

AN OVERVIEW OF FACTORS INFLUENCING THE HEALTH OF CANADIAN INUIT INFANTS

ABSTRACT

Background. Inuit infants throughout the Arctic experience higher mortality and poorer health than their non-Inuit counterparts, and suffer disproportionately from bacterial and viral infections.

Study design. This review examines the health status of these infants, with a focus on Canadian Inuit communities and reference to other circumpolar regions, as appropriate. It is based on a Medline search (1965 to present), special analyses of the 1996 Canadian Census and various national surveys, and selected government reports and documents.

Results. A wide range of inter-related factors affect the health of Inuit infants: their demographic, social, economic and physical environment, as well as personal health practices and the availability of high quality, culturally appropriate health services. Some of these factors may influence the susceptibility of Inuit infants to infection. Smoking is highly prevalent in Inuit communities, and its indisputable negative effects on health, including increased risk of respiratory tract infection in infants, represent an urgent public health challenge.

Conclusion. Locally driven, focused and methodologically sound epidemiological research that addresses key gaps in knowledge could lead to more appropriate and effective preventive strategies to improve health in northern communities.

Keywords: Arctic regions, Canada, Infant, Infection, Inuit, Risk factors

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INTRODUCTION

The Inuit in northern Canada are part of a larger circumpolar Inuit population that includes Alaska, Greenland and Russia. There are four Inuit regions in Canada (Figure 1). Approximately 41,000 people identified themselves as Inuit in the 1996 Canadian Census (1). The vast majority (94%) resides outside of Canada's 25 Census metropolitan areas and about 60% live in the Northwest Territories (NWT), Nunavut and Nunavik, the northern part of the province of Quebec.

While the gender distribution of the Inuit population is similar to that of the general Canadian population, the Inuit population is considerably younger: in 1996, 15% of the Inuit population was under the age of five, compared to 7% of the total population; only 3% of the Inuit population was aged 65 and over, compared to 12% of the



Figure 1: Inuit Settlement Areas in Canada.

The four Inuit regions in Canada are Inuvialuit, Nunavut, Nunavik and Nunatsiavut. Inuvialuit is found in northern Northwest Territories (NWT). In 1993, the new territory of Nunavut was created through federal law, and split from the NWT on April 1, 1999. Nunavut is comprised of three regions: the Qikiqtaaluk (or Baffin) region in eastern and northern Nunavut, the Kivalliq (or Keewatin) region in the southern and central portions of Nunavut near Hudson Bay, and the Kitikmeot region in central and western Nunavut. Nunavik is located in northern Quebec, and Nunatsiavut in northern Labrador.

total population (2). The Inuit population is also growing more rapidly: its fertility rate is more than twice that of the general Canadian population (3). There are few reliable statistics on adoption rates, but those in Nunavik (1994/1995) indicate that, of Inuit aged 15 to 24, 30% were adopted, while of those aged 25 and older, about 15% were adopted (4).

In Canada, all citizens and permanent residents are entitled to medical care with universal coverage. There are a variety of additional services provided free of charge to the Inuit population, including prescription medications, eye glasses and other medical devices, dental care, individual mental counseling and transportation to access medical services (5). In practice, however, some of these additional health services are not available in remote communities, where the majority of Inuit live, and where there can be great distances to the nearest hospital, or tertiary care centre. Most remote Inuit communities have nursing stations staffed by a nurse or community health representative, with physicians and other specialists flying in periodically. A recurring problem in the provision of culturally appropriate health services in the north is the issue of medical transfers, where aboriginal patients are transferred to southern Canada for more advanced medical care.

Despite important improvements in health outcomes over the last 30 years in Inuit communities, such as life expectancy, maternal and infant mortality and morbidity, disparities between their health status and that of other Canadians remain. In 1996, life expectancy at birth for Canada as a whole was 78.4 years (75.4 for men and 81.2 for women), compared to 64.8 years in Nunavik (60.7 for men and 70.0 for women), where 90% of the population is Inuit (4), and 70.1 years in Nunavut (68.3 for men and 71.3 for women), where 75% of the population is Inuit (6-7). Among other factors, high infant mortality contributes to this shorter life expectancy: infant mortality rates in Nunavik and Nunavut are over three times higher than the overall Canadian rate (8).

Bacterial and viral infections account for much of the excess morbidity and mortality in Inuit infants compared to other Canadian infants, despite significant advances in living standards and health care delivery (4, 9-16). This paper first examines the health status of Canadian Inuit infants, by reviewing relevant data from Canada and other regions of the circumpolar north, where appropriate. Then,

the various demographic, social, economic, physical, behavioural and cultural factors that affect their health are outlined. Finally, the potential influence of such factors on the susceptibility of Inuit infants to infection is discussed.

