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Risk Factors for Acute Respiratory Tract Infections in Young Greenlandic Children

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Acute respiratory infections cause considerable morbidity among Inuit children, but there is very little information on the risk factors for these infections in this population. To identify such factors, the authors performed a prospective community-based study of acute respiratory infections in an open cohort of 288 children aged 0–2 years in the town of Sisimiut, Greenland. Between July 1996 and August 1998, children were monitored weekly, and episodes of upper and lower respiratory tract infections were registered. Risk factor analyses were carried out using a multivariate Poisson regression model adjusted for age. Risk factors for upper respiratory tract infections included attending a child-care center (relative risk = 1.7 compared with home care) and sharing a bedroom with adults (relative risk = 2.5 for one adult and 3.1 for two adults). Risk factors for lower respiratory tract infections included being a boy (relative risk = 1.5), attending a child-care center (relative risk = 3.3), exposure to passive smoking (relative risk = 2.1), and sharing a bedroom with children aged 0–5 years (relative risk = 2.0 for two other children). Breastfeeding tended to be protective for lower respiratory tract infections. The population-attributable risk of lower respiratory tract infections associated with passive smoking and child-care centers was 47% and 48%, respectively. The incidence of acute respiratory infections among Inuit children may be reduced substantially through public health measures.

child; cohort studies; Eskimos; infection; respiratory tract infection; risk factors

Abbreviation: CI, confidence interval.

Inuit children of the Arctic are at high risk of acute respiratory tract infections, both upper (including otitis media) and lower respiratory tract infections, compared with populations in developing as well as in industrialized countries (1–8). In spite of the high incidence of acute respiratory infections, there is very little information on the risk factors for these infections. We have previously reported that mannose-binding lectin insufficiency among Greenlandic children is associated with an increased risk of acute respiratory infections, but this explains only a small fraction of the variation in incidence in this population (9).

During the last decades, Inuit populations in Greenland, Canada, and Alaska have undergone development from traditional hunting and fishing societies to modern, Western societies where most people occupy jobs in trade, administration, and services, a development also reflected in housing and living conditions in general. Thus, although respiratory tract infections both in earlier days and at present are frequent, the risk factor pattern may have changed with the living conditions, and risk factors for acute respiratory infections in today's Greenland might be closer to those pertinent to Western countries than to poor societies.

A longitudinal population-based cohort study of acute respiratory infections among children aged 0–2 years in the West Greenlandic town of Sisimiut was established with the specific objective to determine risk factors for acute upper and lower respiratory tract infections. Special emphasis was on the roles of age, gender, birth characteristics, ethnicity,

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breastfeeding, socioeconomic factors, housing conditions, crowding, passive smoking, and child care.

MATERIALS AND METHODS

Study area and population

Sisimiut is the second largest town in Greenland with 5,117 inhabitants (88 percent born in Greenland and 12 percent outside Greenland, primarily in Denmark), 3 km from one end to the other, and connected by flights year-round to the main airport in Greenland. With a fishing fleet and Greenland's biggest fish factory, Sisimiut is dependent upon mainly fishing and some whaling, but not seal hunting as in other districts. Other enterprises are mainly smaller workshops. Most persons are unskilled workers or fishermen. The average income per year per taxpayer is approximately US $14,500, slightly higher than the average for Greenland (10). Houses are traditional one- or two-family wooden or concrete-block houses or terraced houses made from wood and concrete. All health care and medications are provided free of charge by a single health center, staffed with up to five physicians and a midwife.

As previously described in detail elsewhere (1), an open cohort of children aged 0–2 years was formed by April 1, 1996, comprising all children living in the town as of April 1, 1996, and all children either born in or moving into Sisimiut in the subsequent period until June 1, 1998, irrespective of ethnicity and other factors. The cohort was monitored weekly from July 30, 1996, to August 13, 1998, by specially trained Danish medical students and local interpreters supervised by Danish physicians.

Surveillance program and case definitions

Children were enrolled as soon as possible after identification but, in general, not prior to 6 weeks after birth, and they were excluded at 2 years of age. The children were visited weekly, and information on symptoms of acute respiratory infections was obtained. If symptoms were reported, a clinical examination including tympanometry was carried out. If any of the following signs were recorded, the episode, modified from the description by Selwyn (11), was characterized as a lower respiratory tract infection: respiratory rate of >50/minute and cough or difficult breathing, rales, stridor, wheezing, cyanosis, or subcostal chest indrawing. If none of these but any of the following were recorded, the episode was characterized as an upper respiratory tract infection (again modified from Selwyn's description (11)): purulent nasal discharge, cough, red and bulging tympanic membrane with loss of normal landmarks and abnormal tympanometry compliance, purulent ear discharge, or pharyngo-tonsillar erythema or exudate. Clear nasal secretion as the only finding was excluded from definitions (11). Together, episodes of upper and lower respiratory tract infections constituted episodes of acute respiratory infection. If health center attention was sought during an episode of respiratory symptoms, physicians' diagnoses of the episode as croup, bronchitis, bronchiolitis, or pneumonia were considered lower respiratory tract infections, and physicians' diagnoses of the episode as rhinitis, pharyngitis, tonsillitis, or acute otitis media were considered upper respiratory tract infections. A 7-day, symptom-free interval had to elapse before a new episode could occur. Days at risk for acute respiratory infections were counted as days free from symptoms, including the first day of a new episode but exclusive of the 7 days free from symptoms following an episode.

