

HEART DEFECTS AND OTHER MALFORMATIONS IN THE INUIT IN CANADA: A BASELINE STUDY

ABSTRACT

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Objectives. Birth defects occur in all ethnic groups, remaining an important world-wide cause of perinatal and infant morbidity. This contributes greatly to an excess of health care dollars allocated to the care and repair of those affected. This is especially true when those affected live in remote geographical locations.

Study design. A chart review of 2567 live births of children of Inuit parents residing in Arctic Quebec (Nunavik) and on Baffin Island (Nunavut) between 1989 and 1994 (five years) was carried out compared to rates of anomalies of the Alberta Congenital Anomalies Surveillance System (ACASS).

Results. Birth defects were higher in the Inuit sample in nearly every major ICD-9 category with the exception of neural tube defects, eye anomalies and chromosome abnormalities. (Total: 99.7/1000 Vs 51.5/1000; OR 1.93 95% CI 1.7-2.3). Congenital heart defects were significantly increased 22.9/1000 Vs 5.6/1000, with an OR of 4.18 (95% CI 3.2-5.4) in the ICD-9 category 745. In particular, ventricular septal defects (VSDs) and atrial septal defects (ASDs) (OR 4.9 CI 3.5-6.9 and 4.6 CI 2.9-7.2) were frequent.

Conclusions. A high rate of heart defects was an important contributor to the nearly two times rate of total birth defects in the Inuit compared to the ACASS. Further study should be carried out to determine the contributing factors. Genetic predisposition to specific heart defects, and a diet low in folate and vitamin A are considerations. The use of alcohol may exacerbate vitamin status in pregnancy. Optimizing vitamin status in the periconceptional period may reduce the rate of birth defects. (*Int J Circumpolar Health* 2004;63(3):251-266)

Key words: Arctic, Inuit, aboriginal, congenital heart malformations, birth defects, folic acid, vitamin A, alcohol exposure, Hirschsprung disease, pyloric stenosis

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INTRODUCTION

The predecessors of modern day Inuit, the Thule, inhabited the Arctic from about 1000 A.D., extending habitation from west to east, eventually arriving in the Eastern Canadian Arctic and Greenland. These were Inuktitut speakers and hunters whose diet consisted mainly of meat (the whole animal) and fish, with little attention being paid to the gathering of food (1). Although the modern day Inuit communities have changed significantly from that time, the preferred diet still reflects the traditional necessary means of survival, consisting largely of meat and fish, and occasionally vegetables, a diet low in folate. Vitamin A is also considered a nutrient of concern in the north (2). Both nutrients are essential for normal embryonic development (3-6).

Birth defects occur in all ethnic groups, remaining an important world-wide cause of infant morbidity and mortality (7). Furthermore, in Nunavik (Arctic Quebec), the rate of infant mortality in the Inuit is 5 times that of non-aboriginal Quebec, where 2/3 of neonatal deaths are due to birth defects (8). Over a 3-year period in Arctic Quebec, (1991-1993), the overall mortality rate of newborns and infants due to birth defects was 9 times higher than for Quebec as a whole (8). World wide, heart defects are considered to be the most common birth defect (9,10), contributing greatly to an excess of health care dollars allocated to the care and repair of those affected (11). The impact is even more significant when those affected live in remote communities far from tertiary care centers, such as in the regions of Arctic Quebec and Baffin Island. Although communities remain geographically remote, most health care needs are met at 3 local hospitals. Tertiary care is less accessible, however, and most children with birth defects must travel to southern centers for investigation and treatment. At the Montreal Children's Hospital, where much of tertiary care services had been provided over a period of twenty years, a higher than expected number of Inuit children were followed with birth defects such as congenital heart malformations, and brain malformations. In order to confirm that the rates of birth defects were indeed higher in the Inuit, a 5-year consecutive chart review of all births to Inuit parents between 1989 and 1994 was carried out in the Baffin Health Care region (now part of Nunavut), and Nunavik (Quebec Arctic). The rates of birth defects were compared to data from the Alberta Congenital Anomalies

Surveillance System (ACASS). Since this study was carried out prior to folic acid fortification, it will serve as an important baseline to determine whether the rates are now lower.