Relevant scientific literature was identified using Medline (1965 to present) supplemented by manual searches of pertinent journals and contact with experts. In addition to peer-reviewed publications, the following data sources were used: 1) The 1996 Census of Canada, which suffered from under-coverage of aboriginal populations, owing to incomplete enumeration (1) and other factors related to the possible under-reporting of aboriginal status and the increased mobility of aboriginal populations (17); 2) the National Public Health Survey; and 3) the National Longitudinal Survey of Children and Youth. The two latter surveys have been conducted by Statistics Canada every two years, starting in 1994, and the sampling frame for both excluded on-reserve First Nations people and Inuit in the provinces, but included aboriginal peoples in Yukon, NWT and Nunavut; 4) the First Nations and Inuit Regional Health Survey (1995/1996), developed to provide comparable data on aboriginal communities outside of the Territories. Data were collected from 183 First Nations communities across the country and five Inuit communities in Labrador (18-19); 5) a report from the Nunavik Regional Board of Health and Social Services entitled "Health and what affects it in Nunavik: how is the situation changing?" (4), based largely upon the 1992 Quebec Health Survey, which reached 22% of the Inuit population of Nunavik (20) and 6) the Statistics Canada, Indian and Northern Affairs Canada, and Health Canada internet sites (www.statcan.ca, www.ainc-inac.gc.ca and www.hc-sc.gc.ca) and government-housed published reports (3, 21-25).

I. HEALTH STATUS

Infant mortality

Higher rates of infant mortality persist in Inuit communities compared to the general Canadian population. In 1996, the infant mortality rate was 20.9 and 17.9 deaths per 1000 live births in Nunavik and Nunavut, respectively, compared to the national rate of 5.8 deaths per 1000 live births (8). In Nunavik, deaths due to congenital causes, infection and

sudden infant death syndrome (SIDS) each accounted for approximately one third of total infant deaths (4). The post-neonatal death rate was 16 per 1000 live births (1990 to 1994): eight times the national average (4). Over one half of post-neonatal deaths were attributed to SIDS, a rate 20 times that observed for the rest of Quebec (4).

Birth weight

Although fetal growth and birth weight are important determinants of infant health, there are no standardized data available for Inuit infants. The rate of low birth weight in Inuit communities, using norms based on non-aboriginal infants (i.e. < 2500g, as per the World Health Organization), appears to be similar to that for the rest of Canada; (7.4% in Nunavut and 6 % in Nunavik, compared to the national average of 5.8% in 1996 (26)). However, the rate of prematurity was found to be higher in Nunavik (8.4% in 1991 to 1993) than in Quebec (6.8%) for the same time period (4).

In the 1980's, the incidence of infection in Canadian Inuit infants was extremely high relative to other diseases, and accounted for up to 80% of outpatient illness visits (15). Pneumonia/bronchiolitis, gastro-enteritis and bacterial meningitis have been the most common infectious causes of early childhood morbidity and mortality in the Inuit throughout the Arctic (4, 9-10, 13, 15-16, 27). The reasons for the high incidence of infection are unknown, but have been generally attributed to socio-economic factors, poor access to health care, harsh environment and crowded living conditions (12, 14, 28-31). Exposure to environmental contaminants and tobacco smoke have also been proposed as risk factors(10, 32). A summary of published epidemiological studies on the health of Canadian Inuit infants is presented in Table I.

INFECTIOUS DISEASES

Lower respiratory tract infections

Lower respiratory tract infections (LRTIs) remain a major health concern for Inuit infants. A retrospective chart review, conducted recently in the Baffin region, yielded a rate of 306 hospital admissions for bronchiolitis per 1000 infants during the first year of life and identified respiratory syncytial virus as a pathogen in a signifi-

REVIEW

Table I. Epidemiological Studies on the Health Status of Canadian Inuit Infants.