Risk factors

At enrollment, a standardized questionnaire was used to collect information on risk factors within the following item categories: ethnicity, socioeconomic factors, birth history, crowding, housing, smoking, child care, and breastfeeding. A similar interview carried out at the end of the study period validated the enrollment information. Information on child care and breastfeeding was additionally obtained at the monthly morbidity visits. Official files and registers kept by the Chief Medical Officer of Greenland and by the Sisimiut community validated the information on birth history, use of public child care, change of address, housing construction, and water supply. For all risk factors, the information obtained at the time of enrollment was used, except for information on breastfeeding and child care, which was updated monthly and treated as a time-dependent variable in each case. Because factors concerning crowding, housing, and smoking in the household would invariably change in the case of a change of address, information on these variables was used only for the period prior to moving. This caused a reduction in the time at risk for these variables of approximately 10 percent.

Ethnicity was defined as Greenlandic, Danish, or mixed according to the biologic parents' place of birth. Social class was on the basis of vocational training and employment status classified according to the Danish social classification system (12), with hunters/fishers classified as unskilled workers. The effect of social class was assessed only in families with both a mother and a father. Child care was divided into home care, day care (being looked after outside the home but not in a child-care center), or child-care centers.

Statistical methods

Incidence ratios and 95 percent confidence intervals were used as measures of relative risk. Incidence was calculated as the number of episodes divided by the time at risk. The number of episodes and days at risk for each child were calculated on a monthly basis, assuming a constant incidence within each month. Because each child could contribute with respiratory events in different calendar months, the model had to account for the possible correlation between episodes from the same child. Therefore, a generalized estimating equation method with correlation structure between measurements from the same child was used in a Poisson regression model. A banded Toeplitz correlation structure with five bands was applied. With this correlation structure, episodes with a maximal interval of 6 months from the same child were considered correlated, while those with larger intervals were regarded as independent. Relative risk estimates were obtained from the generalized estimating equation model, and confidence intervals were calculated using a robust covariance estimator for the estimated effects. Wald's test was used to test the effect of any risk factor, using the fact that estimates based on the generalized estimating equation method are asymptotically normally distributed (13). In tests for trend, the categorized variable was treated as continuous using the median within each category as the score. The GENMOD procedure in SAS version 6.12 was used for the generalized estimating equation model (14).

Risk factor analyses as both univariate and multivariate analyses were carried out using the generalized estimating equation model. To allow dependence upon age, gender, ethnicity of the interviewer, and calendar period (year and month), we adjusted for these factors in all the analyses. Each risk factor was analyzed separately in a univariate model and, based on these results, a multivariate generalized estimating equation regression model was constructed. From this common model, multivariate analyses for upper and lower respiratory tract infections were carried out separately, removing the variables stepwise according to the highest p value for each step ("backwards elimination"), until all the p values had reached levels below 0.10.

The population-attributable risk, an estimate of the fraction of the total number of acute respiratory infections that would not have happened if the effect of a specific risk factor had been eliminated, was estimated as described by Bruzzi et al. (15) on the basis of the adjusted relative risks and the distribution of exposure in the episodes.

Prior to initiation, the study was approved by the Scientific Ethics Committee for Greenland.

RESULTS

Study population

A total of 312 children were enrolled, while 44 refused (participation rate, 88 percent), none for reasons associated with respiratory tract infections. Of the enrolled children, 17 had for various reasons no time of follow-up, one was excluded because of laryngomalacia, and six did not have any days free from symptoms before any episode, leaving 288 children in the study (231 Greenlandic children, 11 Caucasian, and 30 of mixed descent). The descent of 16 children was classified as unknown, as the place of birth of only one parent was known. Among the enrolled children, 527 episodes of upper respiratory tract infections and 292 episodes of lower respiratory tract infections were recorded in 33,228 days at risk, yielding an incidence of 1.59 episodes per 100 child-days at risk of upper respiratory tract infections (95 percent confidence interval (CI): 1.46, 1.73) and 0.88 episodes per 100 child-days at risk of lower respiratory tract infections (95 percent CI: 0.78, 0.99).

Tables 1, 2, 3, and 4 present risk factor distributions. The median household was a family of four persons (interquartile range, 4–5) including two children, one of whom was less than 5 years of age. The median number of persons per room per household was 1.5, and the median number of rooms per household was three (interquartile range, 3–4). Almost all houses had electric cooking and running water or tank water, and all had central heating. Most (87 percent) houses had a flush toilet, while 13 percent had a plastic bag toilet.

