ABSTRACT

Objectives. Inuit infants experience higher mortality and poorer health than other Canadian infants, and suffer disproportionately from bacterial and viral infections. A wide range of inter-related factors affect their health and susceptibility to infection. The objective of the study was to describe hospitalization and morbidity patterns in a cohort of 46 healthy Inuit infants from Iqaluit, Nunavut, over their first year of life.

Study design. Risk factors for hospitalization and infections were assessed using multiple linear regression.

Results. Infants experienced an average of four respiratory tract infections (RTIs) annually, which accounted for half of the hospitalizations in the cohort. Some interesting trends were evident from the assessment of risk factors using multiple linear regression. Adoption was associated with adverse health effects in addition to those that would be expected due to lack of breast-feeding alone; among infants who were not breast-fed, adopted infants had three more RTIs per year than non-adopted infants.

Conclusion. The results of this pilot study provide support for undertaking larger epidemiological studies in order to clarify the role of these risk factors, so that future preventive efforts can be informed and effective. (Int J Circumpolar Health 2004; 63: 61-70)

Keywords: Canada; Epidemiology; Infant; Infection; Inuit; Risk Factors
INTRODUCTION

Historically, Inuit infants have had much higher rates of morbidity and mortality compared to other infants in Canada, and have suffered disproportionately from infections (1-10). Today, lower respiratory tract infections (LRTIs) and otitis media (OM) are still major health concerns for Inuit infants (5,6,11). The reasons for the high incidence of infection have not been investigated systematically but have been attributed generally to socio-economic factors, harsh environment and crowded living conditions (3,10,12-15).

This prospective study describes hospitalization and morbidity patterns and examines associated risk factors in a birth cohort of healthy Inuit infants from Iqaluit, Nunavut, over their first year of life.

METHODS

A birth cohort of Inuit infants was enrolled over a 22-month period, from September 1995 to October 1997. Each infant was followed for one year. Healthy infants between one and three months of age who resided in the study area, were of at least 50 % Inuit ancestry, and were not born prematurely, were eligible for recruitment. Of 196 infants born at Baffin Regional Hospital in Iqaluit, Nunavut during this period, 100 were eligible, of which 52 were enrolled in the study; the care-givers of 37 declined to participate and 11 could not be contacted. Of the 96 infants who were not eligible, 53 were non-Inuit, 13 were less than 50% Inuit ancestry, 20 had moved from Iqaluit and 10 were premature.

The infants were identified from the Iqaluit Birth Register, or Baffin Regional Hospital records and their primary care-givers were contacted by an Inuit research assistant. Infants were enrolled by the study investigator (KNC) after review of their medical histories and after informed consent forms were signed by their primary care-givers.

Data were collected using a series of specifically-designed questionnaires administered at enrolment by a trained health worker, with the assistance of an Inuit interpreter if necessary. Information was collected from the primary care-giver on general demographics (ethnicity of mother and father), household demographics (number of rooms in the house, number of people living in the household, number of smokers in the household, education and employment of mother and father), prenatal histo-
ry (history of maternal infection, maternal use of drugs, alcohol and cigarettes), perinatal history (APGAR score, birth-weight, length, head circumference), the infant’s past medical history (medical illnesses and hospitalizations from birth to enrolment) and nutritional history (breast-fed, or not, at enrolment). Complete physical evaluations were also performed at enrolment.

The infants were followed up at three-month intervals for one year, by questionnaire and physical examination as per the first visit. Monthly phone calls to the primary care-giver were made by the Inuit research assistant to obtain interim infant health information, including date and type of medical illnesses, clinic visits and hospitalizations. Data were verified by examining medical records. The number of infections for each infant during the first year of life was determined from the medical records and episodes were grouped in the following categories: 1) LRTI, with or without OM, with or without upper respiratory tract infection (URTI); 2) OM without LRTI, with or without URTI; 3) URTI without LRTI and without OM; 4) total RTIs (sum of categories 1, 2 and 3); 5) total gastro-intestinal (GI) infections; 6) total "other" infections (skin, mouth, eye and urinary tract infections); and 7) total infections (sum of categories 4, 5 and 6). If there was more than one infection in a given category in any seven-day period, only one infection was counted. If there was more than one category of RTI in any seven-day period, only the more severe infection was counted.

The outcomes considered were: 1) annualized number of hospitalizations for infections; 2) annualized total number of days hospitalized due to infections; and 3) annualized number of LRTI, OM, URTI, total RTI, GI, "other" and total infections; all determined from birth to end of follow-up. Annualized rates were used rather than counts, because there were slight variations in the length of follow-up of study infants. Independent variables included the season at birth, sex, maternal education, maternal smoking during pregnancy, household smoking (smokers per household), household crowding (persons per room) at enrolment, breast-feeding (any/none) at enrolment, and adoption status. Birth-weight was not considered as an independent variable, since premature infants were excluded from this study. Outcome data were complete for the infants who completed the study, as were data on independent variables, except that two mothers did not report their smoking status during pregnancy.

