Eur Respir J, 1996, 9, 2623–2629
DOI: 10.1183/09031936.96.09122623

European Respiratory Journal
ISSN 0903 - 1936

Breastfeeding, maternal smoking and

P. Nafstad*, J.J.K. Jaakkola*+, J.A. Hagen*, G. Botten*, J. Kongerud**

Breastfeeding, maternal smoking and lower respiratory tract infections. P. Nafstad, J.J.K. Jaakkola, J.A. Hagen, G. Botten, J. Kongerud. ©ERS Journals Ltd 1996.

ABSTRACT: The objective of the study was to assess the relationship between breastfeeding and lower respiratory tract infections (LRTIs) during the first year of life, with special reference to maternal smoking.

A cohort of 3,754 children born in 1992–1993 in the City of Oslo, Norway was recruited and data were collected at birth, 6 and 12 months of age. Complete information was obtained from 3,238 children (follow-up rate 86%). The main outcome was an episode of a LRTI, such as pneumonia, bronchitis or bronchiolitis, based on a self-administered questionnaire addressed to parents when the child was 6 and 12 months old. The outcome was specified as physician-diagnosed.

In logistic regression analysis adjusting for confounding, maternal smoking increased the risk of LRTIs in children breastfed for 0–6 months (odds ratio (AOR) 1.7; 95% confidence interval (95% CI) 1.2–2.4), but not essentially when the child was breastfed for more than 6 months (AOR 1.1; 95% CI 0.7–1.6). Short-term breastfeeding (0–6 months) and no maternal smoking was related to an adjusted AOR of LRTIs of 1.3 (95% CI 1.0–1.7), and short-term breastfeeding combined with maternal smoking was related to an adjusted AOR of 2.2 (95% CI 1.6–3.1), as compared with long-term breastfeeding and no maternal smoking.

The present study indicates a protective effect of long-term breastfeeding on the risk of lower respiratory tract infection during the first year of life. The results suggest that the protective effect is strongest in children exposed to environmental tobacco smoke.

Eur Respir J., 1996, 9, 2623–2629.

*Section of Epidemiology, Dept of Population Health Sciences, National Institute of Public Health, Oslo, Norway. +Environmental Epidemiology Unit, Dept of Public Health, University of Helsinki, Helsinki, Finland. **Dept of Thoracic Medicine, Rikshospitalet, Oslo, Norway.

Correspondence: P. Nafstad
Section of Epidemiology
Dept of Population Health Sciences
National Institute of Public Health
Postboks 4404 Torshov
0403 Oslo
Norway

Keywords: Breastfeeding
children
lower respiratory tract infections
passive smoking

Received: January 16 1996
Accepted after revision August 17 1996

Economic support was given by the Norwegian Research Council.

Lower respiratory tract illnesses, including infections, in small children have an important public health impact both in industrialized and developing countries [1–4]. These illnesses in early childhood may predispose for chronic obstructive pulmonary disease (COPD) later in life [5–7]. Several environmental exposures, such as environmental tobacco smoke, nitrogen dioxide, family characteristics and day-care attendance have been studied as possible determinants of the incidence of such illnesses [3, 4, 8–12]. The effect of environmental tobacco smoke, and in particular maternal smoking, is so far best established [4, 8, 10, 13–15]. The protective effect of breastfeeding has been difficult to establish. Results from developing countries are consistent with a protective effect of breastfeeding [16–18], while studies undertaken in industrialized societies have shown conflicting results [19–31]. There is recent evidence from a cross-sectional study of Australian children that breastfeeding protects from the adverse effects of passive smoking on acute respiratory illness [29].

A birth cohort was established in Oslo in 1992–1993 to study the environmental determinants of respiratory health in children. A high proportion of Norwegian women breastfeed their children, and the median length of breastfeeding is over 7 months [32]. The objective of the present study was to assess the relationship between the length of breastfeeding and risk of lower respiratory tract infections (LRTIs) during the first year of life, with special reference to maternal smoking.

Methods

Study population

The source population included children born during a period of 15 months in the city of Oslo, Norway, with a population of approximately 500,000. The recruitment for the study was carried out by midwives in the maternity wards at Aker and Ullevål Hospitals, the two main birth clinics in Oslo. About 90% of the mothers with permanent address within the city of Oslo attend maternity ward at these two birth clinics. Only in periods when capacity is insufficient do normal deliveries take place at another hospital. This birth clinic was not included for organizational reasons. The recruitment period was from January 1 to December 31, 1992 at Ullevål Hospital (2,694 children born live), and from March 10, 1992 to March 9, 1993 at Aker Hospital (3,706 children born live). A delay in authority approval necessitated the later start at Aker Hospital.