There were smokers in 81 percent of the households, with a median number of two smokers in each household. The median number of cigarettes smoked per day per household was 10 (interquartile range, 3–20), and the median number of cigarettes per day per person in a household was 7.5 (interquartile range, 4–11). Sixty-six percent of mothers and 68 percent of fathers smoked. Of the mothers who smoked, 26.1 percent smoked 1–4 cigarettes daily, 37.5 percent smoked 5–9, and 36.4 percent smoked more than 10 cigarettes per day.

Most (83 percent) of the children were taken care of outside their homes during the monitoring period. Of these, 26 percent had at some point attended day care, and 70 percent attended child-care centers. The median age at the start of day care was 170 days (interquartile range, 131–286 days), and the age at the start of child-care center attendance was 244 days (interquartile range, 185–364 days). The median number of children in day care including the child was four (interquartile range, 3–4).

Five of the 288 children had never been breastfed. Of 110 children at 3 months of age, 45 were exclusively breastfed, 43 were partly breastfed, 19 were weaned, and three had never been breastfed. Of 139 children at 6 months of age, six were exclusively breastfed, 84 were partly breastfed, 46 were weaned, and three had never been breastfed. The median age at weaning was determined to be 154 days for the 198 children, who stopped breastfeeding in the monitoring period and before turning 2 years of age.

Risk factor analyses

Tables 1, 2, 3, and 4 present the results of the univariate risk factor analyses. A number of factors within all item groups were significantly associated with increased risk of upper or lower respiratory tract infections or both (age, gender, ethnicity, gestational age, social class, nighttime crowding, passive smoking, type of child care, and lack of breastfeeding). In contrast, weight at birth, weight for gestational age, year of construction of house, heating facilities, cooking gear, type of toilet, and water supply were not associated with increased risk of upper or lower respiratory tract infections (not shown in tables), nor was calendar period (calendar month and year) associated with either upper (p = 0.57 and p = 0.20, respectively) or lower (p = 0.11 and p = 0.35, respectively) respiratory tract infections. The interviewer was associated with an increased risk of upper respiratory tract infections (p = 0.002) but not with lower respiratory tract infections (p = 0.91).

The common multivariate generalized estimating equation model consisted of the following 12 variables: ethnicity, social class of the household, mother's and father's education, gestational age, mother's age at the child's birth, number of children aged 0–5 years and number of adults sleeping in the same room as the child, type of house, smokers in household, child care, and breastfeeding, besides the five variables that were similarly adjusted for in the univariate analyses (age, gender, year, month, and interviewer). Most of the 12 variables were chosen as those with a p value of less than 0.10 in the univariate analyses. The mother's education was chosen as it showed the same, although not significant, trend for upper respiratory tract infections as did the father's education.

TABLE 1. Child-related, birth, and social factors as risk factors for upper and lower respiratory tract infections in 288 children less than 2 years of age in Sisimiut, Greenland, 1996–1998*

Risk factor	No. of children	Days at risk	Upper respiratory tract infection				Lower respiratory tract infection			
			No. of episodes	Relative risk	95% confidence interval	*p* value	No. of episodes	Relative risk	95% confidence interval	*p* value
Age (months)	—†					<0.001				<0.001
0–5		6,924	42	0.30	0.20, 0.46		40	0.87	0.54, 1.42	
6–11		8,423	168	1.12	0.84, 1.50		103	1.78	1.23, 2.57	
12–17		8,858	170	1.17	0.91, 1.51		97	1.58	1.11, 2.23	
18–23		9,023	147	1			52	1		
Gender (*n* = 288)						0.87				0.007
Girls	149	18,720	308	1			133	1		
Boys	139	14,508	219	1.02	0.81, 1.28		159	1.61	1.14, 2.29	
Ethnicity (parents' place of birth) (*n* = 272)						0.04‡				0.04§
Greenland/Greenland	231	26,653	446	1			216	1		
Greenland/Denmark (other)	30	3,512	42	0.72	0.51, 1.02		57	1.79	1.09, 2.93	
Denmark (other)/Denmark (other)	11	1,628	15	0.57	0.25, 1.29		4	0.40	0.07, 2.21	
Gestational age (weeks) (*n* = 275)						0.009				0.16
<37	6	340	9	2.05	1.20, 3.51		6	2.50	0.69, 9.10	
≥37	269	31,976	505	1			276	1		
Mother's age (years) at child's birth (*n* = 286)						0.08				0.95
15–19	40	3,866	72	1.27	0.92, 1.76		27	0.92	0.50, 1.69	
20–24	66	6,186	118	1.56	1.12, 2.17		61	1.01	0.64, 1.61	
25–29	89	10,914	154	1			104	1		
30–34	62	8,146	128	1.22	0.91, 1.64		60	0.84	0.53, 1.33	
≥35	29	3,911	53	0.98	0.60, 1.59		35	0.92	0.47, 1.80	
Social class, higher of parents in families with father (*n* = 245)¶						0.02#				0.74**
1–2	23	3,476	43	1.05	0.57, 1.94		20	0.67	0.32, 1.39	
3	50	5,966	75	1			61	1		
4	88	9,975	155	1.33	0.89, 1.99		98	0.90	0.56, 1.45	
5	80	8,636	165	1.68	1.16, 2.44		70	0.83	0.47, 1.44	
Outside classification	4	641	10	1.63	0.99, 2.66		5	0.65	0.26, 1.57	
Education, father (*n* = 247)††						0.09‡‡				0.46‡‡
1	15	2,422	27	1			8	1		
2	114	12,786	186	1.38	0.76, 2.52		113	1.73	0.61, 4.91	
3	13	1,956	22	1.19	0.55, 2.59		26	2.40	0.77, 7.51	
4	94	10,596	191	1.63	0.90, 2.95		89	1.79	0.63, 5.12	
5	11	1,049	26	2.35	1.20, 4.59		18	4.37	1.22, 15.7	
Education, mother (*n* = 286)††						0.34‡‡				0.21‡‡
1	19	2,378	30	1			16	1		
2	83	9,642	153	1.21	0.75, 1.96		115	1.50	0.67, 3.38	
3	18	2,314	34	1.14	0.55, 2.34		19	1.18	0.45, 3.10	
4	142	15,715	265	1.30	0.81–2.07		121	1.06	0.46, 2.48	
5	24	3,027	41	0.98	0.56, 1.70		21	0.82	0.29, 2.47	