Ethics approval for this study was obtained through the ethics committee and institutional review board of the Montreal Children’s Hospital and the Baffin Regional Inuit Health Board.
Means, standard deviations, medians and ranges for continuous variables, and proportions for categorical variables, were calculated. Relationships between independent variables and outcomes were investigated by standard linear regression. Independent variables were included in multiple linear regression models if 1) there was a priori evidence that they could be independent predictors of the outcome, or 2) if correlations, or results of simple linear regressions suggested, that the given variable was a predictor, or a confounder. 95% confidence intervals were reported for all regression parameters. SAS® software (version 8) was used for statistical analyses (SAS Institute Inc., Cary, NC, USA).

RESULTS

Forty six of 52 Inuit infants from Iqaluit, Nunavut who were enrolled in the study completed the one year follow-up, with a mean age at enrolment of 61.9 ± 31.2 days. Of these infants, 16 were female (35%), one-quarter were adopted, and 54% were breast-fed at the time of enrolment into the study. Tobacco exposure was extremely high in the study population: 85% of infants were exposed to tobacco smoke in utero and 94% were exposed to second-hand smoke in the home.

Hospitalization and morbidity patterns for the 46 infants who completed follow-up are summarized in Table I. There were 51 hospitalizations, for all causes, involving 18 infants; three-quarters of these hospitalizations (39 of 51) were for infection, 64% of which were RTIs (25 of 39). Thirty-sevent percent of the infants in the study (17 of 46)

Table I: Hospitalization and morbidity patterns for Inuit infants from Iqaluit, Nunavut. 46 infants completed follow-up for one year. LRTI, lower respiratory tract infection; OM, otitis media; URTI, upper respiratory tract infection; GI, gastro-intestinal.

| OUTCOMES                     | Mean (SD) | Median | Min   | Max  |
|------------------------------|-----------|--------|-------|------|
| Length of follow-up (days)   | 451.50 (39.00) | 457.00 | 357.00 | 524.00 |
| Hospitalization rate*        | 0.66 (1.08) | 0      | 0     | 5.13 |
| Days hospitalized per year   | 4.10 (12.88) | 0.72  | 0     | 83.55 |
| LRTI rate                    | 1.13 (1.68) | 0.91  | 0     | 6.39 |
| OM rate                      | 1.58 (1.61) | 1.48  | 0     | 5.18 |
| URTI rate                    | 1.73 (1.33) | 1.48  | 0     | 5.18 |
| Total RTI rate               | 4.49 (2.58) | 4.09  | 0     | 13.19 |
| GI infection rate            | 0.68 (0.81) | 0.72  | 0     | 2.83 |
| "Other" infection rate       | 1.82 (1.33) | 1.63  | 0     | 5.82 |
| Total infection rate         | 6.87 (3.22) | 7.12  | 1.57  | 16.86 |

* Overall rates are expressed per year
were hospitalized for infection at least once in their first year of life, spending a median of 6.0 days in hospital (range 1.0–114.0) over their total follow-up period. The infants experienced a median of 7.1 total infections per year (range 1.6–16.9), of which 4.1 (range 0–13.2) were RTIs. Fifty-two percent of infants (24 of 46) experienced at least one LRTI annually, and 42% of these (10 of 24) had more than two episodes per year. One-fifth of the study infants (9 of 46) experienced three, or more, OM episodes per year and over half suffered a GI infection during the course of the study, with 10% of infants (5 of 46) having more than two episodes.

Risk factor-outcome relationships in this study were examined by multiple linear regression, but these results were generally inconclusive due to the small sample size of the study. Infants who were breast-fed at enrolment had, on average, 0.33 (95% CI: -1.0 to 0.3) fewer hospitalizations, 1.0 (95% CI: -2.5 to 0.5) fewer RTIs, 0.7 (95% CI: -1.7 to 0.3) fewer LRTIs, 0.7 (95% CI: -1.6 to 0.3) fewer episodes of OM, and spent 4.2 (95% CI: -11.9 to 3.5) fewer days in hospital annually, compared to infants who were not breast-fed. Adopted infants experienced, on average, 0.4 (95% CI: -0.3 to 1.1) more hospitalizations, 2.4 (95% CI: 0.8 to 4.0) more RTIs, 1.4 (95% CI: 0.3 to 2.4) more LRTIs, 1.1 (95% CI: 0.05 to 2.1) more episodes of OM, and spent 7.9 (95% CI: -0.6 to 16.4) more days in hospital annually than non-adopted infants.