First Author	Year	Location	Study Population	Description
Banerji (10)	Oct 1997- June 1998	Iqaluit, Nunavut	42 Inuit infants (under six months) admitted to Baffin Regional Hospital for LRTI*	Prospective case study of LRTI in Inuit infants
Banerji (9)	Mar 1995- Feb 1996	Iqaluit, Nunavut	78 Inuit children (birth to 48 months) admitted to Baffin Regional Hospital for bronchiolitis	Retrospective chart review of bronchiolitis in Inuit infants
Dewailly (32)	July 1989- Sept 1990	Puvirnituq and Kuujuaq, Nunavik	171 Inuit infants (birth to one year) born in one of Nunavik's two community hospitals	Prospective cohort study examining the association of organochlorine exposure and the susceptibility to infections
Willows (82)	July 1989- Sept 1990	Nunavik	Inuit infants from the Dewailly et al. study (32)	Anemia and iron status in Inuit infants
Hodgins (78)	July 1989- Sept 1990	Nunavik	Inuit infants from the Dewailly et al. study (32)	Iron status in pregnancy and infancy
Godel (83)	1988-1991	Ten communities in western NWT	135 mother-infant pairs, 53 of which were Inuit, who presented for prenatal care in their community and gave birth in Inuvik	Perinatal vitamin A status in mothers and infants
Godel (81)	Not stated likely 1988- 1991	Ten communities in western NWT	171 mother-infant pairs, 37 of which were Inuit	Iron status in pregnancy and infancy
Godel (115)	Sept 1987- Jan 1990	Ten communities in western NWT	162 women, 56 of whom were Inuit, who presented for prenatal care in their community and gave birth in Inuvik	Effect of maternal smoking and alcohol and caffeine intake on fetal growth
Hammond(54)	Apr 1981- Mar 1984	Manitoba and Keewatin, NWT	90 children (under 5 years) with <i>H. influenzae</i> meningitis, 9 of whom were Inuit	Community-based surveillance study for <i>H. influenzae</i> meningitis
Carson (27)	1982	Keewatin and Baffin districts of NWT	260 Inuit children (birth to eight years)	Retrospective survey of Inuit children from 1973-1974 PIMM** cohort (116), examining LRTI
Postl (15)	Jan-July 1982	Keewatin and Baffin districts of NWT	584 children (birth to eight years), 353 of whom were Inuit	Retrospective survey of Inuit children from 1973-1974 PIMM cohort (116), examining health care utilization, morbidity and mortality
Gurwith (52)	1976- 1979	Winnipeg, Berens River and Eskimo Point, Manitoba	144 families, at least 15 of which were Inuit	Longitudinal study of diarrhea among infants and small children in three northern
Timmermans (48)	1977	Nain, Labrador	238 Inuit and 47 Caucasian children (birth to 15 years)	Prevalence of OM***, history of breast feeding
Spady (116)	Apr 1973- Mar 1974	NWT	All infants (1191) born over calendar year, 449 of whom were Inuit	PIMM study
Wotton (57)	Oct 1972- Feb 1977	Northern Manitoba, Keewatin and Baffin districts of NWT	36 cases of bacterial meningitis (two months to 20 years), 30 of which were Inuit, in the catchment area of the Churchill Health Centre	Prospective surveillance study examining incidence of bacterial meningitis
Schaefer (46)	1965- 1966	Five areas of the Canadian Arctic	536 Inuit of all ages	Survey of infant feeding habits and the incidence of chronic OM

* LRTI, lower respiratory tract infection. ** PIMM, Perinatal and Infant Morbidity and Mortality. *** OM, otitis media.

cant proportion of admissions (9). A prospective study in the same region found an annualized incidence rate of hospital admission for LRTI of 484 per 1000 infants (10), based on 51 hospital admissions of 42 infants less than six months of age over an eight-month period. Similarly, in Nunavik, one baby is hospitalized for bronchitis and pneumonia in the first year of life for every three born (4). Parallel trends have been observed in Alaska: a retrospective analysis of hospital discharge records has shown that the bronchiolitis-associated hospitalization rates for Alaskan native infants less than one year old are more than two times greater than the rates estimated for all US infants (33). A prospective study of infants in southwestern Alaska, conducted from 1993 to 1996, showed that respiratory syncytial virus infection was the single most frequent cause of infant hospitalization, with hospital admission rates ranging from 53 to 249 per 1000 infants (34).

Risk factors for LRTI have been examined in studies in Inuit populations. A 1989 study in Nunavik found that entirely breast-fed Inuit infants contracted fewer pulmonary infections in the first year of life than bottle-fed infants (mean 1.2 (95% CI: 0.9, 1.6) versus 2.0 (95% CI: 1.3, 2.6)) (32). Additional risk factors that have been proposed include household crowding (35), defects in cell-mediated immunity (36-38), adoption (10) and exposure to tobacco smoke (10).

