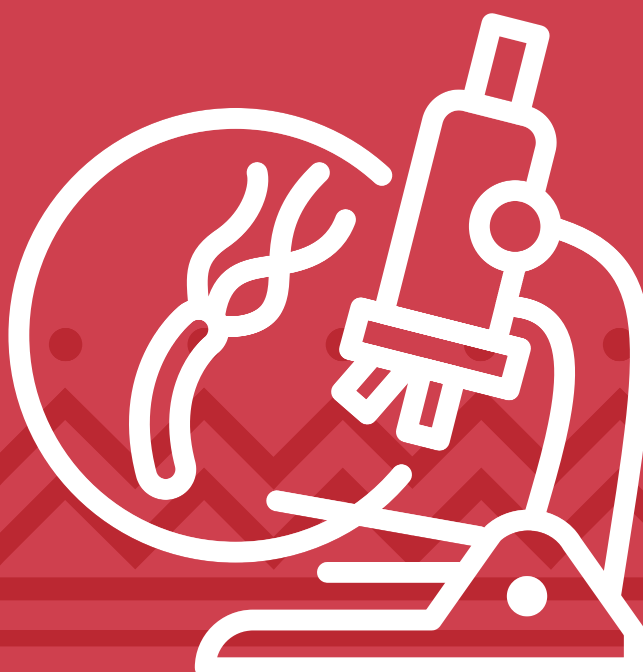
Qanuilirpitaa?
NUNAVIK 2017

ZOONOTIC AND GASTROINTESTINAL DISEASES

QANUILIRPITAA? 2017

Nunavik Inuit Health Survey



RÉGIE RÉGIONALE DE LA SANTÉ ET DES SERVICES SOCIAUX DU NUNAVIK
NUNAVIK REGIONAL BOARD OF HEALTH AND SOCIAL SERVICES

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Nunavik Inuit Health Survey

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RÉGIE RÉGIONALE DE LA SANTÉ ET DES SERVICES SOCIAUX DU NUNAVIK
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QANUILIRPITAA? 2017 HEALTH SURVEY

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In memory of Audrey Flemming and Linda Shipaluk.

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LIST OF ACRONYMS

AGI	Acute gastrointestinal illness
CI	Confidence interval
CV	Coefficient of variation
DNA	Deoxyribonucleic Acid
EDTA	Ethylenediaminetetraacetic acid
ELISA	Enzyme-linked Immunoassay
FFQ	Food frequency consumption questionnaire
IgG	Immunoglobulins G (antibodies)
HpSA	*Helicobacter pylori* stool antigen
MALT	Mucosa-associated lymphoid tissue
MAPAQ	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec
NRBHSS	Nunavik Regional Board of Health and Social Services
NTPP	Nunavik Trichinellosis Prevention Program
PHFSQ	Physical health and food security questionnaire
PSQ	Psychosocial questionnaire
SAT	Stool antigen test
SDQ	Sociodemographic questionnaire
UBT	Urea-breath test

GLOSSARY

Anthroponosis: An infectious disease where humans are the source of infection and inter-human transfer is typical

Chronic carriers: In the context of this thematic report, this term represents individuals who harbour the bacteria *Helicobacter pylori* in their gastrointestinal tract

Dyspepsia: A group of symptoms that cause pain and discomfort in the abdomen

Endoscopy: A method to explore visually the cavities of the human body

Equivocal results: Laboratory results that are not clearly positive or negative

***Igunak*:** Fermented walrus or seal meat

Immunocompromised: Individuals that have an impaired immune system

***Lyssavirus*:** A genus of viruses of the *Rhabdoviridae* family that encompasses the rabies virus

Melena: The presence of blood in stools that is digested (black)

Prevalence: The number of individuals with a specific outcome over the number of individuals in a population or sample. The prevalence is expressed as a proportion (%).

Seroconversion: Designates the phase where antibodies develop and become detectable in the blood or serum

Seroprevalence: The number of individuals with antibodies against a specific outcome in their serum over the number of individuals that submitted serum. Seroprevalence is also expressed as a proportion (%).