* All variables adjusted for age, gender, calendar period, and interviewer (Greenlandic vs. Danish speaking). *p* value test for homogeneity if not stated otherwise.

† Because age is treated as a time-dependent variable, the number of children in each stratum cannot be calculated.

‡ *p* value test for trend.

§ No linear structure; *p* value test for homogeneity.

¶ Social class: 1, persons with academic education or top executives; 2, persons with a longer but not academic education or independent with 6–20 subordinates; 3, other employees or independent with 0–5 subordinates; 4, skilled workers; 5, unskilled workers or hunters/fishers.

p value test for trend for levels 1–2 through 5 only.

** No linear structure; *p* value test for homogeneity for levels 1–2 through 5 only.

†† Education: 1, long or theoretical education of medium length; 2, short or practical education of medium length; 3, short courses or education not completed; 4, none; 5, studying.

‡‡ *p* value test for trend for levels 1–4 only.

TABLE 2. Housing and crowding parameters as risk factors for upper and lower respiratory tract infections in 288 children less than 2 years of age in Sisimiut, Greenland, 1996–1998*

Risk factor	No. of children	Days at risk	Upper respiratory tract infection				Lower respiratory tract infection			
			No. of episodes	Relative risk	95% confidence interval	*p* value	No. of episodes	Relative risk	95% confidence interval	*p* value
Type of house (*n* = 287)						0.87				0.06
Apartment	138	12,789	214	1			139	1		
Terrace/cluster houses	81	7,898	115	0.94	0.72, 1.24		54	0.63	0.42, 0.96	
Single or double family house	68	7,912	112	0.92	0.66, 1.30		59	0.68	0.43, 1.09	
No. of persons in household (*n* = 287)						0.60				0.99
2–3	62	6,021	91	1.23	0.83, 1.81		53	0.94	0.54, 1.63	
4	83	7,527	125	1.13	0.79, 1.61		72	1.06	0.66, 1.70	
5	74	7,896	127	1.25	0.88, 1.75		68	1.00	0.60, 1.67	
≥6	68	7,270	99	1			59	1		
No. of persons per room (*n* = 279)						0.06				0.65
0	11	1,714	13	0.45	0.17, 1.18		12	0.73	0.16, 3.27	
1	127	12,467	216	0.85	0.63, 1.16		122	0.86	0.55, 1.33	
1.5	74	6,778	112	1			63	1		
2	67	6,836	96	0.68	0.50, 0.94		49	0.71	0.42, 1.20	
No. of children aged 0–5 years sleeping in the same room as the child (*n* = 275)						0.10†				0.002†
0	196	24,026	363	1			195	1		
1	69	6,521	127	1.31	1.02, 1.69		77	1.67	1.13, 2.45	
2	10	815	16	1.37	0.71, 2.63		11	1.86	0.96, 3.62	
No. of children aged 5–15 years sleeping in the same room as the child (*n* = 280)						0.85†				0.20†
0	237	22,951	357	1			193	1		
1	33	4,132	59	0.86	0.60, 1.22		48	1.19	0.80, 1.76	
2	10	720	14	1.30	0.65, 2.57		8	1.59	0.71, 3.52	
No. of adults sleeping in the same room as the child (*n* = 283)						0.001†				0.54†
0	17	1,568	12	1			16	1		
1	44	4,147	62	2.67	1.22, 5.85		40	0.93	0.49, 1.78	
2	226	22,884	367	3.29	1.57, 6.90		196	1.10	0.63, 1.90	

* All variables adjusted for age, gender, calendar period, and interviewer (Greenlandic vs. Danish speaking). *p* value test for homogeneity if not stated otherwise.
† *p* value test for trend.

Breastfeeding was chosen because this variable showed a clear trend in relative risk for lower respiratory tract infections, in particular for children less than half a year of age. For the breastfeeding variable, children never breastfed were included in the group designated "stopped." No restrictions were made for the other variables.