Otitis media

A recent literature review concluded that aboriginal peoples from diverse geographic regions (Canada, the United States, Greenland and Australia) were at highest risk of developing chronic suppurative otitis media (OM)(39). Studies in Canadian Inuit infants and children reported a prevalence of OM of between 7 and 31%, compared to less than 1% in the United States, the United Kingdom, Denmark and Finland (39). OM is endemic in the Inuit populations across the Arctic (40-48) and a 1989 study, designed to assess the impact of environmental contaminants on infant health, found that OM was still the most frequent health problem among Inuit infants in Nunavik (32). Of 118 of the 213 infants in the cohort for whom follow-up was complete, 40% had three or more episodes of OM during the first year of life. Repeated infections can result in perforation, scarring and permanent hearing loss (4). Indeed, one quarter of children in

Nunavik have significant hearing loss in at least one ear by the age of five (4).

Risk factors for OM have been examined in Inuit populations. Although previous studies found a decrease in the prevalence of OM with increasing age at which bottlefeeding was commenced (46, 48), more recent studies have failed to show a relationship between OM and breast feeding in the Inuit (32, 49). Moreover, results from studies of the association between household crowding and OM, conducted in the Arctic region, have been contradictory (44, 49-51). Exposure to environmental organochlorines through breast feeding may also be associated with an increased risk of OM in the Inuit (32), although further studies are required to clarify the nature and strength of this relationship, given the benefits of breast feeding in general.

Gastrointestinal illness

Epidemiologic data on the incidence of gastrointestinal illnesses in Inuit infants are surprisingly scarce. A small longitudinal study of infectious diarrhea in northern Canada, conducted in the late 1970's, found that the rate of infection due to rotavirus in neonates was significantly higher in remote Inuit settlements than in a major urban centre (1.07 versus 0.36 episodes per child per year); re-infections also occurred more frequently during the first six months of life in Inuit infants (52). Risk factors hypothesized to play a role were household crowding and lack of outdoor activity in the colder season. Among American Indian and Alaskan native infants, retrospective analysis of hospital discharge records revealed that, during the first year of life, diarrhea-associated hospitalization in 1993 to 1995 was 45% more frequent than for the national population; rotavirus appeared to be an important contributor to diarrheal morbidity in this population (53).

Meningitis

Meningitis has also been a major health problem affecting the Inuit in North America (54-57) and has caused more infant and child deaths over the past 20 years in Nunavik than any other type of infection (4). A recent review of worldwide trends in *Haemophilus influenzae* type b (Hib) disease found that the aboriginal populations of Alaska, northern Canada and central and northern Australia had the highest recorded annual incidence rates of Hib meningitis in the pre-vacci-

nation era; indeed, the rate reported among the Keewatin Inuit in the 1980's was found to be the highest ever recorded (58). Prior to vaccine availability, the annual incidence of invasive Hib disease among Alaskan natives in the United States was five- to twelve-fold higher than in the general population (54, 56, 59). Since Hib vaccines were introduced, the incidence of Hib disease in Canada and the United States has decreased significantly, both in the general population and among aboriginal populations (60-61). Notably, the incidence remains high in remote parts of Alaska despite widespread vaccination (59, 62). Although immunization has succeeded in virtually eliminating Hib meningitis from Nunavik, meningitis due to other bacterial organisms persists (4).

Tuberculosis

In the 1960's, tuberculosis (TB) case rates in Canadian Inuit were among the highest ever recorded in a human population (63); and the rates remained 24 times higher among Inuit than in the general Canadian population from 1970 to 1984 (64), and 11.5 times higher among the Inuit of Quebec than in Canada from 1990 to 1994 (65). In 1998, the incidence of new active and relapsed TB among the Inuit was 58.7 per 100,000 compared to 21.3 and 1.5 among foreign-born and Canadian-born non-aboriginals, respectively (23). There were no cases of new active or relapsed TB in Inuit infants less than one year old reported in 1998, while the rate for Canada as a whole was three cases per 100,000 population in this age group (23). Alaska has a high rate of pediatric TB: a population-based, retrospective analysis of all reported cases of TB among children aged 0 to 14 during 1987 to 1994 found that Alaskan natives have a relative risk of clinical TB of 65 (95% CI: 20, 207) compared to Caucasians (66). Risk factors proposed for pediatric TB in Inuit communities include inadequate housing conditions, differences in access to health care, genetic susceptibility and nutritional deficiencies (66).

Impaired immune function

While immune system abnormalities may help to explain the increased incidence and severity of disease in Inuit populations, there are little published data examining immune function in the Inuit. In one study, 23 Inuit children aged between three and 18 months were examined when they were clinically well, but recovering from recur-

rent pneumonia, OM, severe diarrhea, or failure to thrive (67). They were found to have low percentages of T cells, increased levels of B cells and impaired mitogen responses compared to non-Inuit controls. However, these children represented a highly selected group that may have been more likely to demonstrate immunologic aberrations.