Seropositive: Represents individuals that have antibodies in their serum above the threshold established for positivity

Seronegative: Represents individuals that may have antibodies in their serum below the threshold established for equivocal results

Zoonosis (or Zoonotic disease): An infectious disease where animals are the source of infection and inter-human transfer is exceptional

1 BACKGROUND OF THE *QANUILIRPITAA?* 2017 HEALTH SURVEY

The *Qanuilirpitaa?* 2017 Health Survey is a major population health survey conducted in Nunavik that involved the collection, analysis and dissemination of information on the health status of Nunavimmiut. The last health survey conducted prior to it in Nunavik dated from 2004. Since then, no other surveys providing updated information on the health of this population had been carried out. Thus, in February 2014, the Board of Directors of the Nunavik Regional Board of Health and Social Services (NRBHSS) unanimously adopted a resolution to conduct a new health survey in all 14 Nunavik communities, in support of the Strategic Regional Plan.

The general objective of the 2017 health survey was to provide an up-to-date portrait of the health status of Nunavimmiut. It was also aimed at assessing the evolution of trends and following up on the health and health determinants of adult participants since 2004, as well as assessing the health status of Nunavik youth. This health survey has strived to move beyond traditional survey approaches so as to nurture the research capabilities and skills of Inuit and support the development and empowerment of communities.

Qanuilirpitaa? 2017 included four different components: 1) an adult component to document the mental and physical health status of adults in 2017 and follow up on the adult cohort of 2004; 2) a youth component to establish a new cohort of Nunavimmiut aged 16 to 30 years old and to document their mental and physical health status; 3) a community component to establish the health profiles and assets of communities in a participatory research approach; and 4) a community mobilization project aimed at mobilizing communities and fostering their development.

This health survey relied on a high degree of partnership within Nunavik (Nunavik Regional Board of Health and Social Services (NRBHSS), Makivik Corporation, Kativik Regional Government (KRG), Kativik Ilisarniliriniq (KI), Avataq Cultural Institute, Qarjuit Youth Council, Inuulitsivik Health Centre, Ungava Tulattavik Health Centre), as well as between Nunavik, the Institut national de santé publique du Québec (INSPQ) and academic researchers from three Canadian universities: Université Laval, McGill University and Trent University. This approach followed the OCAP principles of Ownership, Control, Access and Possession (First Nations Information Governance Centre, 2007).[1] It also emphasized the following values and principles: empowerment and self-determination, respect, value, relevance and usefulness, trust, transparency, engagement, scientific rigour and a realistic approach.

TARGET POPULATION

The survey target population was all permanent Nunavik residents aged 16 years and over. Persons living full time in public institutions were not included in the survey. The most up-to-date beneficiaries register of all Inuit living in Nunavik, provided by the Makivik Corporation in spring 2017, was used to construct the main survey frame. According to this register, the population of Nunavik was 12 488 inhabitants spread out in 14 communities. This register allowed respondents to be selected on the basis of age, sex and coast of residence (Hudson coast and Ungava coast).

SURVEY FRAME

The survey used a stratified proportional model to select respondents. Stratification was conducted based on communitiesand age groups, given that one of the main objectives of the survey was to provide estimates for two subpopulations aged, respectively, 16 to 30 years and 31 years and over. In order to obtain precise estimates, the targeted sample size was 1 000 respondents in each age group. Assuming a 50% response rate, nearly 4 000 people were required to obtain the necessary sample size. From this pool, the number of individuals recruited from each

1. OCAP® is a registered trademark of the First Nations Information Governance Centre (FNIGC).

community was proportionate to population size and took into account the number of days that the survey team would remain in each community – a situation that imposed constraints on the number of participants that could be seen. Within each stratum, participants were randomly selected from the beneficiaries register. However, the individuals from the 2004 cohort, all 31 years old and over (representing approximately 700 individuals), were automatically included in the initial sample.

DATA COLLECTION

Data were collected from August 19, 2017 to October 5, 2017, in the 14 villages. The villages were reached by the *Amundsen*, a Canadian Coast Guard Icebreaker, and participants were invited on board the ship for data collection purposes. Two recruitment teams travelled from one community to another before the ship's arrival. An Inuk assistant in each community helped: identify, contact and transport (if necessary) each participant; inform participants about the sampling and study procedures; obtain informed consent from participants (video) and fill in the identification sheet and sociodemographic questionnaire.

