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NUNAVIK CHILD DEVELOPMENT STUDY (NCDS): SUMMARY OF RESULTS

INTRODUCTION

During the last 25 years, environmental monitoring and research activities have provided evidence that Inuit traditional food, whose nutritional benefits are well documented, is also the primary source of exposure to environmental contaminants (polychlorinated biphenyls (PCBs), mercury, and lead) for Northerners. With the exception of lead, these contaminants are transported by atmospheric and oceanic currents from industrial regions in the South, accumulate in the Arctic food chain, putting the population at risk for greater exposure. The primary source of lead is the use of lead-containing ammunitions.

In 1994, researchers from Laval University and Wayne State University met with the Public Health Department (PHD) of the Nunavik Regional Board of Health and Social Services, the Nunavik Nutrition and Health Committee (NNHC) and several municipal councils to discuss a plan to study effects of pre- and postnatal exposure to contaminants on infant and child development. All expressed their support for such a study if it would also focus on a broad range of factors that influence child development, including nutrients from traditional food (omega-3 fatty acids), life habits during pregnancy (smoking, alcohol and drug use), and other influences (e.g., maternal stimulation, food insecurity), in addition to environmental contaminants (PCBs and pesticides, mercury and lead). The researchers readily agreed to this proposal and subsequently obtained funding from many sources, particularly the U.S. National Institute of Environmental Health Sciences and the Northern Contaminants Program from Indian and Northern Affairs Canada.

The first phase of the study was initiated in 1996. We investigated the role that nutrients from traditional food, life habits during pregnancy, environmental contaminants and other factors have on infant development. Almost 300 mothers and their infants from Puvirnituq, Inukjuak and Kuujjuaraapik participated in the study between 1996 and 2002. Results and implications from the first phase of this study, when infants were examined at 6 and 11 months of age, were communicated to the Nunavik population by the researchers and public health officials in 2003 and 2004. Key findings of the infancy study were:

- Fatty acids were found to be beneficial for infants' birth weight, vision, ability to communicate or solve problems, ability to sit, stand and walk.
- Prenatal exposure to PCBs had some negative effects on birth weight, duration of pregnancy and visual memory. This exposure did not result in an increased number of low birth weight babies or premature births. Prenatal fatty acid exposure partially reduced the adverse effects associated with PCBs.
- Prenatal exposure to mercury was associated with a decrease in the infant's ability to maintain attention.

- Prenatal exposure to lead was associated with slower processing of information in memory.
- Smoking and alcohol consumption were both associated with some negative effects on infant's growth and/or development. Both alcohol and smoking have the same negative impact as PCBs were found to have on birth weight in this study.
- Maternal intellectual stimulation has a positive effect on infant's mental development.

Based on these findings, public health recommendations were provided at that time to the population by the PHD. However it was not clear if adverse effects found at 6 and 11 months of age would impact on child development at school age. It was therefore decided to continue to follow children to monitor their development and its influencing factors. An evaluation was conducted at age 5 years and similar results were found. Now we are reporting results of the most recent phase of the study; that is, when the children were 11 year old.

RESEARCH PROCEDURES WITH 11 YEAR OLD CHILDREN

Between September 2005 and February 2010, 294 children and their mothers from all 14 Nunavik communities participated to this study. The participants were 11 year old children who participated at birth to the Cord Blood Monitoring Program (1993-1998), which was designed to document the amounts of environmental contaminants and nutrients in newborns. Participants met with the research staff about half a day in the three larger Nunavik villages (Puvirnituq, Kuujjuaq, Inukjuaq). Participants who resided in other communities were transported by plane with their mother to one of the larger villages for testing. Mothers were contacted by phone, were provided with information about the study protocol, and invited to participate with their 11 year old children. Written informed consent was obtained from the mother of each participant; oral assent, from each child. The research was approved by the NNHC, and ethics committees from Laval University and Wayne State University.

Exposure to environmental contaminants and measures of nutrients were measured in cord blood samples (for prenatal exposure) and from a blood sample taken from the child at time of testing (for current/childhood exposure). Child growth (weight, height, head circumference) and vision were assessed by the research nurse. Intellectual function was assess by our research professional, with the test that is used most extensively to assess overall intellectual competence in children, the Wechsler test. Most of the test is appropriate for Inuit culture. It includes 10 subtests, which focus on verbal ability, visuo-spatial reasoning, working memory, and information processing speed. Only the verbal subtests include questions about things that may be unfamiliar to Inuit children. Instead of the three verbal subtests usually included in the Wechsler, we substituted two verbal tasks that included only items that are familiar to Inuit children. The Wechsler is useful because it is a good predictor of how the child will do in school and how, as an adult, he or she will perform in intellectually challenging work.