Other preliminary data have shown that Inuit infants on Baffin Island may have defects in cell-mediated immunity (36-37). In a study comparing immune cell phenotypes, Inuit infants were found to have lower CD4+ T cell and higher CD8+ T cell numbers than their non-Inuit counterparts (36). The significance of this observation is unclear, but may reflect exposure to viral infection, during which CD8+ cell populations are known to expand considerably, albeit transiently (68). Inuit infants had a larger percentage of memory cells (CD45RO), indicating exposure and response to foreign antigens, and a higher expression of activation markers on CD8+ T cells (36). Inuit infants also had higher expression of CTLA-4 on CD4+ T cells and of CD86 on B cells after mitogen stimulation, perhaps reflecting a state of heightened immunological reactivity (37). Further analysis is required to determine the clinical relevance of these findings.

Several viral infections are known to cause immuno-suppression through direct and indirect effects on cell-mediated immunity (67, 69-70), which has led to the hypothesis that exposure to viruses during early life may pre-dispose Inuit infants to more frequent, or severe, infections by other organisms. Serologic studies of the herpes viruses, hepatitis A virus and hepatitis B virus have been performed in various regions of the Arctic (71-76), and sero-conversion rates for hepatitis A (74), Epstein Barr virus (71), cytomegalovirus (75-76) and herpes simplex virus (75) have all been documented to occur at an earlier age than typically seen in non-Inuit populations. It is not known whether early sero-conversion reflects earlier exposure to viruses during infancy, or environmental and/or genetic factors that heighten the susceptibility to viral infection. Preliminary data demonstrate that Inuit infants are much more likely to be infected with Epstein Barr virus, cytomegalovirus and herpes simplex virus during the first year of life compared to non-Inuit infants, with the majority of infections occurring between four and 13 months of life (77). Several of the herpes viruses are known to exert immuno-suppressive effects (67, 69-70) and, therefore, may affect the develop-

ment and/or the functional activity of the immune systems of infected infants.

Nutritional deficiencies

Although clinical evidence of nutritional deficiencies has not been documented systematically in Arctic populations, some studies have shown that iron, folacin, calcium, and vitamin A intakes are below dietary standards established by Health Canada, especially among women of reproductive age (78-80). There is also accumulating evidence that Inuit infants may be deficient in iron (78, 81-82) and vitamin A (83).

Prevalence data gathered in 1989 as part of a population-based study of Inuit infants from Nunavik found that 21% of infants aged two months, 47% aged six months and 38% aged 12 months were anemic (82). One-quarter of Inuit infants in that study had iron deficiency anemia by six months of age. Using the same data source, another analysis found that 49% of infants aged four to nine months (123 of a total of 213 infants in the study population) were at least moderately anemic (hemoglobin < 105 g/L), and half of these were definitely, or probably, iron-deficient (78). The latter study also reported that 40% of pregnant women in Nunavik were iron-deficient at term.

A study of over 100 infant-mother pairs in the NWT, carried out between 1988 and 1991, found no clinical evidence of vitamin A deficiency among the infants, but 18% of Inuit infants in the study had mean plasma retinol concentrations in the 'deficient' range, compared to 11% of non-Inuit infants, while 41% had concentrations in the 'depleted' range, compared to 15% of non-Inuit infants (83). Nunavik babies were found to have serum vitamin A levels about one-third lower than babies in southern Quebec at birth (4).

Subtle nutritional deficiencies may affect immune function among Inuit infants. Among Alaskan native children, anemia has long been associated with the occurrence of respiratory infections (13, 84). In a 1960's cohort study of Alaskan native infants, low hemoglobin levels were not found to be predictive of infection, but a history of previous infections was associated with subsequent low hemoglobin levels (85). This relationship has not yet been studied in Canadian Inuit populations, but preliminary evidence suggests a high prevalence of iron deficiency anemia in Nunavik infants (78, 82). Vitamin A deficiency is also thought to increase the risk of infection (86-87). Studies

indicate that serum vitamin A levels are lower in Inuit infants compared to their non-Inuit counterparts (4, 83), but the significance of these observations is difficult to evaluate since random serum levels do not always correlate with total body stores of vitamin A.

There is abundant evidence of continued disparities between the health of Inuit infants and that of other infants in Canada. The next section explores some of the factors in the social, economic, physical, behavioural and cultural environment of the Inuit that are most likely to influence the health of their infants.