There was a strong, inverse relationship between breast-feeding and adoption; none of the 12 adopted infants who participated were breast-fed. In multiple linear regression analyses, controlling for breast-feeding had little effect on the magnitude of the relationships between adoption and hospitalization and RTI rates; regression coefficients for adoption remained essentially unchanged, with 95% confidence intervals widened only slightly in models containing the breast-feeding variable (Table II). Stratifying by breast-feeding gave similar results; among the 20 infants who were not breast-fed, those who were adopted still had, on average, 2.8 (95% CI: 0.5, to 5.1) more RTIs per year than non-adopted infants. Controlling for adoption, however, reduced the magnitude of the regression coefficient for breast-feeding (Table II). Although it was impossible to separate the effects of these two variables in this study, it appeared that adoption exerted additional effects on infection rates that could not be accounted for by lack of breast-feeding alone.
**Table II:** Investigation of effects of adoption and breast-feeding on RTI rates and hospitalization outcomes. RTI, respiratory tract infection; LRTI, lower respiratory tract infection; OM, otitis media; URTI, upper respiratory tract infection. Rates are expressed per year.

| Outcome                      | Independent variable | Simple linear regression coefficient (95% CI) | Multiple linear regression coefficient (95% CI) | Variables in model |
|------------------------------|----------------------|-----------------------------------------------|-----------------------------------------------|-------------------|
| Hospitalization rate         | adoption             | 0.39 (-0.34 to 1.12)                          | 0.26 (-0.71 to 1.22)                          | adoption          |
|                              | breast-feeding      | -0.33 (-0.97 to 0.32)                         | -0.18 (-1.03 to 0.67)                         | breast-feeding    |
| Days hospitalized            | adoption             | 7.91 (-0.57 to 16.39)                         | 8.30 (-2.97 to 19.57)                         | adoption          |
|                              | breast-feeding      | -4.21 (-11.87 to 3.45)                        | 0.53 (-9.40 to 10.47)                         | breast-feeding    |
| LRTI rate                    | adoption             | 1.36 (0.29 to 2.44)                           | 1.44 (0.02 to 2.87)                           | adoption          |
|                              | breast-feeding      | -0.72 (-1.71 to 0.27)                         | 0.11 (-1.15 to 1.37)                         | breast-feeding    |
| OM rate                      | adoption             | 1.10 (0.05 to 2.14)                           | 1.05 (-0.34 to 2.45)                         | adoption          |
|                              | breast-feeding      | -0.66 (-1.61 to 0.29)                         | -0.06 (-1.28 to 1.17)                        | breast-feeding    |
| Total RTI rate               | adoption             | 2.37 (0.76 to 3.98)                           | 2.69 (0.62 to 4.76)                          | sex               |
|                              | breast-feeding      | -1.01 (-2.53 to 0.51)                         | 0.69 (-1.14 to 2.51)                         | adoption          |

Table III: Hospitalization and social factors in Inuit infants. Particular attention should be paid to the 95% confidence intervals of the regression coefficients for the various risk factors: many included both zero and potentially interesting effects. Rates are expressed per year.

| Outcome                      | Independent variable | Simple linear regression coefficient (95% CI) |
|------------------------------|----------------------|-----------------------------------------------|
| Hospitalization rate         | season of birth      | -0.6 (-1.3 to -0.03)                          |
|                              | (winter; Nov-Apr)    |                                               |
|                              | maternal education   | -0.6 (-1.3 to 0.04)                          |
|                              | (≥ grade 8)          |                                               |
|                              | household crowding   | 0.5 (-0.6 to 1.6)                            |
|                              | (per unit increase)  |                                               |
| Days hospitalized            | season of birth      | -4.9 (-12.5 to 2.7)                          |
|                              | (winter; Nov-Apr)    |                                               |
|                              | maternal education   | -7.0 (-14.8 to 0.7)                          |
|                              | (≥ grade 8)          |                                               |
|                              | household crowding   | 5.2 (-7.5 to 17.9)                           |
|                              | (per unit increase)  |                                               |
| Total RTI rate               | sex (F)              | -1.6 (-3.2 to -0.05)                         |
| URTI rate                    | sex (F)              | -1.0 (-1.8 to -0.2)                          |
| "Other" infection rate       | sex (F)              | 1.3 (0.5 to 2.0)                             |
|                              | season of birth      | -0.9 (-1.6 to -0.1)                          |
|                              | (winter; Nov-Apr)    |                                               |
Some interesting trends were observed that might warrant exploration in a larger study (Table III). Analyses of tobacco as a risk factor for morbidity were hampered by the lack of variability in the exposures: 85% of mothers in the study reported smoking during pregnancy and 94% of infants were exposed to tobacco smoke in the household.