Questionnaires were provided to the child's teacher through the school principal, who obtained the forms from our research nurse. The teacher was ask to report whether specific behaviours were not seen, somehow/sometimes seen or very/often seen. Examples of questions are:

- To document rule breaking behaviours..." disrupts class discipline"
- To document aggressive behaviours... "gets in many fights"
- To document attention problems... "can't concentrate, pay attention for long"

Research on the effects of exposure to contaminants on child development is challenging because a child who is exposed to one contaminant is also likely to be exposed to others. For example, if a child is exposed to both mercury and PCBs, it can be difficult to determine which contaminant is responsible for how the child performs on a test. To deal with this challenge, we use statistical analysis. We start with one contaminant, such as prenatal mercury exposure and then add prenatal PCB exposure to the analysis. The statistics program then can determine how much of the child's score is affected by the mercury and how much by the PCBs. A second challenge comes from the fact that other variables that affect child development may also be particularly prevalent in more heavily exposed children. For example, more heavily exposed children may come from intellectually less stimulating homes. Again, statistical analysis makes it possible to assess how much of the effect is attributable to the contaminant and how much to the social environment. The following variables were assessed during an interview conducted with the child's mother to document known risk/protective factors for child development that needed to be taken into account in analyses looking at effects of environmental contaminants:

- child characteristics: age, gender, birth weight, duration of the pregnancy with this child, adoption status, breastfeeding status;
- maternal and family characteristics: caregiver (usually the mother) age, education, employment, marital status and non-verbal reasoning abilities, number of persons living in the house, food insecurity, current use of tobacco, alcohol and drugs;
- other prenatal exposures: smoking, alcohol, and drug use during pregnancy.

RESULTS

The following results are obtained once all of the other relevant factors were included in the analysis.

1. Omega-3 fatty acids

Sources and trends: Fish and marine mammal fat are the main sources of omega-3 fatty acid intake in Nunavik. Among the fish species available, Arctic char has the greatest omega-3 fatty acid content. Health surveys conducted in Nunavik in 1992 and 2004 (Qanuippitaa) showed that there was a 30% decline of omega-3 fatty acid levels in adults due to a decrease in country food consumption during that decade. One main conclusion derived from the 2004 health survey was that this drastic change from traditional diet to store bought foods is likely to increase the risk of chronic diseases such as heart diseases.

Current results: In the follow-up of 11-year-old children, omega-3 fatty acids were found to be beneficial for many aspects of child development. Higher intake of fatty acids while the mothers were pregnant was associated with better intellectual function at school age, greater attention and memory when performing intellectual tasks, and greater fine motor function. Thus, the beneficial effects seen during infancy in Nunavik continue to be seen at school age. It should be emphasized that these beneficial effects were specifically related to maternal intake of omega-3 fatty acids during pregnancy.

Previous studies conducted in several different populations with children have reported beneficial effects of prenatal intake of omega-3 fatty acids on vision and cognitive development during the first year of life. Very few studies have examined the long term effects on child development. Although the beneficial effects of greater maternal fatty acid intake during pregnancy have been suspected for some time, this is the first study to provide such extensive and clear evidence of these benefits to the child's intellectual ability 11 years later.

Mercury

Sources and trends: Mercury is an environmental contaminant originating from both anthropogenic and natural sources. Mercury emissions from industries travel long distances in the earth's atmosphere and are deposited on land, lakes and oceans. Although most of the mercury released in the environment is inorganic mercury, it can accumulate in the water where it is transformed into methylmercury by microbial action. This highly toxic form of mercury is accumulated in animal tissues and is magnified in the food chain. The most significant sources of Inuit exposure to methylmercury are marine mammal meat (especially beluga meat) and certain species of fresh water fish such as lake trout. Health surveys conducted with adults indicated a significant decrease in blood mercury levels (a good marker of methylmercury exposure) between 1992 and 2004. However 72% of women of childbearing age continued to be above the recommended blood level for mercury. Since mercury in the environment has not decreased, the observed decrease in blood mercury concentrations is due to a reduction in consumption of country food.

