsius temperature measurements. Parents were told always to take several measurements before recording the highest temperature reading. They were asked to record their infants' tympanic temperature twice a day at the same time each morning and each evening before bedtime, to check for tooth eruption daily by feeling if a new tooth had broken through the gums, and to record the location of every newly erupted tooth. Parents also kept a daily log of 18 symptoms. All concurrent illnesses, medications, and immunizations were also recorded. All information was maintained on a standard form (Fig 1). Study forms were collected monthly, and if parents did not call in every 2 weeks as instructed, they were contacted to ensure continued participation in the study.

Interpreting Daily Diary Entries

Parents were instructed to record daily information on each variable, using 0 to indicate normal, a single arrow pointing up or down to indicate an increase or decrease, and 2 arrows up or down to indicate a large increase or decrease.

Each response was then classified as normal or abnormal. Any decrease in appetite for liquids, appetite for solids, or sleep duration was considered abnormal. A child's temperature was classified as abnormal if it was higher than 1 standard deviation above that child's own mean temperature over the study. For all other variables, any increase was classified as abnormal.

Temperature was also analyzed as a continuous variable.

Sample Size

We wanted to estimate the proportion of patients with abnormal symptoms during the teething period (thought to be ~30%) and compare it to the proportion with abnormal symptoms outside of the teething period (thought to be ~10%). The projected sample size allowed for a 20% drop-out rate and provided power of ~90% to detect the differences between proportions described above, with a type I error rate of 5%, and estimates that were accurate to within ±9%.

Statistical Methods

For the comparisons described below, multivariate quasi-likelihood models were used, with parameters and standard errors estimated using generalized estimating equations.[11] This method is analogous to logistic regression but with appropriate modifications to account for the repeated measurements on each child. This requires specification of the relationship between the covariates and the mean response, as well as an initial estimate of the correlation structure among multiple observations from the same individual. A logistic model was used for the relationship between the covariates and the binary response from a given individual, and independence, exchangeable, or auto-regressive correlation structures were assumed depending on the model.

First we tested whether the set of 18 symptoms and temperatures together, observed on a particular day, was associated with an increased likelihood of tooth emergence on a different day. For example, it was of interest to know whether symptoms observed on 1 day might indicate that a tooth was coming on the following