The inclusion criteria were: 1) permanent address within the city of Oslo; 2) no plans to move from Oslo within the near future; 3) birth weight more than 2,000 g; 4) no serious illness which might impair respiration (severe respiratory, cardiovascular, neuromuscular or metabolic disease); 5) no assisted ventilation or oxygen therapy after 6 h of life; 6) at least one family member able to speak and write Norwegian (assessed by the midwives); 7) at least one biological parent living together with the child; and 8) no known drug abuse in the family. Families fulfilling these criteria were informed about the main objectives of the study.

The families were asked to sign a parental consent form and to complete a self-administered questionnaire inquiring about pregnancy, smoking habits, details of home environment, and family and socioeconomic characteristics. A reminder was sent to those eligible families who did not return the questionnaire. Most of the immigrant families (identified by hospital records) were found to have insufficient knowledge of the Norwegian language. Immigrant families not responding to the first approach were, therefore, considered not eligible for the cohort (1,045 out of 1,172 immigrant families). The numbers of children in the source population eligible for the cohort, entered in the cohort, and of children with complete information on respiratory health both from 6 month and 12 month follow-up surveys are presented in figure 1. Subjects with no information on respiratory health in the first or second half year of life were considered lost to follow-up. A maximum of 4,973 children were found to be eligible for the cohort.

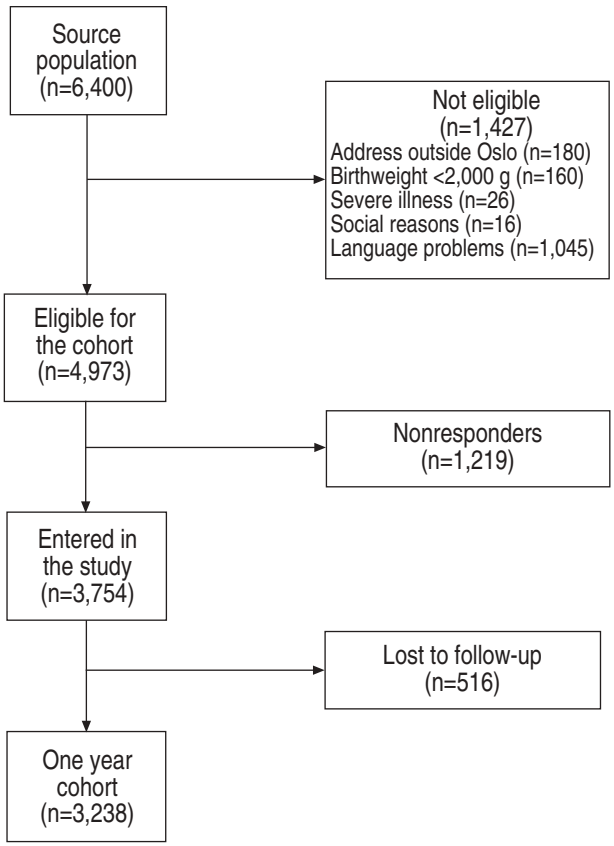

Fig. 1. – Recruitment and follow-up of children in the Oslo Birth Cohort 1992–1993.

Approximately 150–250 of these children (exact number not available) were not included due to plans to move out of Oslo after birth. A total of 3,754 children (76%) were enrolled in the study.

The study was approved by the Norwegian Data Inspectorate and the Regional Ethics Committee for Medical Research.

Data collection

When the child was 6 and 12 months old, the participating families received a questionnaire with questions about the child's health, use of health services and details of their environment. A reminder was sent within 3 weeks. Based upon hospital records, information on family characteristics, pregnancy and birth was registered for 3,743 (99.7%) of the participants (table 1). Corresponding information was also obtained from 1,050 nonparticipating families, who were eligible for the cohort.

Outcome measures

The primary outcome was an episode of a LRTI, such as pneumonia, bronchitis or bronchiolitis. The operational definition of the outcome was based on the following question addressed to parents when the child was 6 and 12 months old: "Has the child been examined by a

Table 1. – Characteristics of children and mothers within the study population and those lost to follow-up in the Oslo Birth Cohort 1992–1993

	One year cohort (n=3,238) %	Lost to follow-up (n=516) %	Entered in the cohort (n=3,754) %
Male gender	52	50	52
Birth weight			
<2,500 g	2	2	2
2,500–3,499 g	42	45	43
≥3,500 g	55	53	55
Firstborn child**	52	45	51
Maternal age**			
<25 yrs	11	17	12
25–30 yrs	36	37	36
>30 yrs	53	46	52
Maternal education**			
<12 yrs	6	14	7
12–15 yrs	39	41	40
>15 yrs	55	45	53
Single parenthood at birth**	5	10	6
Maternal smoking at the end of pregnancy**			
No	76	71	76
Occasional	9	9	9
1–14 cigarettes·day^{-1}	11	15	11
≥15 cigarettes·day^{-1}	4	5	4
Family income per year**			
<200,000 Nkr	15	31	17
200,000–500,000 Nkr	66	53	65
>500,000 Nkr	19	15	18