II. HEALTH DETERMINANTS

Social and economic environment

The socio-economic environment of a population is a strong predictor of health status. Poverty, low educational attainment and unemployment can all adversely affect health outcomes, in part by influencing personal health practices (22).

Education

In many populations around the world, increased access to schooling, especially for girls, has led to improvements in health and well-being. Educational attainment is often associated positively with health status and healthy behaviours (22). In 1996, the proportion of high school graduates (among respondents aged 25 to 29) was 33.3% and 28.6% in Nunavik and Nunavut, respectively, compared to 71.8% nationally (88). The percentage of Inuit women aged 15 and older who reported less than grade nine education was more than double (41%) the percentage of non-aboriginal women (14%), and only 5% of Inuit women reported university as their highest level of education, compared to over 21% of the general female Canadian population (24). Remoteness appears to be a barrier to education: a higher percentage of women with a university education was reported in urban aboriginal populations compared to more rural and remote populations.

Employment and income

Income is strongly associated with health status, as well as with other determinants of health (22). In 1995, the average employment in-

come of the Inuit was \$16,378, about 1.5 times lower than the national average of \$26,474 (21), although the cost of living and income tax status should also be taken into consideration in this comparison. According to the 1996 Census, the unemployment rates for Inuit women (20%) and men (23%) were more than double their respective national counterparts (both 10%) (89). Among Inuit women with a university education, the unemployment rate of Inuit women was still higher than that of non-aboriginal women, illustrating that many factors play a role in the socio-economic environment of Inuit families (24).

Physical environment

Environmental contaminants, as well as inadequate housing, water supply and waste disposal, can have a negative impact on the health status of individuals and communities.

Environmental contaminants

Inuit people are more at risk of exposure to environmental contaminants through their traditional diet of fish and marine mammals, where many contaminants tend to accumulate (90-91). The most recent data on exposure to polychlorinated biphenyls (PCBs) and mercury indicate that some Inuit infants have concentrations beyond the threshold for the appearance of adverse health consequences: mercury, at an average concentration of 14.2 µg/L, was 14 times higher in Inuit infants from Nunavik than in the southern Quebec general population; PCB levels were four times higher, at a concentration of 2 µg/L. Similar, albeit slightly lower, levels of both contaminants were observed among the Inuit living in the Baffin region of NWT (92). The breast milk of Inuit women in northern Quebec has been found to contain levels of PCBs two to ten times higher than those measured in their southern counterparts (93). Mean umbilical cord blood levels of lead were three-fold higher in Nunavik than in control samples from Toronto and Quebec City (5.2 µg/dL versus 1.7 and 1.8 µg/dL, respectively)(94), although these levels are below the concentration thought to put a foetus at risk (10 µg/dL). Studies of Inuit adults from Nunavik (95) and across Canada (96) suggest that a significant proportion of women of reproductive age may have lead and mercury concentrations exceeding those that have been associated with subtle neurodevelopmental deficits in other populations (97).

In Nunavik, prenatal organochlorine exposure was found to be associated with an increased risk of acute OM in Inuit infants during their first year of life, but no increased risk was observed for bronchopulmonary diseases (52). However, these risk estimates were made on the basis of 65 of a total of 213 infants enrolled in the study. Current research efforts are focused on evaluating the possible adverse health and developmental effects of environmental contaminants on Inuit infants. Thus far, the health benefits of breast feeding and consuming traditional food appear to far outweigh the risks posed by contaminants (95-96).

Housing

Inadequate housing and over-crowding are major problems for the Inuit living in the north (17). It was estimated in 1995 that between 25 and 30% of households in Nunavik were over-crowded (4). The mean number of members per household in Nunavut is 3.9 (10), compared to the national mean of 2.6 (98). Inadequate water supply and sewage disposal systems also pose a risk to the health of Canadian Inuit populations. In Nunavik, water is pumped from rivers and lakes into holding reservoirs and chlorinated, or is taken directly from lakes, chlorinated and delivered to homes; sewage is not treated, but released into river systems not used by local residents. The chlorination and testing of water, and the cleaning of municipal water equipment and household tanks, do not appear to be regulated adequately; in 1996, almost one in five household water specimens was found to contain fecal coliforms (4). *Helicobacter pylori* has also been detected in local water supplies of Inuit communities in the central Canadian Arctic (99).