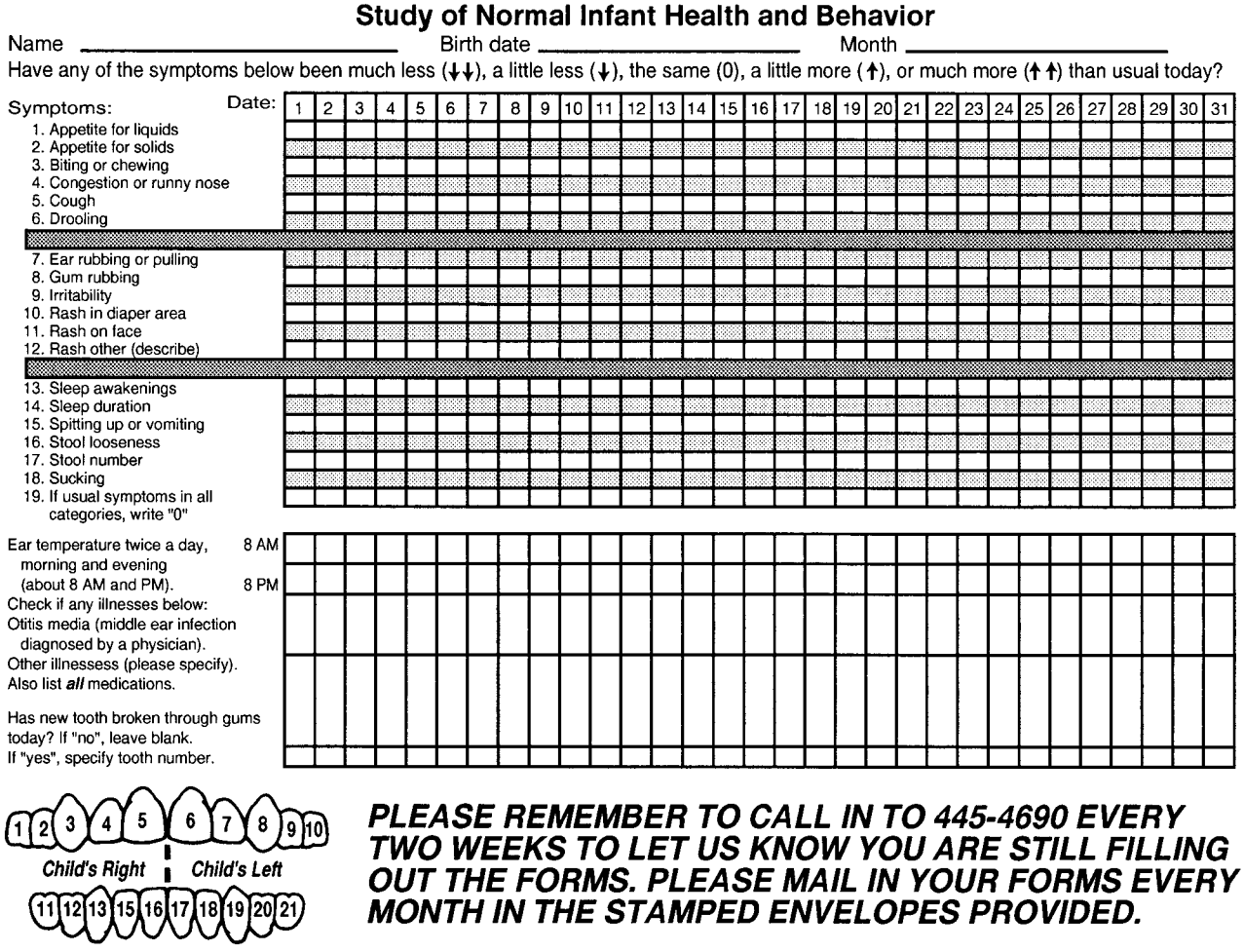

Fig 1. The daily symptom sheet completed by parents was described as a study of normal infant health and behavior.

day. To assess this, a statistical model was fit with a dichotomous outcome of tooth emergence/no tooth emergence and with each symptom's value (normal/abnormal) on the previous day as covariates.[12] Each model also contained the child's age as a continuous measure, the status of each of the symptoms on that day, the presence of concomitant illness, and the emergence of other teeth in the same period. To minimize multicollinearity and interaction problems in this analysis only, rash and rash-face were combined into 1 variable, as were appetite-liquids and appetite-solids, stool-looseness and stool-number, and concomitant illness and other teeth emerging. A Wald test was then used to test the joint hypothesis that all the regression coefficients for all symptoms were zero after adjusting for patient age, concomitant illness, and multiple teeth emerging during the same period. Eight models were fit altogether to assess whether symptoms on 4, 3, 2, or 1 days earlier; the same day; and 1, 2, and 3 days later were associated with an increased likelihood of tooth emergence on a given day.

Models were then fit to further assess the relationship between the probability of a tooth emergence and each symptom on each of the days. Multivariable models were then attempted to assess whether a particular combination of symptoms occurring over a predefined number of days could be used to predict an impending tooth emergence. Nested models were compared using Wald tests, and the predictive ability of the models was assessed using receiver operating characteristics curves.[13]

To assess whether healthy children were more likely to have abnormal temperatures on teething days than on nonteething days, the generalized estimating equations methods described above were used but with the symptom as the dependent variable and tooth emergence (yes/no) as the independent variables. This resulted in estimates and 95% confidence intervals for the proportions of teething days and nonteething days with elevated temperatures.

Descriptive statistics on continuous measures include the median (50th percentile) and the interquartile range (25th–75th percentile). All statistical tests were 2-tailed, and because each symptom was analyzed multiple times, only P values $<.01$ are reported as being statistically significant.

The Institutional Review Board of the Cleveland Clinic Foundation approved this study, and parents of the participants gave informed consent.

RESULTS

Enrollment

Although 125 infants were enrolled, 14 families did not complete any daily symptom information. There were no statistically significant demographic differences between the patients with and without daily symptom information. The study group consists of 111 infants whose parents recorded at least some daily symptom information. Descriptive information about these infants is shown in Table 1.