DISCUSSION

While the summary statistics presented here are similar to those observed in other studies and surveys (5,7,11,16), the Inuit population is not homogeneous; their health status and needs can vary greatly from community to community. It should also be noted that our results are based on a relatively small sample size and that this might introduce some selection bias. Nonetheless, the data presented in this pilot study provide key evidence on selected risk factors which will inform current health promotion activities and future epidemiological studies conducted in this population.

The mean number of members per household was 5.7 ± 2.4 in this study, compared to 3.9 in Nunavut (5) and 2.6 nationally (17). The breast-feeding rate reported here (54%) corroborates that observed in a 1989 cohort study of Inuit infants in Nunavik (57%) (11), and the adoption rate seen in the present study (25%) is comparable to that reported recently in Nunavik (7). The strong, inverse relationship between breast-feeding and adoption in the present study has been observed previously (16).

The high rates of hospitalization and the morbidity patterns in this study demonstrate that RTIs continue to be a major health problem for Inuit infants. A 1997/1998 prospective case study in Iqaluit, Nunavut, reported an annualized incidence rate of hospital admission for LRTI of 484 per 1000 infants (5). A 1989 study in Nunavik, designed to assess the impact of environmental contaminants on infant health, found that OM was still the most frequent health problem among Inuit infants, with 40% of infants (47 of 118) having three, or more, episodes of OM in the first year of life (11).

Relationships between risk factors and outcomes in this study were examined by multiple linear regression, but the results should be interpreted with caution, given the relatively small sample size. With few exceptions, regression results were inconclusive, since the 95% confidence intervals of the regression coefficients for the various risk factors included both zero and potentially interesting effects. Further evidence needs to be collected, in a larger study, to better estimate the magnitude of these potential ef-
fects and determine their clinical importance. However, given the heterogeneous nature of northern populations and the relatively small size of individual communities, large sample sizes can be difficult to achieve. In the current study, over half of the eligible birth cohort of Iqaluit was enrolled over a two-year period. Additional study limitations included potential selection bias due to loss to follow-up and voluntary enrolment. Although the reasons for the withdrawal of six of the infants from the study are unknown, the latter experienced higher annualized rates of hospitalization than infants who completed follow-up. Since their withdrawal from the study appears to be related to outcome, the exclusion of these infants from the analysis, while necessary, was likely to introduce selection bias. The refusal of care-givers to enroll infants who met the eligibility criteria may have introduced an additional selection bias, if refusal was related to the various outcomes. It is difficult to predict the effect of these potential biases on the study results. Future studies would benefit from greater community involvement in design and implementation. In addition, preliminary qualitative research could be conducted with potential participants, health workers and local leaders to shed light on how to overcome barriers to voluntary enrolment. These approaches could lead to a better response rate to achieve a larger sample size and a more representative sample population.

Breast-feeding effects were inconclusive, but protective trends could be noted for hospitalization outcomes, LRTI, OM and GI infection rates. Complex inter-relationships among risk factors, both measured and unmeasured, could have diminished the association between breast-feeding and outcomes. Notably, there appeared to be additional effects of adoption on RTI rates and days hospitalized that could not be accounted for by the lack of breast-feeding. Although very preliminary, these findings warrant further research to determine whether increased health support should be targeted to adoptive families. That adopted children stayed longer in hospital could, for example, be due to differences in living and caregiving arrangements.

The extremely high rate of maternal smoking during pregnancy that was reported in this study (85%) was evident in another recent study in the same region (5) and in prevalence estimates from Nunavik and Nunavut (75% and 73% respectively) (7) (Roberts, A., Medical Officer of Health, Nunavut, personal communication). Given that 94% of infants in this study were exposed to tobacco smoke in the household, culturally appropriate health education programs should be developed by Inuit communities to reduce the known risk of tobacco to their health. In particular, there is
strong epidemiological evidence for an increased risk of respiratory infections in infants exposed to tobacco smoke (18,19).

Risk factors for RTIs have been examined previously in Canadian Inuit populations. Breast-feeding was associated with lower hospitalization rates for LRTI in the first eight years of life (2), lower rates of pulmonary infection in the first year of life (11), and a decreased prevalence of OM (20,21). Other studies failed to show a relationship between OM and breast-feeding (11,22), and results concerning the association between household crowding and OM have been contradictory (22-25). Exposure to environmental organo-chlorines through breast-feeding may also be associated with an increased risk of OM in the Inuit (11), although further study is required to clarify the nature and strength of this relationship, given the benefits of breast-feeding in general.

This study demonstrates that RTIs remain an important source of morbidity in Canadian Inuit infants and underscores the need for larger epidemiological studies that have sufficient statistical power to account for the complex inter-relationships among risk factors. Future studies that are not only well-designed, but also driven and managed locally, should help to clarify the role of risk factors, such as adoption and tobacco smoking exposure, among others, on infection rates in Inuit infants.

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