Study Population

At the time of the study, the Baffin Health Region serviced 13 communities on Baffin Island, and the surrounding mainland of the Northwest Territories. The population was approximately 10,000, of which about 90% were of Inuit origin. The main health centre was, and remains, the Baffin Regional Hospital in Iqaluit. Most births occur in Iqaluit, where a medical chart is started at the time of birth for each child prior to return to the community with their natural, or adoptive parents. The communities are serviced by full-time nurses skilled in remote health care, and physicians visit the nursing stations on a regular basis. Children in need of hospital care are transferred either to the Baffin Regional Hospital, or, if tertiary care was needed, until 1998, were transferred to the Montreal Children's Hospital. All records of significance are kept in a central record room at the Baffin Regional Hospital.

A similar regional health care delivery system is in place in Nunavik. The Katavik Health Board services 14 communities in Northern Quebec along the coasts of Hudson and Ungava Bays. The population consists of about 8,000 people, of whom 90% are Inuit. These are serviced by two main health centers, one on each coast, for births and in-patient hospital care. Thus, most health data can be retrieved at the hospital in Puvirnituq, on the Hudson Bay Coast, and at the hospital in Kuujjuuaq, on the Ungava Bay Coast. Those children in need of tertiary health care are transferred to the Montreal Children's Hospital.

METHODS

Health records of consecutive births of at least one Inuit parent (identified by Inuit names and coded by medical services number) were reviewed from April 1, 1989, to March 31, 1994, at hospitals in Iqaluit (1333 births), Puvirnituq (550 births) and Kuujjuuaq (684 births). After approval from local Inuit Health Boards, data were collected from the mother's prenatal chart, and from the child's subsequent health chart. Birth defects detected by 1 year of age were recorded and coded according to the ICD-9 coding system.

As per convention for comparison with other birth defect registries, birth defects excluded were those malformations in premature infants that were related to prematurity, such as patent ductus arteriosus, undescended testes and inguinal hernias. Further, patent ductus arteriosus (PDA's) not persisting beyond 3 months of age were excluded. All heart defects included in the study were confirmed by a pediatric cardiologist (M. Paquet), by physical exam and by echocardiogram. Syndromes were included only if a definitive diagnosis was made by a geneticist, or a neurologist.

Rates of birth defects were compared to the Alberta Congenital Anomalies Surveillance system (ACASS) report of a similar time period (1980-1995), where all birth defects of live and stillbirths are reported and recorded through a central registry (12). This registry was used as a comparison, because it is likely the most complete Canadian source of birth defects. The population of the southern Canadian province of Alberta is diverse, consisting of both urban and rural populations. Approximately 4 percent of the population of Alberta is aboriginal (primarily First Nations/North American Indian). The database derives information from numerous sources and is considered to be reflective of rates of birth defects in Canada. The Alberta registry has a thorough collection system, which includes the physicians notice of birth (PNOB), medical certificate of stillbirth, medical certificate of death, and a form called 'congenital anomalies reporting form', which is completed by hospital health records personnel after birth, or admission. Out-patient information from clinics is collected in the same way. These sources continue to report birth defects until the age of 1 year. The published results of birth defects through the Alberta Registry is slightly higher than other registries from around the world, suggesting the ascertainment is at least comparable, if not more precise compared to other registries (13). Other comparisons for selected birth defects include those from Atlanta Georgia, Australia, Central East France, England, Wales, Finland, Hungary and Norway.

Because of the possibility of over-ascertainment of insignificant birth defects with a chart review, only major malformations were compared in each ICD-9 category. ICD-9 coding was used and preferred because of the timing of the study and the comparison data, which was only available with ICD-9 codes until 2001.

The Alberta Registry also includes birth defects of stillbirths (all fetal deaths after 20 weeks gestation) and these were included in the data collected. This data was rarely available for the Inuit cohort. Pregnancy terminations (of fetuses less than 20 weeks gestation) were not available in either sample.

Statistical analyses were carried out with InStat computer software program using odds ratios with confidence intervals, chi square and Fisher's exact tests when appropriate.

Table 1. Results of Arctic birth defect cohort.