Current results: Prenatal exposure to mercury was associated at 11 years of age with poorer intellectual function, and poorer attention in classroom according to the child's teacher. By contrast, negative effects were not seen from postnatal exposure to mercury. Prenatal exposure to mercury has been associated in previous studies with impaired performance on intellectual tasks requiring the child to be attentive, but the extent to which these cognitive deficits translate into attention deficit observable in the classroom remains unknown. Our results suggest for the first time that prenatal mercury exposure is a risk factor for attention deficit in childhood.

2. Lead

Sources and trends: Lead can be found in Nunavik Inuit, mainly due to past and present use of lead shots for harvesting wild game. A ban on the sale of lead shots was adopted by major Nunavik organizations in 1998, which was followed by a marked decrease in blood lead levels

in adults and newborns. However, a recent monitoring of ammunition in Nunavik stores indicated that the ban is no longer effective, and widespread use of lead shot has resumed.

Current results: Prenatal exposure to lead was associated with reduced body and head size and poorer intellectual function at school age. Lead exposure during childhood was related to more rule-breaking behaviours and hyperactivity in school as reported by the child's teacher. Our study replicates previously reported associations between childhood lead exposure and child behaviours, and corroborates the main conclusion of the most recent lead studies, which is that negative effects are seen at very low exposure levels. However, few other studies have reported negative effects from prenatal lead exposure.

3. PCBs and pesticides

Sources and trends: Polychlorinated biphenyls (PCBs) and chlorinated pesticides (which are called POPs for persistent organic pollutants) represent a group of organic contaminants of concern for child health. Most of them are no longer manufactured but persist in the environment. These compounds accumulate in fatty tissues. The Inuit are exposed to these compounds primarily through the consumption of marine mammal fat. A substantial decline in these compounds among Inuit newborns and newborns from other Quebec regions has been observed in studies during the past 15 years. Similar declines have been observed in Arctic wildlife species that are the primary sources of exposure for Nunavik Inuit. This decline can be explained, in part, by the implementation of the 2004 Stockholm Convention on POPs. This Convention is an agreement among many countries including Canada aiming to reduce and eventually eliminate the release of these chemicals into the environment. The international actions by Inuit leaders contributed to the signing of this Convention.

Current results: In contrary to other studies conducted with fish eating populations, we found no effects of prenatal exposure to PCBs and chlorinated pesticides on intellectual function and child behaviour at 11 years. Childhood exposure to PCBs (but not with pesticides) was related to small decreases in height and head size, an effect not previously reported in fish eating populations exposed to PCBs.

4. Cigarettes smoking during pregnancy, food insecurity experiences by families and social/family environment of the child

Smoking during pregnancy: Smoking during pregnancy, a well known risk factor for low birth weight, has also been associated with child behavioural difficulties in other large scale studies. In our study, increased aggressive and rule-breaking behaviours in school, as well as attention deficit and hyperactivity were seen in children born to mothers who smoked cigarettes while pregnant.

Family environment: The quality of the family environment was determined by parental years of education, occupational status and intellectual problem solving abilities. Family environment influences the degree to which the child is supported in his/her development and learning. As previously reported in numerous studies and various cultures, our study found

that family environment was associated with better development in many domains, including intellectual function, attention when performing intellectual tasks, fine motor function, and child behaviours.

Access to food: Maternal interviews conducted during the course of the study revealed that three of every 10 families did not have enough food or money to buy food during the month before the interview. Children from these families had poorer intellectual function and manifested more rule-breaking behaviours according to their teachers. Economic precariousness related to unemployment and poor education, and substance use are contributing factors for limiting food access in this study.

SUMMARY

In Summary, omega-3 fatty acids during pregnancy were beneficial to many aspects of child development. With regard to the environmental contaminants examined: prenatal exposure to mercury was related to non optimal child development and behaviour; prenatal exposure to lead was associated with reduced growth and lead exposure during childhood was related to behavioural problems; no negative effects were seen in relation with prenatal exposure to PCBs and pesticides while postnatal exposure to PCBs was related to small decrement in growth.

We have learned a lot from the findings of the research that has been conducted in Nunavik about determinants of child development in Nunavimmiut. Additional studies of these children when they reach adolescence has the potential to contribute valuable additional knowledge about the unique bio-psychosocial factors that influence child development in Nunavik. We, therefore, encourage the NNHC, the PHD, municipalities and communities to continue to support and collaborate in creating new knowledge.

CONTACT INFORMATION

For more information on this project, you can contact the Chairperson of the Nunavik Nutrition and Health Committee at 819 964-2222, extension 229, or Gina Muckle, researcher from Laval University and CHUQ Research Center at 418 656-4141 (46199).

Partenaires et collaborateurs

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