The final reduced multivariate models for upper and lower respiratory tract infections are shown in tables 5 and 6, respectively. The variables with the lowest *p* values at removal were, for upper respiratory tract infections, ethnicity ($p = 0.14$) and, for lower respiratory tract infections, mother's education ($p = 0.35$).

Although the multivariate analyses did not essentially change the number of variables significant in the univariate analyses, the magnitude of the relative risk estimates for some variables changed. In particular, children of the age group 0–5 months who in the univariate analysis had the lowest risk for lower respiratory tract infections had the highest risk in the multivariate model. As this could suggest interaction between age and a number of the other variables, multivariate analyses were performed of the interaction between age and gender, age and children aged 0–5 months sleeping in the same room, age and smoking in the household, and age and child care, besides smoking and child care. All interaction variables were entered into the final multivariate model and thus adjusted for the other variables. No significant interactions were observed.

There was a population-attributable risk of lower respiratory tract infections of 10.6 percent associated with children aged 0–5 months sleeping in the same room as the index child, of 47.1 percent associated with smokers in the house, and of 48.3 percent associated with child care.

DISCUSSION

The present study is the first population-based prospective study of risk factors for acute respiratory infections in Inuit children based on active surveillance. This population is at very high risk of acute respiratory infections (1) compared

TABLE 3. Smoking parameters as risk factors for upper and lower respiratory tract infections in 288 children less than 2 years of age in Sisimiut, Greenland, 1996–1998*

Risk factor	No. of children	Days at risk	Upper respiratory tract infection				Lower respiratory tract infection			
			No. of episodes	Relative risk	95% confidence interval	*p* value	No. of episodes	Relative risk	95% confidence interval	*p* value
Smokers in household (*n* = 287)						0.64				0.026
No	54	6,301	100	1			37	1		
Yes	233	26,812	426	0.93	0.69, 1.26		255	1.88	1.08, 3.27	
No. of smokers in household (*n* = 287)						0.93				0.03†
0	54	6,301	100	1			37	1		
1	67	7,737	122	0.91	0.64, 1.29		74	1.74	0.94, 3.23	
2	134	15,414	246	0.93	0.67, 1.28		146	1.90	1.07, 3.38	
≥3	32	3,661	58	1.00	0.66, 1.51		35	2.09	0.98, 4.47	
Smoking in household by child care‡						0.20§				0.48§
Home										
No smoking		2,905	22	1			5	1		
Smoking		10,949	113	1.32	0.72, 2.40		68	3.26	1.23, 8.61	
Day care										
No smoking		672	8	1			6	1		
Smoking		3,880	64	1.26	0.56, 2.85		27	1.32	0.40, 4.38	
Child-care center										
No smoking		2,724	70	1			26	1		
Smoking		11,983	249	0.79	0.59, 1.06		160	1.79	0.98, 3.27	
Father smokes (*n* = 257)						0.99				0.38
No	82	10,045	153	1			78	1		
Yes	175	19,658	313	1.00	0.76, 1.31		183	1.20	0.79, 1.82	
Mother smokes (*n* = 284)						0.33				0.01
No	98	10,745	181	1			72	1		
Yes	186	22,100	340	0.89	0.70, 1.13		219	1.66	1.11, 2.47	
Daily no. of cigarettes, father (*n* = 220)						0.98				0.49
0	82	10,045	153	1			78	1		
1–4	21	1,938	31	0.99	0.65, 1.50		13	0.88	0.33, 2.32	
5–9	30	3,579	57	0.98	0.64, 1.51		31	0.98	0.58, 1.67	
≥10	87	10,755	179	0.94	0.70, 1.27		108	1.29	0.84, 1.98	
Daily no. of cigarettes, mother (*n* = 282)						0.45				0.009¶
0	98	10,745	181	1			72	1		
1–4	48	5,016	82	0.96	0.69, 1.31		46	1.39	0.87, 2.20	
5–9	69	8,508	122	0.94	0.68, 1.31		76	1.63	0.99, 2.70	
≥10	67	8,485	134	0.79	0.59, 1.06		96	1.83	1.14, 2.92	
Total daily amount of smoking in household (cigarettes per day) (*n* = 271)						0.63				0.13¶
0	54	6,301	100	1			37	1		
1–9	72	7,617	120	1.04	0.72, 1.49		63	1.76	0.91, 3.41	
10–19	67	8,253	135	0.94	0.67, 1.33		86	1.89	1.02, 3.52	
≥20	78	9,719	159	0.85	0.59, 1.21		101	2.28	1.22, 4.24	

* All variables adjusted for age, gender, calendar period, and interviewer (Greenlandic vs. Danish speaking). *p* value test for homogeneity if not stated otherwise.
† *p* value test for trend.
‡ Distribution of child-care changes by time. Thus, the absolute distribution of children cannot be calculated.
§ *p* value test for interaction between levels.
¶ *p* value test for trend for all levels. If "0 cigarettes per day" was omitted, that is, test only among smokers, $p = 0.30$ for mother's amount of smoking and $p = 0.27$ for total daily amount of smoking in household.

with populations in developing countries (Board on Science and Technology for International Development studies: Kenya, Nigeria, Papua New Guinea, the Philippines, Thailand, Colombia, Uruguay, and Guatemala (11)) and in the United States (Tecumseh, Michigan; Seattle, Washington; Washington, DC; and Albuquerque, New Mexico (16–18)).