Daily symptom data were collected on 19 422 child-days. Parents recorded data for a median of 212 days per child (range: 11–268 days; interquartile range: 107–237 days). Most missing data occurred in blocks; only 1% (192/19 305) of successive diary entries were more than 1 day apart.

Tooth Emergence

During the study, 475 teeth emerged in 89 children (22 infants had no teeth emerge during the study period). The median number of teeth per infant was 4 (range: 0–12; interquartile range: 2–7). Teeth often emerged in clusters: 8.8% (34/386) of successive non-first teeth emerged on the same day as another tooth, and 31.9% (123/386) of teeth emerged within 5 days of another tooth. The median number of days between successive teeth was 12 (range: 0–159; interquartile range: 3–33).

TABLE 1. Enrollment Characteristics of 111 Infants With Completed Diaries in Teething Study

Variable	Value	*n*	%
Sex	Male	46	41.4
	Female	65	58.6
Race	White	88	79.3
	Black	7	6.3
	Hispanic	1	.9
	Asian	11	9.9
	Other	4	3.6
Primary liquid nutrition	Exclusively breast milk	38	34.2
	Breast milk and formula	22	19.8
	Formula	51	45.9
Solid nutrition	Missing	2	1.8
	None	45	40.5
	On some days	33	29.7
	Every day	31	27.9
Number of siblings in home	0	51	45.9
	1	46	41.4
	2	10	9.0
	3	2	1.8
	4	1	.9
	5	1	.9
Mother living in home	Not indicated	9	8.1
	Yes	102	91.9
Father living in home	Not indicated	9	8.1
	Yes	102	91.9
At least 1 parent with at least 4-year college degree	Yes	101	91.0
	No	3	2.7
	Missing	7	6.3
Infant in day care	Missing	1	.9
	Yes	28	25.2
	No	82	73.9
Number of h in day care	0 or missing	83	74.5
	>20 h/wk	18	16.2
	<20 h/wk	10	.9
Total number of teeth	0	22	19.8
	1	4	3.6
	2	14	12.6
	3	5	4.5
	4	12	10.8
	5	10	9.0
	6	12	10.8
	7	11	9.9
	8	16	14.4
	10	3	2.7
	11	1	.9
	12	1	.9

Defining the Teething Period

Symptoms occurring 5, 6, or 7 days earlier than a given day, or 4 days later, were not significantly associated with a tooth emergence on that day (Table 2). However, symptoms 1, 2, 3, or 4 days earlier; on the day; and 1, 2, or 3 days later were associated with tooth emergence on a given day. Thus, the teething period was defined as the 8-day period beginning 4 days before a tooth emergence and extending 3 days after the event.

Comparison of Frequency of Symptoms in Teething Versus Nonteething Periods

Although there were statistically significant associations between many symptoms and tooth emergence, no symptom occurred in >35% of infants

TABLE 2. Defining the Teething Period: Results of Testing When Symptoms Were Associated With Tooth Eruption

Symptoms Observed on This Day	*P* Value
7 d earlier	.077
6 d earlier	.777
5 d earlier	.091
4 d earlier	.009
3 d earlier	<.001
2 d earlier	<.001
1 d earlier	<.001
Day 0	<.001
1 d later	<.001
2 d later	<.001
3 d later	.001
4 d later	.070

during their 8-day teething periods, and no symptom occurred >20% more often in the teething period than in the nonteething period. Ten symptoms had a significant relationship to tooth emergence at some point during the teething period: biting, drooling, gum-rubbing, irritability, sucking, sleep awakenings, ear-rubbing, rash on face, decreased appetite for solids, and temperature higher than mean plus 1 standard deviation. Figures 2 and 3 show the frequency with which these 10 symptoms were reported on each day within 1 month of a tooth emergence. Although many combinations of symptoms were examined, no set of symptoms could predict that a tooth was about to emerge.

Each symptom on each day was examined independently to define when and which abnormal symptoms were associated with tooth emergence. Figure 4 shows that abnormal biting and drooling on any day within the 8-day span were significantly associated with tooth emergence on a given day 0. Abnormal gum-rubbing (except 4 days before), irritability (except 3 and 4 days before), and sucking (from 2 days before to 2 days after) were also associated with tooth emergence. Abnormal appetite for solids, wakefulness, ear-rubbing, and facial rash showed associations ($P < .01$) on days close to the tooth eruption but not on days further away.