Data were missing for 0–78 subjects for each characteristic (birth weight=20; maternal age=1; maternal education=38; single parenthood=12; maternal smoking at the end of pregnancy=14; family income=78). *: $p<0.05$; **: $p<0.01$, Chi-squared test for difference between the one year cohort and those lost to follow-up.

physician (during the period of interest)? If yes, fill in at what age and which diagnosis". Due to a common practice among some physicians to describe symptoms of bronchiolitis during infancy as respiratory syncytial virus infection, parental report of such a diagnosis was considered as an episode of LRTI. The outcome was specified as occurring during the first 12 months of life or, alternatively, either during the first 6 months or from 7–12 months of life. Parents were also asked to report episodes of LRTIs needing hospitalization, and these were treated separately.

Breastfeeding and maternal smoking

The length of breastfeeding and maternal smoking were the main determinants. The length of breastfeeding, expressed in months, was based on information on the endpoint of breastfeeding in the 6 month questionnaire, and in the 12 month questionnaire if the child was still breastfed at 6 months of age. In the 6 month questionnaire, the mothers were also asked if they had stopped breastfeeding, if they still gave their child only breast milk, or a combination of breastmilk and formula substitute. Information on smoking was based on the 6 month questionnaire, which was considered the most representative for the exposure during the first year of life. The mothers were asked to state whether they were nonsmokers, occasional smokers or daily smokers. If they were daily smokers, they were asked to state the average number of cigarettes smoked per day. Occasional smokers were those who reported smoking less often than daily.

Covariates

The following covariates included in the analyses were from hospital records or questionnaire information at birth: gender; birth weight; season of birth; maternal age; single parenthood; family income; maternal education; mother's nationality; parental asthma; distance from nearest road open to public traffic; and crowdedness. Information on siblings, sharing of bedroom with siblings and paternal smoking habits were from the 6 month questionnaire, and day-care attendance (at least 10 h per week) both from 6 and 12 month questionnaires. The categories and frequency distributions of the covariates are presented in table 2. Nationality was dichotomized according to mother's country of origin (third world, or other). Crowdedness was defined as floor area (m^2) per person living in the child's home. As combustion products of motor vehicles are the main source of air pollution in Oslo (industrial air pollution is low), the distance between the child's home and the nearest road open to public traffic was used as a crude measure of exposure to air pollution. Parents were asked to report smoking habits of the father, like those of the mother.

Statistical methods

The cumulative incidence was used as a measure of the risk of a LRTI episode. Cumulative incidences from

Table 2. – Characteristics of the study population according to length of breastfeeding (Oslo Birth Cohort 1992–1993)

	Breastfed 0–6 months (n=989) %	Breastfed >6 months (n=2,200) %
Male gender*	55	51
Birth weight**		
<2,500 g	4	2
2,500–3,499 g	46	41
≥3,500 g	50	58
Season of birth		
January–March	23	23
April–June	26	28
July–September	28	26
October-December	22	24
No siblings**	56	50
Shared bedroom**	8	5
Day-care outside home at 6 months (>10 h·week^{-1})	1	1
Day-care outside home at 12 months (>10 h·week^{-1})	15	15
Maternal age**		
<25 yrs	18	9
25–29 yrs	41	34
≥30 yrs	42	57
Single parenthood**	9	5
Family income per year**		
<200,000 Nkr	20	12
200,000–500,000 Nkr	68	66
>500,000 Nkr	12	22
Maternal eduction**		
<12 yrs	11	4
12–15 yrs	53	33
>15 yrs	36	63
Maternal nationality (from third world)	2	2
Parental history of asthma	12	12
Maternal smoking**		
No	58	80
Occasional	9	8
1–14 cigarettes·day^{-1}	21	9
≥15 cigarettes·day^{-1}	11	3
Paternal smoking**		
No	56	68
Occasional	9	9
1–14 cigarettes·day^{-1}	16	12
≥15 cigarettes·day^{-1}	19	10
Distance from nearest road		
<10 m	22	23
10–50 m	21	23
>50 m	58	54
Crowdedness (m^2 per person)		
<15 m^2	5	5
15–25 m^2	46	43
>25 m^2	49	52