ICD-9 code	Inuit # of BD n=2567	Inuit rate/1000	Alberta n=676811 rate/1000/# of BD	Odds ratio/ Confidence Interval	Chi square test (CS) Fishers Exact test (FE)
740-741	2	0.78	0.82/552	0.95 (.2-3.8)	FE p=0.98
742	18	7.01	1.57/1064	4.46*(2.8-7.1)	CS p<0.0001*
743	2	0.78	1.46/988	0.53 (.12-2.1)	FE p=0.5
744	5	1.95	2.83/1914	0.68 (.3-1.66)	CS p=0.5
745	59	22.9	5.6/3782	4.18*(3.2-5.4)	CS p<0.001*
cardiac septal: VSD	36	16.3	2.88/1949	4.9* (3.5-6.9)	
ASD	19	8.3	1.62/1100	4.6*(2.9-7.2)	
○	4	1.5	1.0/733	0.95 (0.35-2.56)	
746	9	3.5	2.41/1628	1.5 (.75-2.8)	CS p =0.35
747	14	5.45	4.78/3238	1.14 (.67-1.93)	CS p=0.73
748	4	1.5	0.70/477	1.56 (.83-5.92)	CS p=0.21
749	8	3.1	1.85/1249	1.6 (.84-3.4)	CS p=0.2
750	13	5.06	1.27/857	4.0*(2.3-6.9)	CS p=0.0001*
7505 pyloric stenosis	12	4.67	0.85/575	5.52*(3.1-9.8)	CS p<0.0001*
751	12	4.67	1.5/1018	3.10*(1.8-5.5)	CS p<0.0001*
752	23	8.95	5.79/3922	1.55*(1.03-2.34)	CS p=0.04*
753	9	3.5	2.38/1611	1.47 (.76-2.8)	CS p=0.34
754/755/756	57	17.8	14.63/9898	1.53*(1.17-1.99)	CS p=0.002
758	3	0.84	1.58/1072	0.74 (.24-2.29)	CS p=0.78
759/760/771...	18	7.0	3.43/1576	3.0*(1.89-4.8)	CS p<0.0001*
Totals	256	99.7	51.5/34900	1.93*(1.7-2.2)	CS p<0.0001*

* Designates Statistical Significance.

ICD-9 code: 740-741 anencephaly, spina bifida and similar anomalies; **742** other congenital anomalies of the nervous system; **743** congenital anomalies of the eye; **744** congenital anomalies of ears, face and trunk; **745** bulbus cordis anomalies and anomalies of cardiac septal closure; **746** other congenital anomalies of the heart; (pulmonic stenosis, hypoplastic left heart, other); **747** other congenital anomalies of the circulatory system; **748** congenital anomalies of the respiratory system; **749** Cleft lip and palate; **750** other congenital anomalies of the upper alimentary tract; **751** other congenital anomalies of the digestive system, including Hirschprung's disease; **752** congenital anomalies of the genital organs; **753** congenital anomalies of the urinary system; **754/755/756** congenital anomalies of the musculo-skeletal system (combined); **758** chromosomes; **759/760/771...** unspecified and selected anomalies (outside ICD-9 Chapter 9).

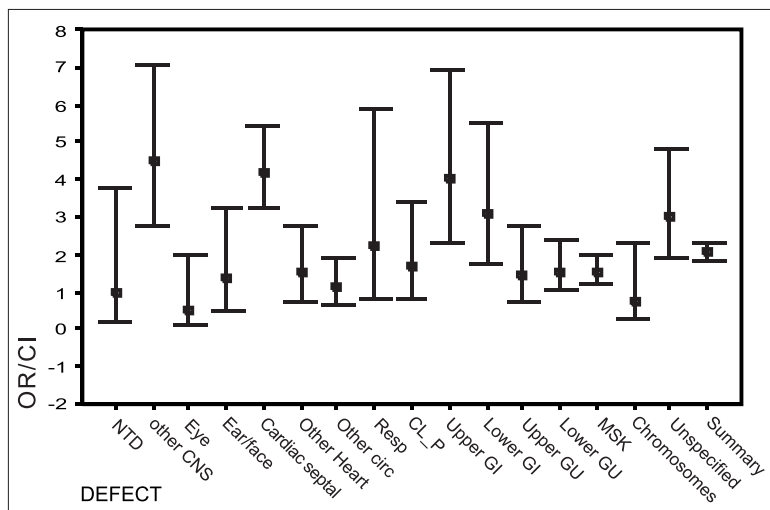


Figure 1. Odds ratios with confidence intervals for birth defects in 2567 Inuit children from Baffin Island and Arctic Quebec.

Table II. Type of heart defects.