Data collection procedures for the survey included questionnaires, as well as clinical measurements. The survey duration was about four hours for each wave of participants, including their transportation to and from the ship. Unfortunately, this time frame was sometimes insufficient to complete the data collection process. This survey received ethical approval by the Comité d'éthique de la recherche du Centre Hospitalier Universitaire de Québec – Université Laval.

Aboard the ship, the survey questionnaires were administered by interviewers, many of whom were Inuit. Face-to-face interviews were conducted using a computer-assisted interviewing tool. If there were problems with the laptop connections, paper-form questionnaires were filled out. The questionnaires were administered in Inuktitut, English or French, according to the preference of the participants. Interviewers received training in administering the questionnaires prior to the start of the survey. The questionnaires were divided into five blocks: psychosocial interview (blocks 1 and 3), physical health and food security interview (block 2), food frequency questionnaire (block 4), and sociodemographic interview (block 5).

The survey also included a clinical component, with tests to document aspects of physical health, sampling of biological specimens (such as blood, oropharyngeal swab, urine, stool, and vaginal swab), spirometry, and an oral clinical exam. These sessions were supervised by a team comprised of nurses, respiratory therapists, dentists, dental hygienists and assistants, and laboratory technicians.

PARTICIPATION

There were a total of 1 326 participants, including 574 Nunavimmiut aged 16 to 30 years old and 752 Nunavimmiut aged 31 years old and over, for total response rates of 30.7% and 41.5%, respectively. The participants' distribution between the two coasts (Ungava and Hudson) was similar. The distribution of men and women was unequal, with twice as many women (873) than men (453) participating in the survey. If the results obtained from this sample are to be inferred to the target population, survey weights must be used.

Overall, as compared to the 2004 survey, the response rate (i.e., the rate of participants over the total number of individuals on the sampling list) was lower than expected, especially among young people. This includes the refusal rate and especially a low contact rate. Several reasons might explain the low response rate, including the short time period available to contact individuals prior to the ship's arrival in the community and non-contact due to people being outside of the community or on the land. Nevertheless, among the individuals that were contacted (n = 1 661), the participation rate was satisfactory with an internal participation rate of 79.9% More details on the collection, processing and analysis of the data are given in the Methodological Report.

2 MESSAGE FROM THE AUTHORS

This thematic report covers only the microbiological and parasitological risks associated with pathogens that can be found in local country food or water, or that are associated with specific realities encountered in Nunavik. It is of the utmost importance that readers remain aware of the multiple benefits of country food harvesting and consumption, including Inuit cultural resilience, subsistence activities, food security and nutrient intake. These subjects are covered in other reports.

3 INTRODUCTION

Nunavik is inhabited by about 12 000 Inuit, a population that shares one language (Inuktituk), a common culture and beliefs (Inuit Tapiriit Kanatami, 2018). Although the way of life of Nunavimmiut has markedly changed in the last century, the communities share a vibrant culture, involving several traditional activities such as hunting, fishing, trapping and berry picking, and the consumption of local foods (Shephard & Rode, 1996). Some cultural practices and preferences, such as eating raw meat, may increase the risk of exposure to certain zoonotic diseases (Wormworth, 1995). Many people in Nunavik are concerned about wildlife diseases and the consequences that they can have on people's health. Wildlife harvesters are sensitive to abnormal behaviour in animals or the unusual appearance of animal flesh, which may indicate a zoonotic disease. It is therefore important to study potential pathogens that can be found in country food and to develop and communicate recommendations accordingly, especially in the context where meat is often eaten raw. Other northern particularities related to different sources of drinking water and to overcrowding may also contribute to the transmission of gastrointestinal diseases. This thematic report covers two specific groups of infectious diseases, namely, those transmitted by animals (also called zoonoses) and those affecting the gastrointestinal tract, as well as a number of related issues such as animal bites, acute gastrointestinal illness and blood in stool.