Data were missing for 0–123 subjects for each characteristic (breastfeeding=49; birth weight=19; siblings=36; sharing bedroom=8; maternal age=1; single parenthood at birth=5; family income per year=53; maternal education=26; maternal nationality=9; maternal smoking=20; paternal smoking=123; distance from nearest road=21; and crowdedness=73). *: $p<0.05$; **: $p<0.01$, Chi-squared test for difference between 0–6 months breastfed and >6 months breastfed.

birth to 12 months and from 7 to 12 months were estimated for different categories of breastfeeding stratified by maternal smoking. The odds ratio (OR) was used as a measure of association between the occurrence of respiratory infections and breastfeeding. The adjusted odds ratios (AORs) were estimated in logistic regression analyses, controlling for the covariates in table 2. Based on previous knowledge, eight core covariates (gender, siblings, sharing of bedroom, day-care attendance, maternal education, parental asthma, maternal and paternal smoking habits) were always included in the model. The other covariates were included, if their inclusion had an impact on the accuracy and precision of the estimate of the relationship studied [33].

The independent effects of breastfeeding and maternal smoking, as well as their joint effect, were studied in logistic regression analyses using long-term breastfeeding (>6 months) and no maternal smoking, the largest and most preferable category, as the reference category. The following three categories were contrasted to the reference category: 1) long-term breastfeeding (>6 months), maternal smoking; 2) short-term breastfeeding (0–6 months), no maternal smoking; and 3) short-term breastfeeding, maternal smoking. The children of occasionally smoking mothers (n=262) were excluded.

The analyses were performed using the Statistical Package for the Social Sciences (SPSS) for Windows, version 6.0 [34].

Results

Participation

The children and families entered in the study were not different from those not participating as to birth weight, maternal age and percentage of families with first born child. Smoking during early pregnancy and maternal history of allergy were more common in nonparticipating than participating mothers (40 *versus* 33% and 20 *versus* 17%). Of the 3,754 families entered in the cohort, 3,563 (95%) answered the 6 month questionnaire and 3,452 (92%) the 12 month questionnaire. Nonresponders at 6 months received a 12 month questionnaire in the same way as the others. Due to an error in the data-handling procedure, information collected on respiratory health during the first 6 months of life was lost for 124 (3%) of the children. This left a total of 3,238 (86%) children with information on respiratory health both at 6 and 12 months.

The baseline characteristics of the children in the 1 year cohort and those lost to follow-up are presented in table 1. Children in the 1 year cohort (n=3,238) did not differ from those entered in the cohort (n=3,754). The proportion of mothers reporting a history of asthma was similar among the 1 year cohort and those lost to follow-up (6.9 and 6.0%, respectively).

Breastfeeding

Information on the length of breastfeeding was obtained from 3,189 (99%) of the 1 year cohort. Only 30 (1%) children were not breastfed at all, and 837 (26%) were still breastfed at the age of 12 months. Of 2,200 children still breastfed after 6 months, 1,738 (69%) were breastfed without infant formula at 6 months of age, and 453 (21%) were breastfed and received infant formula (missing=9). The characteristics of the children and children's families according to breastfeeding status at 6 months are presented in table 2. Breastfed children had older and more educated mothers than children breastfed for 0–6 months, and their parents were less likely to smoke. Daily smoking mothers reporting breastfeeding at the 6 month questionnaire smoked on average 9 cigarettes·day^{-1} (SD=5, median=10), compared with 11 cigarettes·day^{-1} (SD=5, median=10) for the mother who had stopped breastfeeding ($p<0.01$).

Breastfeeding, maternal smoking and lower respiratory tract infections

A total of 569 of the 3,238 children followed for 2 yrs (18%) experienced at least one episode of LRTI during their first year of life. Among these, 112 had been hospitalized for a LRTI, and 139 had experienced two or more LRTIs. Boys were affected more often than girls (20 *vs* 15%). No difference in the risk of LRTI was found between children breastfed with (cumulative incidence (CuI) 16%) and without formula (CuI 17%) at 6 months (p=0.78).

The CuI of LRTI was estimated by the length of breastfeeding stratified by level of maternal smoking (table 3). The CuI was higher in children breastfed 0–6 months (CuI 22%; 95% confidence interval (95% CI)

Table 3. – Cumulative incidences (CuI) and 95% confidence intervals (95% CI) estimated for lower respiratory tract infections during the first year of life by length of breastfeeding, stratified by maternal smoking (Oslo Birth Cohort 1992–1993)

	Breastfed 0–6 months			Breastfed >6 months			
Maternal smoking	n	CuI%	95% CI	n	CuI%	95% CI	p-value‡
No	575	20	(16–23)	1751	16	(14–17)	0.03
Occasional	85	19	(10–27)	177	15	(9–20)	0.39
1–14 cigarettes·day^{-1}	209	23	(17–28)	206	16	(11–21)	0.09
≥15 cigarettes·day^{-1}	112	32	(23–41)	54	15	(5–25)	0.02
Total	981	22	(19–24)	2188	16	(14–17)	<0.0001

‡: Chi-squared test. Missing information: length of breastfeeding was not specified in 49 children; maternal smoking habits incompletely reported in 20 children (11 missing and 9 daily smoking mothers without information of daily number of cigarettes smoked).