Inadequate housing is also a determinant of infection in the north (21). The cold northern climate keeps people indoors, amplifying the effects of household crowding, smoking and inadequate ventilation. Crowded living conditions favour the transmission of infectious diseases, such as respiratory infections, including TB, gastro-enteritis and skin infections, and could contribute to the overall higher rates of infectious diseases among aboriginal people (28). In addition, care-giving practices may play a role in the transmission of infectious disease: children tend to circulate among several homes, usually within the same extended family (4). Household crowding has been proposed as a risk factor for lower respiratory tract infections

among Alaskan natives (35, 84). While some studies in the Arctic region have shown a link between episodes of OM and crowding (46, 48-49), others have failed to confirm this association (44, 50-51). An ecological study of 49 predominantly native communities in the NWT showed that the rate of health centre visits, as a measure of morbidity, was negatively correlated with housing and socio-economic status indicators (31). However, since poor housing is associated with low socio-economic status, any conclusion that housing is associated with health must control for socio-economic status. When both variables were considered jointly in a multiple regression model, socio-economic status was by far the stronger factor predicting the frequency of health centre visits.

Inadequate water supply and sewage disposal may also influence the health status of Inuit infants. Two major epidemics of fecal-oral transmitted diseases were reported in the NWT during the 1990's: a large epidemic of hemorrhagic enterocolitis (caused by *Escherichia coli* 0157:H7) in the Keewatin region in 1991 (100), and a large hepatitis A outbreak in the Baffin region in 1992. In both epidemics, person-to-person spread was the most important mode of transmission (4).

Personal health practices

Lifestyle behaviours, such as smoking, alcohol dependence, and breast feeding, can affect an individual's health, as well as that of his/her dependents (22). Health-seeking behaviours among the Inuit may also be adversely affected by the loss of traditional cultural values and lifestyles. Displacement of traditional health teachings by western medical approaches, together with a host of other factors, may play a role: interviews with older Inuit women in Keewatin and other regions indicate a perceived decrease in knowledge about female sexuality and reproductive health (101-103), and a reduced sense of personal responsibility for healthy childbirth (104).

Smoking

Smoking is an extremely important determinant of poor health in Inuit communities. Rates of smoking among the Inuit are more than twice the national average, and smoking begins at a young age: 69% of Inuit youth reported smoking by the time they are teenagers (105). A national database on breast feeding among First Nations and Inuit women in Canada found that 80% of women smoked during preg-

nancy (106). More recently, the prevalence of smoking during pregnancy in Nunavik and Nunavut has been estimated at 75% and 73%, respectively (4) (Roberts, A., Medical Officer of Health, Nunavut, personal communication). Inuit infants thus have a very high risk of exposure to tobacco *in utero* and to second-hand smoke in the home, especially given the amount of time people spend indoors due to adverse weather conditions.

Despite the high prevalence of smoking in Inuit communities and the strong epidemiological evidence of increased risk of respiratory infections in infants exposed to environmental tobacco smoke (107-108), research on the effect of tobacco exposure on infant health within Inuit populations has been limited. A role for tobacco exposure in the persisting high rates of LRTI among Inuit infants has been suggested (10). Furthermore, over half of post-neonatal deaths reported in Nunavik from 1990 to 1994 were attributed to SIDS. Based on the existing high smoking rates during pregnancy, and a relative risk for SIDS of three to four for infants born to mothers smoking during pregnancy, passive smoke exposure likely accounts for most of these deaths (4).

Alcohol consumption

Although some studies have suggested that fetal alcohol syndrome is more prevalent among Canadian aboriginal children than non-aboriginal children, the evidence does not appear to be conclusive (109). There are no reliable statistics on the prevalence of fetal alcohol syndrome and fetal alcohol effects in northern Inuit communities. However, 25 to 30% of women surveyed in Nunavik and 18% in Nunavut reported alcohol use during pregnancy (4) (Roberts, A., Medical Officer of Health, Nunavut, personal communication). Similar percentages of women aged 15 to 34 (including pregnant women) in Nunavik reported a "binge" pattern of drinking: at least monthly drinking sessions of five drinks, or more (4). National data from the 1996/1997 National Population Health Survey indicate that 17.5% of all Canadian women reported consuming alcohol during their pregnancy, with only 2.5 % of these women reporting "binge" drinking (22).