The realities encountered in Nunavik diverge from those of southern Quebec. These differences have led public health authorities to organize distinct population surveys with the objective of documenting Nunavimmiut health issues. Three specific survey-based health profiles have been produced in the region: Santé Québec's *"A Health Profile of the Inuit"* (1992), the *Qanuippitaa?* 2004 Nunavik Health Survey and the present *Qanuilirpitaa?* 2017 Nunavik Health Survey (Hamel et al., 2020; Gouvernement du Québec, 1994; Rochette & Blanchette, 2007). From here on, the last two surveys will be referred to in the text as *Qanuippitaa?* 2004 and *Qanuilirpitaa?* 2017.

Based on current knowledge and regional needs, the *Qanuilirpitaa?* 2017 Steering Committee prioritized three zoonotic diseases (rabies, trichinellosis, toxoplasmosis) and two gastrointestinal diseases (cryptosporidiosis and helicobacteriosis). Whereas both of these gastrointestinal diseases are transmitted from humans to humans, cryptosporidiosis can also be of zoonotic origin.

All words in bold are defined in the glossary.

3.1 RABIES *LYSSAVIRUS*

Rabies is caused by a ***Lyssavirus*** which is transmitted to humans mainly via bites or contact with the saliva of infected susceptible hosts (Rupprecht et al., 2017). The virus can enter the human body by a breach in the skin and travel to the central nervous system by replicating in peripheral nerves. Once clinical signs have appeared, the infection is considered uniformly fatal (Jackson, 2005). Throughout the world, only a handful of individuals have survived after the onset of symptoms, and they generally have important neurological sequelae (De Souza & Madhusudana, 2014).

Rabies is a major concern for the region since Nunavik is considered endemic for the fox variant of the virus (Nadin-Davis et al., 2012). Arctic and red foxes as well as wolves act as the main reservoir, but spillover of rabies in domestic dogs living in or around Nunavik communities is documented almost annually (ACIA, 2020). Because dogs are generally left outdoors (e.g., free-roaming, attached or sometimes in enclosures or on islands), they can acquire the virus from wildlife and pose a risk to human health. Vaccination of domestic dogs against rabies is offered to decrease the risk of transmission to humans (Aenishaenslin et al., 2014).

Even though animal rabies is endemic in Nunavik, no human cases have ever been reported. Post-exposure prophylaxis in humans has been recorded since 1996 in the rabies immunization registry maintained by the Nunavik Public Health Department. The registry also contains information about the animal interactions that prompted each visit. Since this registry potentially underestimates the proportion of residents who are bitten or scratched by an animal, the Nunavik Regional Board of Health and Social Services (NRBHSS) became interested in using *Qanuilirpitaa?* 2017 to estimate the frequency of these types of animal contacts in the region.

In addition, the literature review conducted in preparation for *Qanuilirpitaa?* 2017 found 11 studies suggesting that rabies-specific neutralizing antibodies have been observed in unvaccinated humans in various parts of the world, including among Inuit hunters from Nunavut (Augusto Lopez et al., 1992; Black & Wiktor, 1986; Doege & Northrop, 1974; Follmann et al., 1994; Gilbert et al., 2012; Iroegbu & Uhuegbu, 1992; Ogunkoya et al., 1990; Orr et al., 1988; Ruegsegger et al., 1961; Ruegsegger & Sharpless, 1962). Because rabies is endemic in Nunavik wildlife and since handling wild carnivores is a traditional activity, a retrospective research project was initiated.

The objective of this sub-project was to evaluate the presence of rabies-specific neutralizing antibodies in Nunavik, using *Qanuippitaa?* 2004 archived serum samples, before undertaking the *Qanuilirpitaa?* 2017 survey. The key findings of this sub-project are summarized in the present thematic report.

3.2 *TRICHINELLA NATIVA*

Trichinella nativa is a small encapsulated nematode parasite found in the muscles of animals, mostly carnivores (Dick & Pozio, 1971). For example, a recent study showed that ~60% of polar bears, ~10% of arctic foxes and 7% of black bears in Nunavik have been infected by the parasite. In addition, 2 to 4% of Nunavik walruses have been exposed to the parasite as opportunistic scavengers feeding on infected animal carcasses (Larrat et al., 2012). Antibodies to the parasite have infrequently been detected in seals elsewhere in the Arctic (Forbes, 2000). In Nunavik, seal meat is not included in the community-led *Trichinella* screening program but it can be tested if necessary when an outbreak investigation occurs (Proulx, 2013).