19–24), compared with children breastfed for more than 6 months (CuI 16%; 95% CI 14–17). The difference in CuI between the breastfeeding categories increased with increasing amount of cigarettes smoked by the mothers.

In logistic regression analysis controlling for the core covariates, the AOR of LRTIs increased on average by a factor of 1.05 (95% CI 1.02–1.08) per 1 month decrease in duration of breastfeeding. Consequently no breastfeeding increased the AOR of LRTIs to 1.7 (95% CI 1.2–2.5) compared with 12 months breastfeeding. The corresponding estimate for children of nonsmoking mothers was 1.03 (95% CI 1.00–1.07), and for children of daily smoking mothers 1.07 (95% CI 1.02–1.13) per 1 month decrease in duration of breastfeeding.

In logistic regression analysis adjusting for the core covariates, maternal smoking increased the risk of LRTIs in children breastfed for 0–6 months (AOR 1.7; 95% CI 1.2–2.4). Corresponding figures for hospitalized LRTIs were AOR 3.2, 95% CI 1.6–6.7. The effect of maternal smoking showed an exposure-response pattern (1–14 cigarettes·day^{-1}: AOR 1.5, 95% CI 0.9–2.4; ≥15 cigarettes·day^{-1}: AOR 2.3, 95% CI 1.4–3.9 for all LRTIs). However, maternal smoking did not essentially increase the risk of LRTIs, when the child was breastfed for more than 6 months (AOR 1.1, 95% CI: 0.7–1.6). Paternal smoking was not significantly related to the outcome (figures not given).

The relationship between the occurrence of LRTIs and breastfeeding was elaborated for all LRTIs, and separately for hospitalized infections, in different categories of maternal smoking (table 4). Breastfeeding had a protective effect on infections in children of nonsmoking mothers. Short-term breastfeeding resulted in a greater risk of all infections (AOR 1.3; 95% CI 1.0–1.7), and hospitalized infections (AOR 1.4; 95% CI 0.8–2.5) than long-term breastfeeding. Short-term breastfeeding combined with maternal smoking was related to an AOR of 2.2 (95% CI 1.6–3.1) for all infections and of 4.6 (95% CI 2.5–8.3) for hospitalized infections, when compared to long-term breastfeeding and no maternal smoking.

To elaborate a meaningful time sequence between exposure and outcome, analyses were carried out focusing on exposure during the first 6 months and outcome from 7 to 12 months of age (table 5). The risk estimates for the protective effect of breastfeeding and adverse effect of maternal smoking on LRTIs did not differ essentially from those focusing on the whole year.

Table 5. – The risk of lower respiratory tract infections from 7–12 months of life in relation to the length of breastfeeding (long is >6 months) and maternal smoking (Oslo Birth Cohort 1992–1993)

		All infections		Hospitalized infections	
Breast-feeding	Maternal smoking	AOR‡	95% CI	AOR‡	95% CI
>6 months	No	ref	-	ref	-
>6 months	Yes	1.0	0.6–1.5	1.0	0.3–3.6
0–6 months	No	1.4	1.0–1.8	1.5	0.7–3.3
0–6 months	Yes	1.9	1.3–2.7	5.0	2.2–11.5

‡: logistic regression analysis adjusting for gender, having siblings, sharing of bedroom, day-care outside home, maternal education, parental history of asthma and paternal smoking. For definitions see legend to table 4. Missing information: on length of breastfeeding=49; on maternal smoking=11. Children of occasional smoking mothers (n=262) excluded.

Discussion

In this cohort study of 3,754 Oslo children, short-term breastfeeding (0–6 months) without maternal smoking increased the risk of LRTIs, as compared to long-term breastfeeding without maternal smoking (AOR 1.3; 95% CI 1.0–1.7). Maternal smoking increased the risk of LRTIs in children breastfed for 0–6 months (AOR 1.7; 95% CI 1.2–2.4), and this effect showed an exposure-response pattern. For children breastfed more than 6 months, maternal smoking did not increase the risk significantly (AOR 1.1; 95% CI 0.7–1.6). Short-term breastfeeding combined with maternal smoking was related to an AOR of 2.2 (95% CI 1.6–3.1) compared to long-term breastfeeding and no maternal smoking.