Breast feeding

Surveys conducted in 1996 show that aboriginal mothers are less likely to initiate breast feeding than mothers in the general Canadian popu-

lation (54% versus 75%), but are more likely to breast feed six months, or more (39% versus 24%) (18, 110). Rates specific to Inuit mothers and infants were not reported in this study, but have traditionally been high in Inuit communities (4, 106, 111). A national database on breast feeding among Canadian First Nations and Inuit women (that excluded NWT and Saskatchewan) was started in 1983 and found that, overall, 60.7% of mothers initiated breast feeding (partial, or full), 42% were still breast feeding at three months, and 30.6% at six months (106), although there was considerable variation in breast feeding frequencies between regions: rates were highest in the Yukon (91% at birth, 53% at six months) and northern Quebec [79% at birth, 54% at six months]. In the Nunavik region, almost half of the infants in this survey were still breast-fed at six months; this prevalence jumped to 65% when adopted babies were excluded (106). A cohort study of Inuit infants in Nunavik, conducted in 1989, found that 57% were breast-fed (partial, or full) versus 43% that were bottle-fed (32).

In general, studies conducted in Inuit populations have confirmed the importance of breast feeding in preventing infections (27, 111). In Nunavik, entirely breast-fed infants contracted fewer pulmonary infections during the first year of life than bottle-fed infants (32) and were better protected against iron deficiency (82). Some studies have found an association between the lack of breast feeding and an increased risk of OM in Inuit infants (46, 70), while others have failed to show such a relationship (32, 49). Breast feeding appeared to be protective against pneumococcal illness (112) and Hib disease (29) in Alaskan native children less than two years of age.

Health Services

Access to high quality, culturally appropriate health services also contributes to the health of a population. In the Inuit context, both geographic and cultural factors can act as barriers to the access of such services, and can render health services less effective. Physical barriers include geographic remoteness, while cultural obstacles include communication problems, differences in values, attitudes and beliefs, and the existence of racism and prejudice (113).

Health service utilization

The National Population Health Survey in 1994/1995 indicated few

barriers to health care in the Yukon and NWT, where only 6 to 7% of residents reported difficulty receiving needed health care, or advice, compared to 4% for the rest of Canada (114). The sources of care sought, however, differed from the rest of Canada: 36% of aboriginal people in the territories had consulted general practitioners in the previous year, compared to 60% for non-aboriginal northerners and 77% for the rest of Canada; while 41% of aboriginals had consulted a nurse, compared to 18% of non-aboriginal northerners and 7% for the rest of Canada. Similar trends were observed in data drawn from the 1991 Aboriginal Peoples Survey (25) and a Quebec Health survey conducted in the early 1990's (4). These differences reflect, in large part, how health services are organized in the north.

Satisfaction with health services

Almost half of the First Nations and Labrador Inuit (Nunatsiavut) respondents of the 1995 First Nations and Inuit Regional Health Survey thought that their health services were not at the same level as the rest of Canada; those living in isolated communities were more likely to believe that services are unequal (19). Those who felt that services were not equal expressed a clear desire for improved services on the whole. The largest percentage (86%) thought that pediatric services needed improvement.

III. FUTURE RESEARCH

This paper has summarized some important factors that influence the health of Inuit infants in Canada, and has revealed gaps in knowledge that, if addressed, could lead to more effective and focused preventive approaches. Potential areas of future research could include: 1) assessing the potential relationship between iron deficiency anemia and/or vitamin A deficiency and immune function in Inuit infants; 2) evaluating the potential role of environmental contaminants in increasing the susceptibility to infection; 3) measuring the contribution of household crowding to infection rates; 4) clarifying the role of tobacco smoking as a risk factor for infections and SIDS in Inuit communities; 5) determining the potential impact of infant adoption, and the subsequent lack of breast feeding, on infection rates in

Inuit infants; 6) exploring whether the early acquisition of viral infections predisposes Inuit infants to secondary infections. There appears to be a clear need to focus on preventive anti-tobacco programs in Inuit communities, given the high prevalence of smoking and its proven adverse health effects.

Subtle nutritional deficits, environmental contaminants, household crowding and associated socio-economic factors, prenatal and second-hand exposure to tobacco smoke, breast feeding status, and history of viral infection, may all contribute to making Inuit infants more susceptible to infectious illness. Complex inter-relationships between these various risk factors underline the importance of taking a methodologically sound approach to research in Inuit communities that accounts for confounding and interacting effects. Studies conducted in the north often lack the statistical power to take such an approach. This short-coming needs to be addressed, but is only part of the challenge. Steps need to be taken, together with Inuit communities and health professionals, to identify and overcome barriers to research, so that clear and meaningful results can be achieved. Continuing to raise the research capacity within Inuit communities, in order to ensure local ownership of, and participation in, research in the north, is a critical part of this process. Epidemiological studies that are not only well-designed, but also driven and managed locally, are urgently required to clarify factors contributing to the increased incidence of infection in Canadian Inuit infants, so as to shape and inform future preventive efforts.

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