TABLE 4. Child care and breastfeeding variables as risk factors for upper and lower respiratory tract infections in 288 children less than 2 years of age in Sisimiut, Greenland, 1996–1998*

Risk factor	Days at risk	Upper respiratory tract infection				Lower respiratory tract infection			
		No. of episodes	Relative risk	95% confidence interval	*p* value	No. of episodes	Relative risk	95% confidence interval	*p* value
Child care†					<0.001				<0.001
Home	14,707	136	1			73	1		
Day care	4,557	72	1.27	0.83, 1.94		33	1.49	0.85, 2.61	
Child-care center	13,964	319	1.81	1.37, 2.40		186	3.29	2.14, 5.05	
Child care by age (months)†					0.53‡				0.51‡
0–11									
Home	10,130	86	1.09	0.72, 1.67		57	1.98	0.94, 4.19	
Day care	2,126	36	1.55	0.84, 2.88		17	2.65	1.02, 6.90	
Child-care center	3,091	88	2.27	1.47, 3.49		69	7.47	3.76, 14.9	
12–23									
Home	3,834	50	1			16	1		
Day care	2,431	36	1.08	0.65, 1.80		16	1.59	0.80, 3.16	
Child-care center	11,616	231	1.56	1.11, 2.20		117	2.76	1.52, 5.03	
Breastfeeding†,§					0.31				0.16
Exclusively	2,284	11	1			5	1		
Partly	13,227	218	1.93	0.81, 4.60		119	3.67	1.00, 13.5	
Stopped	16,913	293	1.84	0.77, 4.42		161	4.51	1.15, 17.7	
Never been breastfed	804	5	0.75	0.13, 4.35		7	5.27	0.79, 35.2	
Breastfeeding, children 0–5 months of age only†,¶					0.53				0.06
Exclusively	2,136	8	1			5	1		
Partly	3,248	22	1.34	0.64, 2.82		21	2.56	0.94, 7.00	
Stopped	1,381	12	1.62	0.69, 3.79		14	3.73	1.24, 11.2	

* All variables adjusted for age, gender, calendar period, and interviewer (Greenlandic vs. Danish speaking). *p* value test for homogeneity if not stated otherwise.
† Distribution of child-care and breastfeeding changes with time. Thus, the absolute distribution of children cannot be calculated.
‡ *p* value test for interaction (same type of child care compared among age groups).
§ If tested among children ever breastfed ("never been breastfed" excluded), *p* values for upper respiratory infection = 0.31 and for lower respiratory infection = 0.09.
¶ Children never breastfed (n = 5) included in "stopped" group.

We invited all children in the community to participate, and the rate of participation was 87 percent, higher than in community studies from the United States (19). As episodes of acute respiratory infections often appear and disappear in a few days and are of highly varying severity and duration, the registration of these episodes is liable to recall and selection bias. In addition, the incidence may change from one calendar year to another. To minimize this, we set up an intensive surveillance system based on weekly morbidity visits during a 2-year period in order to register all episodes. In total, 11,081 morbidity visits were paid during the monitoring period. Background information was collected prior to monitoring and validated at the end of the study period. Time-dependent exposures were updated regularly. Furthermore, we adjusted for the possible correlation between episodes from each child, a factor often neglected but warranted in longitudinal studies of repeated outcomes (20).

The risk factors for upper respiratory tract infections were age (higher risk among children aged 6–23 months than among children aged 0–5 months), attending child-care centers, and sharing a bedroom with adults. For lower respiratory tract infections, the risk factors were young age (being 0–5 months of age compared with being older), male gender, attending child-care centers, passive smoking, and sharing a bedroom with other children aged 0–5 years. These findings are important from a public health perspective, as the risk factors except for age and gender are possible targets for intervention.

Attending a child-care center was a strong risk factor for both upper and lower respiratory tract infections and the strongest one for lower respiratory tract infections, confirming findings from other parts of the world (21–26). Studies from Finland and Norway have reported relative risks and odds ratios of 0.95–1.99 for upper respiratory tract infections and of 0.9–6.69 for lower respiratory tract infections among children aged 1–2 and 4–5 years in child-care centers (24, 25) and, among children aged 1.5–17 months from the United States, odds ratios of respiratory illness in general of 1.6 have been reported (26). Although difficult to compare because of the different methodologies, outcome

TABLE 5. Multivariate risk factor analysis, final model, for upper respiratory tract infections in 283 children less than 2 years of age in Sisimiut, Greenland, 1996–1998*

Risk factor	Upper respiratory tract infection			
	Distribution of time at risk (%)	Relative risk	95% confidence interval	*p* value
Age (months)				<0.001
0–5	22.9	0.49	0.30, 0.79	
6–11	25.4	1.45	1.07, 1.96	
12–17	25.3	1.37	1.04, 1.79	
18–23	26.4	1		
Gender				0.79
Girls	55.2	1		
Boys	44.8	1.03	0.80, 1.33	
No. of adults sleeping in the same room as the child				0.004†
0	5.5	1		
1	14.5	2.51	1.21, 5.18	
2	80.0	3.13	1.60, 6.11	
Child care				0.002
Home	43.3	1		
Day care	14.7	1.23	0.80, 1.91	
Child-care center	42.0	1.68	1.25, 2.28	

* All variables adjusted for age, gender, calendar period, and interviewer (Greenlandic vs. Danish speaking). *p* value test for homogeneity if not stated otherwise.