The relationship between breastfeeding and the risk of LRTI is complicated in several ways [30]. Breastfeeding may be associated with other measured determinants of LRTI, and the association observed may be the result of selection bias or confounding. Information on LRTI may be related to breastfeeding habits because of parental reporting, use of health care, or physician's diagnostic habits. A prospective cohort study avoids some of the validity problems, such as bias in the ascertainment of exposure, but losses to follow-up could introduce bias. In the present study, this was not likely as the follow-up rate was high (86%), and the baseline

Table 4. – The risk of lower respiratory tract infections during the first year of life in relation to the length of breastfeeding (long is >6 months) and maternal smoking (Oslo Birth Cohort 1992–1993)

			All infections				Hospitalized infections			
Breast-feeding	Maternal smoking	n	CuI%	COR	AOR‡	95% CI	CuI%	COR	AOR‡	95% CI
>6 months	No	1751	16	ref	ref	-	3	ref	ref	-
>6 months	Yes	264	16	1.0	1.1	0.7–1.6	3	1.1	1.1	0.5–2.7
0–6 months	No	575	20	1.3	1.3	1.0–1.7	4	1.4	1.4	0.8–2.5
0–6 months	Yes	326	26	1.9	2.2	1.6–3.1	9	2.6	4.6	2.5–8.3

‡: logistic regression analysis adjusting for gender, having siblings, sharing of bedroom, day-care outside home, maternal education, parental history of asthma and paternal smoking. CuI: cumulative incidences; COR: crude odds ratio; AOR: adjusted odds ratio; 95% CI: 95% confidence interval; ref: reference category. Missing information: on length of breastfeeding=49; on maternal smoking=11. Children of occasional smoking mothers (n=262) excluded.

characteristics of those followed for 1 year were similar to the total cohort.

The assessment of the outcome depends on parental behaviour in relation to the health services, availability of health care, physicians' diagnostic habits, and parental reporting in the questionnaire. For a severe disorder, parental behaviour is likely to have less influence on ascertainment. To minimize the effect of parental health behaviour, we included only those episodes of LRTI diagnosed by a physician. Also, a separate analysis was carried out for hospitalized cases. The cumulative incidence of LRTIs in this study was lower than in some previous studies using the term "lower respiratory illness" [2, 4], and indicates a more severe outcome. It could be that the present approach resulted in a high proportion of true LRTIs and, thus, justifies the use of the term "lower respiratory tract infection" rather than "lower respiratory illness". In Norway, expenses for medical treatment of children are paid by the government, which ensures practically equal availability of health care and, consequently, also a uniform parental practice in contacting doctors when their children are ill. The frequency of physician visits for respiratory symptoms was not related to the length of breastfeeding. This indicates that the use of health services was not a likely source of bias.

There may be a considerable variation in the diagnostic practice of LRTIs, but there is no reason to believe that breastfeeding of a child *per se*, would affect a doctor's diagnosis of respiratory disease. Except for the first months of life, it is unlikely that doctors are concerned about the length of breastfeeding when they decide on diagnosis or hospitalization.

The parental reporting of LRTI could be related to breastfeeding. It has been argued that active and frequent surveillance is necessary to prevent bias in reporting (information bias). On the other hand, this would focus on the objectives of the study and, thus, introduce the possibility of reporting bias both by parents and data collectors. Blinding of the objectives, as in the present study, might be a better strategy for reducing information bias. The validity of the outcome was assessed by a physician-administered telephone interview of 100 randomly selected participants, who reported no LRTIs shortly after (14 days) receiving the questionnaire. The interview revealed no LRTIs and none of the interviewed families had visited a doctor for lower respiratory tract symptoms during the last 6 months before the interview.

Length of breastfeeding was associated with several known or suggested determinants of LRTIs, such as having siblings, maternal age, socioeconomic status (measured here by maternal education and family income), and parental smoking habits. The potential confounding by these factors was taken into account in logistic regression analysis. However, the crude and adjusted odds ratios were similar. The variance in socio-economic status among Norwegian families is small compared to many other countries and probably reduces the risk of confounding by socioeconomy. Due to a long full-paid maternity leave, very few children in Norway attend day-care before the age of 10 months. Logistic regression models with or without day-care practice at 6 or 12 months gave the same estimates of the protective effect of breastfeeding.