Type of heart defect	number
Truncus arteriosus	1
Tetralogy of fallot	1
Single ventricle	1
Ventricular septal defect	36
Atrial septal defect	19
Endocardial cushion defect	1
Pulmonic valve stenosis	7
Hypoplastic left heart	1
Cardiomyopathy	1
PDA	9
Coarctation of the aorta	1
Anomalies of the peripheral vascular system	4

Table III. Other congenital anomalies of the nervous system.

Other congenital anomalies of the nervous system (ICD-9 742)	number
Encephalocele	2
Microcephaly	5
Congenital hydrocephaly	2
Hydroanencephaly	2
Holoprosencephaly	1
Pachygyria	1
Schizencephaly	1
Optic atrophy	2
Agenesis of septum pellucidum	1
Other brain malformation (absent ventricles)	1

Table IV. Lower gastrointestinal abnormalities.

Other congenital anomalies of the digestive system ICD-9 (751)	number
Meckel's diverticulum	1
Atresia and stenosis of small intestine	1
Atresia and stenosis of large intestine, rectum, anal canal	3
Hirschprung disease and other functional disorders of colon function	4
Anomalies of intestinal fixation	2
Anomalies of gall bladder, bile ducts and liver (biliary atresia)	1

Table V. Congenital anomalies of genital organs.

Congenital anomalies of the genital organs (752)	number
Doubling of uterus	1
Undescended testes	11
Hypospadias and epispadias	8
Other specified anomalies of male genital organs (intra-uterine torsion of testicle)	2
Unspecified anomalies of genital organs	1

Table VI. Other and unspecified congenital anomalies.

Other and unspecified congenital anomalies		
ICD-9 codes 759, 760 and others	number	anomaly
Anomalies of the adrenal gland	1	Adrenal hypoplasia
Anomalies of other endocrine glands	1	Sublingual thyroid
Multiple congenital anomalies described	4	Meckel Gruber syndrome Kabuki Syndrome
Neoplasms	3	Congenital histiocytosis (1) Medullablastoma (2)
Fetus or newborn affected by maternal anticonvulsant use	2	Fetal hydantoin syndrome
Fetal alcohol syndrome/effects	4	FAS (4)
Congenital infection	5	Congenital toxoplasmosis (5)
Other (not included in analysis)	1	Neurofibromatosis type I

RESULTS

The overall rate of birth defects was nearly two times that of the ACASS (99.7/1000 Vs 51.5/1000; OR 1.93, 95% CI 1.7-2.3, $p < 0.001$). Birth defects were higher in the Inuit cohort in nearly every major ICD-9 category, with the exception of neural tube defects, eye anomalies and chromosome abnormalities (see Figure 1 and Table I). In the above 3 categories, the numbers were small, and the rates were not statistically significantly lower. Birth defect categories demonstrating an increased rate, but not statistically significant, were: congenital anomalies of the respiratory system (ICD-9 category 748), cleft lip and palate (ICD-9 category 749) and congenital anomalies of the urinary system (ICD-9 category 753).

Congenital heart defects within the ICD-9 category of 745 were significantly increased in the Inuit cohort at 22.9/1000 Vs 5.6/1000, with an odds ratio (OR) of 4.18 (95% CI 3.2-5.4). In particular, ventricular septal defects (VSDs) and atrial septal defects (ASDs) (OR 4.9, CI 3.5-6.9 and 4.6 CI 2.9-7.2) were frequent (see Table II). Other significantly increased birth defect rates were CNS malformations (OR 4.5 CI 2.8-7.1), pyloric stenosis (OR 5.5 CI 3.1-9.8), and lower GI system malformations including Hirschsprung disease (OR 3.1, CI 1.76-5.51). No one specific brain anomaly is responsible for the increase in CNS anomalies (see Table III). Genital anomalies are also borderline increased, although the rates of hypospadias, epispadias and undescended testes were as expected, or slightly greater than expected, for the population size. Anomalies of the lower GI system and anomalies of the genitals are listed in Tables IV and V, respectively. Musculo-skeletal abnormalities are also borderline increased,

although rates of club foot, and congenital dislocated hips were similar to those reported in the ACASS database. However, there was an increase noted in bowing of the long bones of the leg, although the numbers are small. Unspecified anomalies, also increased with statistical significance are listed in Table VI. Teratogenic syndromes, including fetal hydantoin syndrome, congenital toxoplasmosis and fetal alcohol syndrome, account for the increase.