† *p* value test for trend.

measures, and age groups involved, our risk estimates seem to be relatively high.

Passive smoking was a strong risk factor for lower, but not for upper, respiratory tract infections (27). Indeed, our risk estimate of 2.13 for lower respiratory tract infections associated with smokers in the household was high compared with estimates of 1.54–1.71 for lower respiratory tract infections among children aged 0–2 years observed in both community- and hospital-based studies from Western countries (28). An explanation may be that passive smoking in itself does not increase the risk of infection, as manifested by the lack of effect on upper respiratory tract infections, but increases the risk of complications to upper respiratory tract infections, in this case lower respiratory tract infections. The mechanism behind this may be the known inhibitory effects of smoking on ciliary activity and other local protective mechanisms (29). The risk of passive smoking for lower respiratory tract infections was higher, although not significantly (data not shown), among children in home care compared with children in child-care centers and among children aged 0–1 year compared with children aged 1–2 years, most likely because of increased exposure and increased vulnerability, respectively. Tobacco use in Greenland is very high. On a nationwide scale, 77 percent are smokers (30), which is comparable to the number of smoking parents in our study (66 percent of mothers and 68 percent of fathers). With a population-attributable risk of 47.1 percent of episodes of lower respiratory tract infections associated with passive smoking, this represents a major public health intervention area.

Nighttime crowding was a risk factor for both upper and lower respiratory tract infections, but surprisingly the other crowding parameters were not. In contrast, studies from the Board on Science and Technology for International Development (11) found mixed results for nighttime crowding, mostly showing lack of association. An explanation for our findings could be that, with a Western lifestyle, the effects of crowding during daytime are in fact limited in a family with parents working outside the home and children attending child-care centers, while exposure to infectious agents in the family may be most intense when sharing a bedroom with others. Unlike the common notions that houses in Greenland are small and that airtight housing standards have improved considerably in recent years, most children in Sisimiut (76 percent) now live in ventilated apartments or terraced houses built mainly after 1970 according to Western standards. The mean area of a dwelling was 74.7 m^2, and the median number of rooms per household was three (equivalent numbers for Denmark: 98 m^2 and three rooms per household (31)). Thus, with the average house size in Greenland, it may be possible to reduce the number of persons sleeping in the same rooms.

Age was a strong risk factor for both upper and lower respiratory tract infections, with the highest risk found among children aged 6–11 months. The age between 6 and 18 months has indeed been termed the period of vulnerability (11, 32). Possible mechanisms for this increased risk include degradation of maternal antibodies, immaturity of

TABLE 6. Multivariate risk factor analysis, final model, for lower respiratory tract infections in 260 children less than 2 years of age in Sisimiut, Greenland, 1996–1998*

Risk factor	Lower respiratory tract infection			
	Distribution of time at risk (%)	Relative risk	95% confidence interval	*p* value
Age (months)				<0.001
0–5	20.5	3.04	1.64, 5.61	
6–11	24.9	2.82	1.99, 4.00	
12–17	27.0	1.90	1.34, 2.69	
18–23	27.6	1		
Gender				0.01
Girls	55.9	1		
Boys	44.1	1.53	1.10, 2.12	
Ethnicity (parents' place of birth)				0.07
Greenland/Greenland	82.9	1		
Greenland/Denmark (other)	11.7	1.71	1.04, 2.81	
Denmark (other)/Denmark (other)	5.4	0.45	0.09, 2.31	
No. of children aged 0–5 years sleeping in the same room as the child				0.005†
0	76.1	1		
1	21.1	1.47	1.01, 2.14	
2	2.7	1.95	1.19, 3.19	
Smokers in household‡				0.003
No	19.8	1		
Yes	80.2	2.13	1.30, 3.47	
Child care				<0.001
Home	40.1	1		
Day care	13.5	1.31	0.70, 2.44	
Child-care center	46.4	3.28	2.12, 5.06	
Breastfeeding§				0.10
Exclusively	7.2	1		
Partly	39.1	2.98	0.91, 9.71	
Stopped	53.8	3.66	1.06, 12.6	

* All variables adjusted for age, gender, calendar period, and interviewer (Greenlandic vs. Danish speaking). *p* value test for homogeneity if not stated otherwise. An alternative full model was also constructed in which the variable "highest social class of parents" was replaced by "father's social class." The final model remained the same as above, and the *p* values were only marginally changed.

† *p* value test for trend.