Smoking habits within the family were used as a crude measure of the child's exposure to environmental tobacco smoke. Questionnaire information on maternal smoking at the end of pregnancy was compared with biomarkers in umbilical cord serum taken at birth for 202 randomly selected mothers [35]. An excellent agreement was shown, which indicated that the mothers reported their smoking habits correctly. In agreement with previous studies [8], the cumulative incidence of LRTI was significantly related to maternal smoking, but not to paternal smoking. A closer relationship between the mother and the child than between the child and any other person could explain why maternal smoking is of particular importance during the first year of life. Our own unpublished results indicate that occasional smokers are, on average, light smokers [35]. Their smoking rate varies over a large range. Consequently, their children's exposure to tobacco smoke products would vary. Therefore, these children were excluded from some of the analyses.

Earlier studies of the protective effects of breastfeeding on children's health have been inconsistent, and a recent review concluded that the evidence of the protective effect of breastfeeding against infections in developed countries is weak [36]. Some studies have presented a significant relationship between the length of breastfeeding and outcomes, such as respiratory syncytial virus infection, pneumonia, wheezy bronchitis or LRTI [22–26, 28]. On the other hand, in a prospective cohort study, RUBIN *et al*. [20] found no protective effect of breastfeeding on LRTIs during the first year of life.

In contrast to some of the earlier studies, the present study design made it possible to take into account the possible time sequence of breastfeeding and occurrence of infections, because relevant information was collected at birth and at 6 and 12 months. Most information was taken from the birth or 6 month questionnaire, as it was considered to be the most representative and accurate for children's exposure during their first year of life. Focusing on infections between 7–12 months revealed a plausible time sequence supporting a true protective effect of breastfeeding. Our observation of a weaker effect of exposure to tobacco smoke products on LRTIs in long-term breastfed children, is consistent with results of a cross-sectional study of acute respiratory illness among children in Adelaide, Australia [29]. The results do not support a hypothesis that exposure to tobacco smoke products through breastmilk increases the risk of LRTIs. A modification of the effect of environmental exposure to tobacco smoke products on symptoms or infections of the lower airways, could be a possible effect of breastfeeding.

In conclusion, the results of the present study indicate a protective effect of breastfeeding on the risk of lower respiratory tract infections during the first year of life. The results suggest that the preventive effect is stronger in children of smoking mothers compared with children of nonsmoking mothers.

Acknowledgements: The authors would like to acknowledge the staff of the maternity wards at Aker and Ullevål Hospital for their support in data collection, and L. Bakketeig, K.C. Lødrup Carlsen, K.H. Carlsen and L. Øie for their contribution in the planning of this cohort study.