Trichinellosis in human populations is characterized by either severe gastrointestinal and/or muscular symptoms that occur between one and four weeks after eating the infected meat (Capo & Despommier, 1996). Trichinellosis is a notifiable disease in Québec (Chartrand et al., 2018). In Nunavik, past outbreaks of trichinellosis have been linked to the consumption of raw or insufficiently cooked walrus meat, and to a lesser extent, the consumption of fox and polar bear meats (Larrat et al., 2012). In keeping with usual practice in Nunavik, public health authorities recommend that the meat of terrestrial carnivorous mammals be eaten well cooked. Cooking inactivates the parasite *T. nativa,* which is resistant to freezing (Larrat et al., 2012). As for walrus, promoting the cooking of walrus meat is not in line with Inuit culture and has not been successful (Proulx et al., 2002). The Nunavik Trichinellosis Prevention Program (NTPP) was initiated in 1992 and has been available to all communities since 1996.The NTPP allows for the detection of larvae in harvested walrus ahead of consumption (Proulx et al., 2002). This promotes the safe consumption of raw or fermented walrus while decreasing the risk of acquiring the parasite.

Despite the NTPP, occasional trichinellosis outbreaks such as those in 2013 and 2016 still occur in the region. The consumption of insufficiently cooked polar bear meat mistaken for another animal meat and of seal meat were respectively suspected as the source of infection with this parasite in the 2013 and 2016 outbreaks (Proulx, 2013, 2016). Because the contemporaneous main source of exposure to this parasite needs to be better documented, this parasite was identified as a priority for the *Qanuilirpitaa?* 2017 zoonotic component.

3.3 *CRYPTOSPORIDIUM* SP.

Cryptosporidium is a protozoan parasite found in animals and humans. Even if more than 30 species of *Cryptosporidium* have been identified, humans are generally infected by *C. hominis* through human-to-human contacts (**anthroponosis**) or by *C. parvum* generally through animal contacts (**zoonosis**) (Hubálek, 2003). Cryptosporidiosis can cause gastrointestinal symptoms (e.g., diarrhea, nausea, vomiting, abdominal discomfort) in both adults and children. Chronic infections can impede child growth as well as cognitive development and performance as a result of malabsorption/malnutrition (Checkley et al., 2015). In immune competent humans, the infection is generally self-limitating and often underdiagnosed in the general population. Cryptosporidiosis is a notifiable disease in Québec and Canada (Government of Canada, 2019; Chartrand et al., 2018).

An outbreak of *C. hominis*, the first ever reported in Nunavik, affected 10 out of the 14 Nunavik communities during 2013 and 2014 (Thivierge et al., 2016). The parasite was identified in the stools of 51 of 283 symptomatic individuals (18%). Using projections for the entire population, it was estimated for 2013 and 2014 that the proportions of infection were 0.4% and 1.3% for the entire Nunavik population and for children under five years of age, respectively (Thivierge et al., 2016). Prior to this outbreak, no cases of cryptosporidiosis had been identified in Nunavik; however, this parasite has not been systematically researched (J. F. Proulx. Pers. Comm.

2020). A smaller outbreak occurred during summer 2014 and was most likely related to the use of the pool in Kuujjuaq. Because *Cryptosporidium* was not identified at the species level, this event could be independent of or related to the 2013-2014 outbreak (M. Brisson. Pers. Comm. 2020).

In neighboring Nunavut, a similar self-contained[2] event with high prevalence of cryptosporidiosis was reported between 2010 and 2011, with 19.8% of stool specimens submitted for diarrheal illness retrospectively found to harbour *Cryptosporidium* sp. (Goldfarb et al., 2013). As in Nunavik, surveillance after this period documented the disappearance of *Cryptosporidium* in subsequent years. However, in contrast to Nunavik, all Nunavut isolates were found to be the zoonotic species *C. parvum*, suggesting different epidemiologic drivers in this region.