DISCUSSION

The results of this 5-year chart review of more than 2,500 Inuit births from Nunavut and Nunavik suggest that total congenital anomalies are increased in the Inuit sample compared to the ACASS data. Although this sample size was relatively small, and few significantly increased congenital anomalies were individually noted, the data may be of importance as a baseline for comparison and for the consideration of mechanisms for some birth defects.

Although the study was a chart review, and presumably may reveal more birth defects than a registry with reporting sources, the Alberta congenital anomalies surveillance system was chosen because it is considered the most active and complete registry in Canada, depending on numerous reporting sources until the age of 1 year. Because of the concern of possible over-ascertainment, minor anomalies were not recorded in this study. Indeed, there may be an under-ascertainment of birth defects in the Inuit cohort, since information regarding stillbirths was rarely available, but was included in the Alberta registry. Although the ICD-9 coding system has been updated to ICD-10 by the WHO, with more specific information and more practical categorization of birth defects, the ICD-9 system was the one in use at the time the cohort was studied. Indeed, the Alberta registry used that system to determine rates of birth defects until 2001 and, therefore, comparable data was available only as per the ICD-9 coding system.

The most frequent birth defect present in the Inuit cohort was that of heart defects, specifically ventricular septal defects (VSDs) and atrial septal defects (ASDs), that were nearly 4 times more frequent than expected in Canadian populations (12,14). This study does not imply a temporal increase in VSDs and ASDs as would be expected with improving technology and access to it, but rather higher rates of heart

defects than in a comparable population at a comparable time. Although a temporal increase may be occurring as noted in other populations, this was not examined in this study.

Other birth defects notably increased included hypertrophic pyloric stenosis and Hirschprung disease, both with significant odds ratios, above 4, although the actual numbers were small (12 and 4 respectively). The smaller number of affected individuals suggests that the health care impact will not be as substantial. However, both defects occurred in all 3 populations sampled, and in significantly greater numbers than would be expected. Both conditions have a strong genetic component.

For example, for hypertrophic pyloric stenosis, the chance of occurrence is increased by at least 5 times if a sibling is affected. The etiology is considered multifactorial, and prenatal smoking has been implicated (15). Some also feel that, for this multifactorial anomaly, postnatal smoke exposure may also play a role. In our study, more than 80% of the mothers smoked during their pregnancy. One study demonstrated a protective effect of multi-vitamins during pregnancy (3). A follow-up study did not find a specific protective effect of folic acid, however (4). All hypotheses are worth considering and, perhaps, should be evaluated as a case control study in this population.

Hirschprung disease (absence of ganglionic nerve cells in the distal colon) usually occurs in about 1 in 5000 children. It also has a high heritability component, with several genes known to be responsible for the condition (16). Although some prenatal exposures have been implicated, such as valproic acid, there is little evidence to suggest that other exposures (such as smoking, or infectious agents) play a role (17).

Syndromes secondary to teratogen exposures were increased in the Inuit sample. Four cases of Fetal Alcohol Syndrome were definitively diagnosed in the Inuit cohort. Although there were other possible cases, these were not included in our collection of data. The ACASS reports a rate of approximately 9/100000, suggesting likely under-reporting in that registry and a possible inflation of the results in that category for the Inuit sample. Fetal Alcohol Syndrome describes a pattern of abnormalities, including those of cranio-facial, growth, and a wide range of associated birth defects. It is considered to be amongst the most frequent syndromes, and estimated to have a prevalence of 1/500 (18). However, it may be diagnosed at various ages (for example, often

over 1 year), or with more zeal in some populations than in others. Therefore, there is great difficulty in comparing the detection rate in one population compared to another.

Also of interest were 5 cases of congenital toxoplasmosis reported in the three areas during our 5-year study. Congenital toxoplasmosis had been reported as a concern in 1987, when there were 5 cases recognized on the Ungava coast of Arctic Quebec (19,20). After an evaluation of foods eaten that might have contributed, guidelines for its prevention were developed (20).