References

1. Denny FW, Clyde WA. Acute lower respiratory tract infections in nonhospitalized children. *J Pediatr* 1986; 108: 635–645.
2. Wright AL, Taussig LM, Ray G, Harrison HR, Holberg CJ, and GHMA. The Tucson children's respiratory study. II. Lower respiratory tract illness in the first year of life. *Am J Epidemiol* 1989; 129: 1232–1246.
3. Monto AS, Ross H. Acute respiratory illness in the community: effect of family composition, smoking and chronic symptoms. *Br J Prev Soc Med* 1977; 31: 101–108.
4. Fergusson DM, Horwood LJ, Shannon FT, Taylor B. Parental smoking and lower respiratory illness in the first three years of life. *J Epidemiol Commun Health* 1981; 35: 180–184.
5. Samet JM, Tager I, Speizer F. The relation between respiratory illness in childhood and chronic airflow obstruction in adulthood. *Am Rev Respir Dis* 1983; 127: 508–523.
6. Burrows B, Knudson RJ, Lebowitz MD. The relation of childhood respiratory illness to adult obstructive airway disease. *Am Rev Respir Dis* 1977; 115: 751–759.
7. Shaheen SO, Barker JP, Shiell AW, Crocker FJ, Wield GA, Holgate ST. The relationship between pneumonia in early childhood and impaired lung function in late adult life. *Am J Respir Crit Care Med* 1994; 149: 616–619.
8. United States Environmental Protection Agency. Respiratory health effects of passive smoking: lung cancer and other disorders. United States Environmental Protection Agency, EPA/600\6-90\006F, 1992. Washington DC.
9. Samet J, Lambert WE, Skipper BJ, *et al*. Nitrogen dioxide and respiratory illnesses in infants. *Am Rev Respir Dis* 1993; 148: 1258–1265.
10. Morgan WJ, Martinez FD. Risk factors for developing wheezing and asthma in childhood. *Pediatr Clin North Am* 1992; 39: 1185–1203.
11. Leeder SR, Corkhill R, Irwig LM, Holland WW. Influence of family factors on the incidence of lower respiratory illness during the first year of life. *Br J Prev Soc Med* 1976; 30: 203–212.
12. Louhiala PJ, Jaakkola N, Ruotsalainen R, Jaakkola JJK. Form of day-care and respiratory infections among Finnish children. *Am J Public Health* 1995; 85: 1109–1112.
13. Martinez FD, Cline M, Burrows B. Increased incidences of asthma in children of smoking mothers. *J Pediatr* 1992; 89: 21–26.
14. Wright AL, Holberg CJ, Martinez FD, Taussig LM, and GHMA. Relation of parental smoking to wheezing and nonwheezing lower respiratory tract illnesses in infancy. *J Pediatr* 1991; 118: 207–214.
15. Stoddard JJ, Miller T. Impact of paternal smoking on the prevalence of wheezing respiratory illness in children. *Am J Epidemiol* 1995; 1412: 96–102.
16. Chen Y, Shunzhang Y, Li W. Artificial feeding and hospitalization in the first 18 months of life. *Pediatrics* 1988; 81: 58–62.
17. Victora CG, Fuchs SC, Flores JAC, Fonseca W, Kirkwood B. Risk factors for pneumonia among children in a Brazilian metropolitan area. *Pediatrics* 1994; 93: 977–985.
18. Foreman MR, Graubard BI, Hoffman HJ, Beren R, Harley EE, Bennett P. The Pima infant feeding study: breastfeeding and respiratory infections during the first year of life. *Int J Epidemiol* 1984; 13: 447–454.
19. Howie PW, Forsyth JS, Ogston SA, Clark A, Florey CV. Protective effect of breastfeeding against infection. *BMJ* 1990; 300: 11–16.
20. Rubin DH, Leventhal JM, Kransilnikoff PA, *et al*. Relationship between infant feeding and infectious illness: a prospective study of infants during the first year of life. *Pediatrics* 1990; 85: 464–471.
21. Leventhal JM, Shapiro ED, Aten CB, Berg AT, Egerter SA. Does breastfeeding protect against infections in infants less than 3 months of age? *Pediatrics* 1986; 78: 896–903.
22. Holberg CJ, Wright AL, Martinez FD, Ray G, Taussig LM, Lebowitz MD and GHMA. Risk factors for respiratory syncytial virus-associated lower respiratory illnesses in the first year of life. *Am J Epidemiol* 1991; 133: 1135–1151.
23. Wright AL, Holberg CJ, Martinez FD, Morgan WJ, Taussig LM, GHMA. Breastfeeding and lower respiratory tract illness in the first year of life. *Br Med J* 1989; 299: 946–949.
24. Ford K, Labbok M. Breastfeeding and child health in the United States. *J Biosoc Sci* 1993; 25: 187–194.
25. Pullan CR, Toms GL, Martin AJ, Gardner PS, Webb JKG, Appleton DR. Breastfeeding and respiratory syncytial virus infection. *Br Med J* 1980; 281: 1034–1036.
26. Rylander E, Pershagen G, Eriksson M, Nordwall L. Parental smoking and other risk factors for wheezing bronchitis in children. *Eur J Epidemiol* 1993; 9: 517–526.
27. Beaudry M, Dufour R, Marcoux S. Relation between infant feeding and infections during the first six months of life. *J Pediatr* 1995; 126: 191–197.
28. Pisacane A, Graziano L, Zona G, *et al*. Breastfeeding and acute lower respiratory infection. *Acta Paediatr* 1994; 83: 714–718.
29. Woodward A, Douglas RM, Graham NMH, Miles H. Acute respiratory illness in Adelaide children: breastfeeding modifies the effect of passive smoking. *J Epidemiol Commun Health* 1990; 44: 224–230.
30. Baucher H, Leventhal JM, Shapiro ED. Studies on breastfeeding and infections: How good is the evidence? *JAMA* 1986; 256: 887–892.
31. Cunningham AS, Jelliffe DB, Jelliffe EFP. Breastfeeding and health in the 1980s: a global epidemiologic review. *J Pediatr* 1991; 118: 659–666.
32. Oshaug A, Botten G. Human milk in food supply statistics. *Food Policy* 1994; 19(5): 479–482.
33. Kleinbaum DG. Logistic regression: a self-learning text. Ann Arbor, Springer-Verlag, 1994.
34. SPSS for Windows. Release 6.0. Chicago, USA, SPSS Inc.
35. Nafstad P, Kongerud J, Botten G, *et al*. Fetal exposure to tobacco smoke products: a comparison between self-reported maternal smoking and concentration of cotinine and thiocyanate in cord serum. *Acta Obstet Gynecol Scand* (in press).
36. Statement of the Standing Committee on Nutrition of British Paediatric Association. Is breastfeeding beneficial in the UK? *Arch Dis Child* 1994; 71: 376–380.