Increased congestion, stool looseness, stool number, and decreased sleep duration were more frequent on days close to tooth eruption. However, although the *P* values for these associations were <.05, they were not considered statistically significant because they were larger than .01. Abnormal appetite for liquids, cough, rashes other than facial rashes, and vomiting showed no significant associations with tooth emergence.

Association of Temperatures and Tooth Eruptions

Temperature higher than 1 standard deviation above the child's mean was significantly associated with tooth emergence only on the day or 1 day earlier ($P < .01$).

Table 3 summarizes how often unexplained fevers (no reported illnesses including ear infection, viral infection, cold, sinusitis, stomach flu, croup, viral pneumonia, roseola, and chicken pox) occurred on days a tooth emerged compared with days no tooth emerged. Of the 2067 days children had temperatures over 100°F, only 64 were days there was a tooth emergence. Furthermore, of the 50 days study children had fevers over 103°F, only 1 was a day on which a tooth emerged. In fact, only 1 of 369 tooth emergences occurred when the child's temperature was over 103°F, and no teeth emerged when the child's temperature was higher than 104°F. The numbers of temperature elevations over 100°F, 103°F, and 104°F were the same the day before and the day of tooth emergences. Temperatures over 102°F showed no significant associations with tooth emergence. Temperatures over 101°F showed a significant association ($P < .01$) with tooth emergence.

DISCUSSION

To our knowledge, this is the first large prospective study with daily records of a large number of symptoms possibly associated with teething in healthy outpatients. Our findings largely confirm those of Tasanen,[2] who performed a prospective study of 192 tooth eruptions in 126 healthy institutionalized infants. Tasanen found that tooth eruption

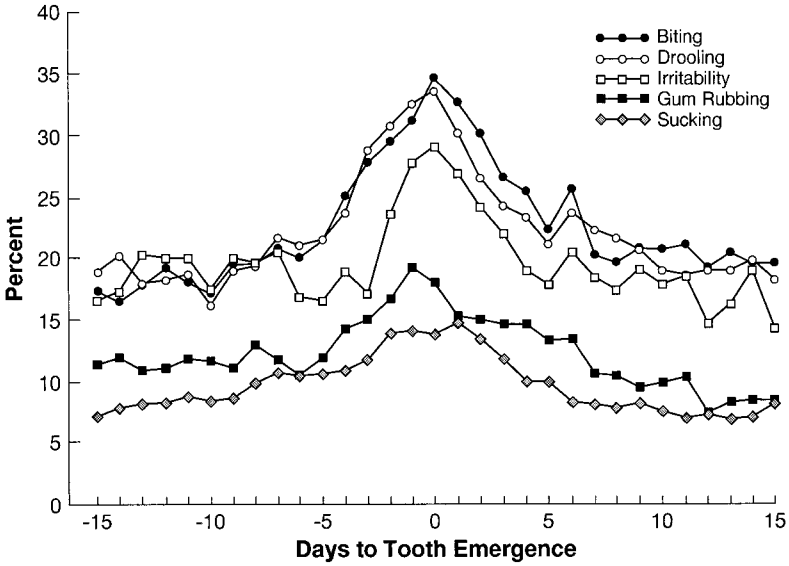

Fig 2. Percentage of days on which abnormal symptoms were reported in the 15 days leading up to and the 15 days after tooth emergence.