Although other birth defect rates were also increased in the Inuit cohort, such as brain malformations (see Tables II and III) the types of specific malformations were not consistently elevated, and mechanisms were therefore not further speculated upon. Of general importance, however, is that two large studies (21,22), as well as compiled data of case control studies (23), have demonstrated a significant reduction in all types of birth defects by peri-conceptual supplementation with vitamins. Indeed, 20-47% of birth defects are shown to be prevented by the use of folic acid. Although the decrease is general, specific defects, such as cleft lip and palate and limb defects, have received special attention. In particular, the protective effect on congenital heart defects, including VSDs, has stimulated a great deal of current interest (23).

Congenital Heart Defects in the Inuit: Because of the frequency and influence on wellness, a high rate of congenital heart defects is likely to have an important impact on health care and health care costs (11). Thus, in our population, it is worth considering the current state of knowledge regarding possible reasons for the high rate of congenital heart defects. Congenital heart malformation is the most common congenital malformation, diagnosed around the world in 0.5 –1.2% of live births (24). Increased rates have been reported in specific ethnic populations, suggesting a genetic predisposition, and in those populations where socio-economic factors affecting diet and pregnancy exposure may influence rates (24). Indeed, high rates of congenital heart defects have been observed in other Canadian and non-Canadian aboriginal populations (25-27). The reasons for the high rates have not been explored, however. In our population, several factors may contribute and deserve attention, since public health efforts focusing on optimal nutrient and lifestyle status may reduce the rates.

The diet of northern aboriginal populations of arctic and subarctic regions have a high component of meat, fowl and fish, rendering them high in protein, cobalamin and 3-omega fatty acids (28). However, the 'northern diet' is also well known to be low in folate and vitamin A (2,28,29). Both of the latter are key factors in early cell division in embryonic development and deficiencies of both are associated with congenital heart malformations (3-6,30,31).

The protective effects of folic acid for neural tube defects is now well accepted internationally (3). The relevance of the protective effect of folic acid for neural tube defects for this study is that further analyses of Czeizal's 1992 land-mark epidemiological study (3), which confirmed that the use of folic acid supplementation reduced neural tube defects as a first occurrence, demonstrated that supplemental folic acid was also protective for congenital heart defects. This was especially true for VSDs and ASDs (4). Furthermore, Shaw et al. (32) demonstrated a protective effect of supplemental folic acid for conotruncal heart malformations, of which VSDs and ASDs are considered a part. In addition, animal studies have demonstrated that congenital heart malformations can be induced with hyper-homocysteine (31). Elevated homocysteine is considered a marker of altered folic acid metabolism, which may result from decreased enzyme activity in the pathway, or decreased folic acid.

By January 1998, both in the United States and in Canada, all enriched flour, rice, pasta, cornmeal and other grain products were fortified with folic acid to a level of 140 µg per 100 grams. It was estimated that folic acid fortification would increase the average daily intake of folic acid by 80-100 µg/day. This has been shown to be true of the general Canadian population, where, since fortification was introduced, substantial increases in RBC folate have been seen and there is evidence that rates of spina bifida are decreasing (33,34). Since the arctic and subarctic diet is known to be high in meat, fish and fowl (and especially low in foods containing folic acid) it remains unclear whether folic acid enrichment has had a similar beneficial effect in the north. For example, in a sample of 219 Cree women in the James Bay region, the average intake of folic acid was less than 98 µg/day (pre-fortification) (35). Current dietary assessments need to be made to determine if Northern aboriginal women, with their common diet, are reaping the same benefits predicted for women in the south.

Vitamin A is a nutrient essential in early development, especially that of the heart (30). Both the lack and excess of vitamin A in embryonic development results in congenital malformations (6). However, chronic vitamin A excess, or deficiency (or a 'less severe' insult), are more likely to present simply as congenital heart defects (30), including septal defects, double outlet right ventricle and persistent truncus arteriosus. It is speculated that altered retinoic acid status may prevent the normal migration of mesenchymal cells important for septal and outflow tract development (30).

Vitamin A is considered a nutrient of concern in the northern diet. Although serum levels of vitamin A may not adequately reflect true depletion, several studies have demonstrated sub-optimal vitamin A levels measured in Inuit infants and women of child-bearing age (36). These low levels are consistent with several northern dietary studies which have evaluated vitamin A intake in the North, declaring vitamin A to be a consistent nutrient of concern (2,37-39). Thus, in considering the mechanism of septal defects, it is essential to consider the impact that vitamin A status may have on fetal heart development. For example, some genes important in heart development are affected by vitamin A status and of particular significance is the expression of retinoid receptors present in heart-forming tissue during early development. Thus, vitamin A deficiency decreases the expression of RAR, in heart-forming tissue in avian studies (30).