‡ With replacement of this variable with 1) "amount of smoking in household in total," 2) "mother's smoking yes/no," or 3) "mother's amount of smoking," all smoking variables remained significant. With replacement of this variable with "number of smokers in household," the variable turned insignificant ($p = 0.15$). For "mother's smoking yes/no," the model remained the same as above with *p* values changed only marginally, while for "number of smokers in household" and "amount of smoking in household," breastfeeding could be excluded from the model ($p = 0.14$ and 0.15, respectively) and, for "mother's amount of smoking," both breastfeeding and ethnicity could be excluded (at *p* values = 0.12 and 0.12, respectively).

§ The group, "never been breastfed," was included in the "stopped" group.

the adaptive immune system, cessation of breastfeeding, and start at child-care centers. The finding of the inverse relative risk of upper and lower respiratory tract infections for children aged 0–5 months in the multivariate analyses has been observed previously (11). Thus, the risk of transmission of infectious agents may be smaller in the youngest age group, as seen by the lower risk of upper respiratory tract infections, but when infected, this youngest age group experiences severity that is worse in terms of a higher rate of lower respiratory tract infections.

The risk of lower respiratory tract infections was increased for boys compared with girls, but not for upper respiratory tract infections. A similar pattern has been observed in some studies (11, 20), although a reverse pattern may be seen in older children (33). In previous studies from Greenland, no gender difference has been observed with respect to otitis media (34, 35) or common illness including common cold and earache (36).

For the risk of lower respiratory tract infections, we found a protective (but insignificant because of low power) effect of being exclusively breastfed compared with being partly breastfed or having stopped. The effect was strongest among children aged 0–5 months, corresponding to the age interval of the majority of breastfed children. A similar protective effect has been observed in previous studies from the Arctic and other parts of the world (37–41), although inconsistently (42). Indeed, the relative risk of 0.27 for lower respiratory tract infections among children aged 0–5 months exclusively breastfed compared with nonbreastfed children was much lower than the relative risk of 0.79 (95 percent CI: 0.67, 0.94) observed among fully breastfed children from New Mexico (38). As the official Greenlandic maternal leave is 4 months (in contrast to 6 months in Denmark), it may not at present be possible for many mothers to breastfeed for more than that period. A longer maternal leave might reduce the risk of lower respiratory tract infections, not only because of better breastfeeding conditions but also because of delaying the time of entry into child-care centers.

Danish children had a lower relative risk for upper and lower respiratory tract infections compared with Greenlandic children, but surprisingly children of mixed descent had the highest risk of lower respiratory tract infections. Although ethnicity may be defined in terms of both biology and culture, we used the biologic parents' place of birth as a proxy variable for biologic ethnicity, a measure often used in Greenland (35, 43). It is difficult to separate biologic effects from those of different living patterns, but there are marked social differences between Greenlandic and Danish families, with Danish families belonging to higher social classes and having better housing conditions than Greenlanders, indicating that the differences in relative risk of acute respiratory infections reflect social factors not accounted for in the multivariate analyses.

In contrast to previous findings, none of the usual socioeconomic factors was a significant risk factor (34, 44, 45). No validated social classification system for Greenland exists, but as Greenland has undergone tremendous changes in living conditions in recent years and as a social structure much like that in Denmark has been implemented, we chose to use that of Denmark. It may not, however, reflect the social factors in Greenland adequately. In addition, the variation in social class and educational level in this population was limited, obscuring the possible effects of socioeconomic factors.

As opposed to the putative effects of primary preventive measures toward acute respiratory infections, the effect of secondary preventive measures in this population would probably be limited. Each Greenlandic town has a hospital, and the iatrogenic threshold is low in Greenland. In our study, 32 percent of the episodes of lower respiratory tract infections and 56 percent of the episodes of upper respiratory tract infections resulted in hospital visits (1), being of the same magnitude as those in the United States (16). Only 1 percent of the episodes of upper and lower respiratory tract infections resulted in hospital admittance, while in the remaining 39 percent of episodes the children were treated at the outpatient clinic. This indicates that parents are sufficiently aware of the physical signs of lower respiratory tract infections in particular to seek medical attention when necessary.

In conclusion, age and crowding measured in terms of nighttime crowding, as well as attending child-care centers, were risk factors for both upper and lower respiratory tract infections. For lower respiratory tract infections, smoking and gender had additional significant effects, while ethnicity and lack of breastfeeding were likely risk factors for lower respiratory tract infections. These findings have major public health implications. Although the burden of acute respiratory infections in Greenlandic children has for many years been high, Greenland today is a modern society. The risk factors for acute respiratory infections are related to child care, passive smoking, and in-house crowding in nuclear families rather than to poverty and a traditional way of life. Although the use of child-care centers is probably increasing in Greenland, a number of measures may reduce their effects on children's health, including the age composition of the children in attendance, the space per child, hygienic measures, and the age at admittance. However, these factors were not evaluated in the present study and should be addressed separately. With 80 percent of the children being passive smokers, smoking in the household should be strongly discouraged. Finally, the number of persons sleeping in the same room should, whenever possible, be reduced, and especially by children less than 5 years of age. Taken together, these measures may reduce the burden of illness in the youngest group of children.

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