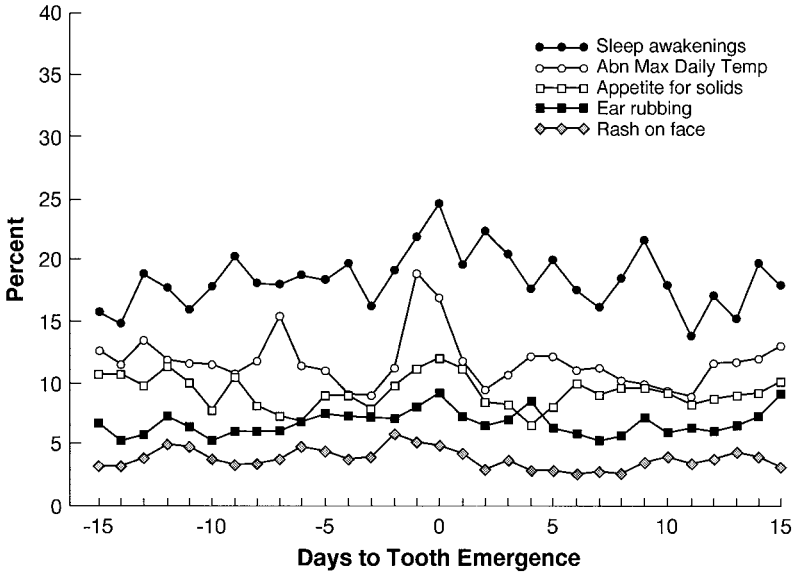

Fig 3. Percentage of days on which abnormal symptoms were reported in the 15 days leading up to and the 15 days after tooth emergence.

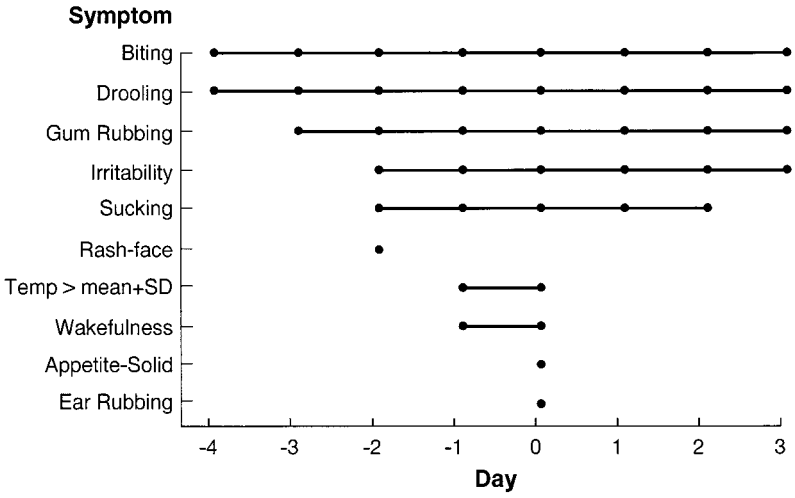

Fig 4. All days *P* values <.01 for the association between symptoms and tooth emergence on a given day 0.

TABLE 3. Percentage of Children With Elevated Temperatures on Days With Tooth Emergences and Days Without Tooth Emergences

Temperatures	Days Without Tooth Emergences		Days With Tooth Emergences		*P* Value
	Percentage	95% CI	Percent	95% CI	
>100°F	12.46	9.45–16.27	17.34	11.49–25.33	.046
>101°F	2.79	2.00–3.88	5.96	2.86–12.03	.001
>102°F	.074	.54–1.01	2.44	.64–8.83	.052
>103°F	.30	.20–.48	.27	.04–1.84	.903
>104°F	.13	— —	.00	— —	—
>105°F	.04	— —	.00	— —	—

CI indicates confidence internal; —, inference not possible because very few children had this symptom on nonteething days; —, inference not possible because no child had this symptom on teething days.

was linked with daytime restlessness, thumb-sucking, gum-rubbing, drooling, and perhaps, a loss of appetite. He found no association with infection, diarrhea, fever, rash, convulsions, sleep disturbance, cough, or rubbing of the ear or cheek. Our study results contradicted those of Tasanen only in that we found tooth eruption to be associated with slight temperature elevation, facial rash, sleep disturbance, and ear rubbing.

Kravitz et al[8] studied 110 normal infants in a suburban pediatric clinic. During monthly visits, a parent was asked to recall the child's experience of 17 symptoms commonly attributed to teething and any association of these symptoms with the child's tooth eruptions. The authors found 6 associated symptoms in more than two thirds of the teething children: drooling, hand-biting, object-biting, lip-biting, restlessness, and nighttime crying. Drooling, object-biting, and hand-biting were found more frequently in early teethers (those who were 3–5 months old) than in older teethers, possibly suggesting that these symptoms are developmental in origin.