It is well known that retinoids, especially the synthetic form (cis-retinoin) used for treatment of acne, are teratogenic if taken during embryogenesis in both animals and humans. In a case control study of rates of cardiac outflow tract defects and vitamin A supplementation designed to determine if a high intake of vitamin A supplementation was teratogenic, those supplemented daily with a dose greater than 10,000 IU of vitamin A (3 mg) had a significantly higher rate of outflow tract defects. However, supplementation of retinol equivalents (RAE) between 5000 and 8000 IU (1.5 and 2.5 mg) did not increase heart defects, and likely decreased the rates by 30% (40), supporting the notion that a critical amount of vitamin A is important during embryonic development, but an excess amount may be teratogenic. Thus, it is considered prudent that, for those pregnant, or considering pregnancy, the daily intake of supplemental vitamin A should not exceed 8000 IU or 2.4 mg retinol activity equivalents (RAE) (41).

Although there is concern that Inuit women may partake in traditional diet practices that include the ingestion of sea mammal liver, which may contain large amounts of retinoids (for example, 200 grams of whale liver may contain up to 80 mg retinol (39), which is potentially teratogenic), dietary surveys from 18 Inuit communities suggest that sea mammal species with the highest liver retinol content, such as whale and walrus, are rarely or never ingested by Canadian Inuit (39). In contrast, for the Canadian Inuit communities surveyed, the most common species of liver consumed were ringed seal, caribou and fish; all of which contain median retinol levels similar to lamb and chicken liver found in grocery stores. Although even small portions (about 10 mg/100 grams) might be considered worrisome during embryogenesis, some consider such caution over-emphasized, since there is little anecdotal evidence that consumption of store-bought liver in other populations is teratogenic (42). Consequently, it has been suggested that eating liver in small amounts (less than 50 grams/week) might be an efficient way to improve nutritional intake of vitamin A and other important nutrients, without increasing the risks of birth defect (42).

A great deal of attention has been directed to the rates of fetal alcohol syndrome in aboriginal populations, with resultant public health efforts to raise the awareness of the harm alcohol intake might confer during pregnancy (43). Of relevance for this analysis is the scientific basis for alcohol exposure and congenital heart defects, especially septal defects. It has been estimated that more than 50% of those with FAS have congenital heart defects, with most being VS-Ds and ASDs (44). On the other hand, it has also been shown by animal studies that the genetic background of the host is important in whether heart defects occur as a response to alcohol exposure (45). Furthermore, alcohol interferes with intestinal absorption of folic acid, and retinol (vitamin A) metabolism is inhibited by alcohol intake (46-48). Thus, a population with a genetic predisposition to congenital heart defects, suboptimal folic acid and vitamin A intake would be particularly susceptible to congenital heart defects as a result of alcohol exposure. It could be postulated that a lower amount of alcohol might be needed to see expression of the defect compared to other populations. It has been shown, through self-reported surveys and studies of alcohol consumption per capita, that the Inuit of the Baffin Region drink significantly less alcohol (about one-quarter

the amount) than their non-Inuit southern counterparts (49). However, other studies of Canadian Inuit and Native Alaskans suggest that, when drinking occurs, it is likely to be consistent with binge drinking, which may be particularly risky to the fetus (8,44,50,51). Although presumed to play a role, prenatal alcohol exposure has not been studied in relationship to birth defects in the Canadian Arctic.

CONCLUSION

A five-year chart review of children born to Inuit parents on Baffin Island and in Arctic Quebec between 1989 and 1994 revealed a significantly higher rate of birth defects than expected for the population's size. Although several birth defect categories were increased significantly, the greatest health care impact is probably secondary to the high rate of congenital heart defects. Further study is needed to determine if the high rate of congenital malformations, and particularly congenital heart malformations, in the Inuit results from 1) a diet with sub-optimal folic acid and/or vitamin A intake, 2) a genetic predisposition altering nutrient status and/or heart formation, and 3) exposure to alcohol intake, which may alter both folic acid and vitamin A status. Further study is also needed to determine how contributing factors may be altered through public health efforts to reduce the rates of birth defects by, for example, optimizing the vitamin status of women during their child-bearing years.

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