In a retrospective study based on answers to a questionnaire given to 224 parents, Seward[9] linked irritability, nighttime crying, drooling, poor appetite, circumoral rash, and gum inflammation with tooth eruption. Schwartzman[10] studied 378 outpatients and found 8 symptoms that had possible associations with teething: rhinitis, fever, anorexia, vomiting, cough, irritability, diarrhea, and drooling. These results generally agreed with his observations of 55 inpatients, 6 of whom had seizures. The study by

Schwartzman had no control periods of observation when the children were well, so the study results are difficult to interpret.

These studies support the widespread belief that fever is associated with teething, but few researchers have prospectively studied the association. Jaber et al[6] did a prospective study of 46 healthy infants and noted a statistically significant increase in the frequency of temperatures above 37.5°C on the day of tooth eruption.

We found only a weak association, which we did not consider statistically significant, between teething and diarrhea. Coreil and colleagues[7] recently reported that 35% of a group of Florida pediatricians believed diarrhea was linked with tooth eruption. The authors document similar beliefs worldwide and point out the need for prospective studies of the possible link between teething and diarrhea.

Our prospective study also has limitations. The degree of adherence among the parents in our study was remarkably high given the demands of recording multiple signs, symptoms, and temperatures daily for 8 months, but some did provide incomplete data. Incomplete data may have introduced biases into our study, and the power of our study to detect associations with teething would have been greater with a more complete dataset. Multiple comparisons and multiple analyses introduce the possibility that symptoms found to be associated with teething inconsistently or only at the $.01 \leq P \leq .05$ level (sleep disturbance, congestion, and stool looseness or number) were spurious. Therefore, we did not consider these associations statistically significant. Because of the demands of the study, we selected parents who were employees of the Cleveland Clinic. Most families, therefore, had medical backgrounds, were highly motivated, were highly educated, had both parents living in the home, and had few other children at home. The parents who enrolled without providing any data may just have wanted the free ear thermometer. Although parents were told we were performing a study of infant behavior, we observed that most seemed to discern from the questionnaire that it was designed to study teething. Preconceived parental notions about symptoms associated with teething may have biased parental reporting. The study also relied on parental reports of tooth eruption. Ideally, all tooth eruptions would have been confirmed by the investigators. However, it was not practical to confirm all tooth eruptions by asking families to bring their child to the pediatrician. It was our impression that these highly educated parents accurately reported when they felt a tooth break through the gums. Finally, our study reported on pooled data. This information offers an overview of the symptoms and signs that might be associated with teething in the general population, but it may not bring to light idiosyncratic reactions of occasional children.

CONCLUSION

In our study, symptoms of decreased appetite for solid foods, biting, drooling, ear-rubbing, gum-rubbing, irritability, rash on face, sucking, and abnormal temperature (defined as being greater than a child's own mean temperature plus 1 standard deviation or fevers <102°F), and wakefulness were found to have some association with the teething process. The association ($P < .01$) between symptoms occurring several days before (or after) a tooth emergence and a subsequent (or previous) tooth emergence imply that these symptoms are linked to the teething process. The strongest associated symptoms were biting, drooling, gum-rubbing, irritability, and sucking, which occurred with greater frequency during the 4 days before and up to 3 days after a tooth emergence. Symptoms that increased in frequency only on the same day and or a day or 2 before a tooth emergence included decreased appetite for solids, wakefulness, ear-rubbing, facial rash, and abnormal temperature. Symptoms that showed association with teething only at the $.01 \leq P \leq .05$ level were sleep disturbance, congestion, and stool looseness or number. Symptoms that showed no significant associations with teething were decreased appetite for liquids, cough, rash other than facial rash, and temperature greater than 102°F.

Of particular note, none of the fevers higher than 104°F and only one over 103°F that occurred during the 369 tooth eruptions were unexplained by another illness known to be associated with fever. Temperatures over 100°F occurred on 2067 days during the study, but only 64 of these were days in which a tooth emerged.

We discovered no evidence that teething was associated with any severe, health-threatening conditions. Thus, before attributing any signs or symptoms of a potentially serious illness to teething, physicians and parents must rule out other possible causes. Additional prospective studies may help determine whether occasionally individuals experience signs and symptoms in association with tooth eruption not described in our article.

ACKNOWLEDGMENTS

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