Besides *C. hominis*, which is mostly reported in humans, *Cryptosporidium*, not identified at the species level, has been found in blue mussels from Nunavik (Lévesque et al., 2010) and in the intestinal contents of ringed and bearded seals as well as in caribou and whales from elsewhere in the Arctic (Dixon et al., 2008; Hughes-Hanks et al., 2005; Santín et al., 2005; Siefker et al., 2002). This parasite has never been identified in municipal or natural waters of Nunavik but may be naturally found in aquatic environments and have been reported elsewhere as the main transmission pathway for some cryptosporidiosis outbreaks (Efstratiou et al., 2017; Isaac-Renton et al., 1999; MacKenzie et al., 1995).

Following the 2013 – 2014 *Cryptosporidium* outbreak in Nunavik, local public health authorities expressed the need to further document exposure to this parasite and identify potential risk factors in the region.

3.4 *TOXOPLASMA GONDII*

Toxoplasma gondii is a parasite that is particularly harmful for the fetus of mothers infected for the first time during pregnancy, as well as for people with compromised immune systems (Weiss & Dubey, 2009). These vulnerable populations may develop severe lifelong consequences following primary toxoplasma infection such as congenital malformation, ocular and neurological disorders and miscarriages (Bollani et al., 2013). Occurrences of congenital toxoplasmosis in Nunavik have been documented since the 1980's, leading to the screening of all Nunavik pregnant women for *T. gondii* antibodies since 1982 (McDonald et al., 1990). Detection of antibodies is indicative of prior exposure to the parasite which offers protection against reinfection when individuals have a competent immune system (Tenter et al., 2000). Hence, no particular recommendations in regards to *T. gondii* are offered to the general population, and only pregnant Inuit women without antibodies against the parasite (i.e., **seronegative**) receive counselling to protect their fetus from congenital infection (NRBHSS, 2018). **Immunocompromised** patients also receive counselling in order to decrease their risk of a primary infection or re-activation through possible water-, food – or soil-borne transmission pathways (Biedermann et al., 1995). The recommendations have evolved over time as a function of scientific knowledge. Current recommendations can be summarized as follows (NRBHSS, 2018):

- avoid drinking untreated/raw water from the land (i.e., without any form of treatment such as boiling or filtering);
- avoid eating raw, smoked or dried meat from land mammals, wild birds, marine mammals and shellfish (unless previously frozen for at least 3 days at –20 °C);
- avoid eating fermented meat from land and marine mammals;
- avoid eating raw wild eggs;
- avoid handling fresh raw meat, animal carcasses and cat poop.

In the 1990s, the percentage of **seroconversion** during pregnancy was estimated between 1.2 to 8.6% with no congenital toxoplasmosis diagnosed during this period. Pregnant women that seroconvert are treated to prevent vertical transmission (Lavoie et al., 2008). Seroconversion against *T. gondii* or acute toxoplasmosis is not a mandatory notifiable condition in Québec anymore and congenital toxoplasmosis remains a rare occurrence (J.-F. Proulx. Pers. Comm, 2020).

Domestic and wild cats are the only documented animals able to excrete the parasite in the environment (in the oocyst form) while other animal species living in the Arctic can only carry the parasite encapsulated in their muscles and nervous tissues (i.e., tissue cysts) (Elmore et al., 2012). Cooking the meat or freezing it for at least 3 days at –20 °C is known to destroy the parasite (Mirza Alizadeh et al., 2018). Because domestic and wild cats are rarely present in Nunavik, direct exposure to the parasite by handling cat feces or through contaminated soil (e.g., gardening) would be surprising. Congenital and medical (by organ or blood donation) transmission can be excluded because of their rare occurrence, leaving consumption of infected raw

2. No new infections related to this outbreak were observed.

animal tissues (that were not previously frozen) or drinking untreated water to be the two main suspected transmission pathways in Nunavik.

Though the aforementioned recommendations contribute to reducing the risk of exposure to *T.gondii* via different transmission pathways, better identifying the main risk factors associated with *T. gondii* in Nunavik remains essential, especially to improve the protection of seronegative pregnant women and immunocompromised groups from the consequences of this disease.

3.5 *HELICOBACTER PYLORI*

Helicobacter pylori is a bacterium that colonizes the mucous overlying the mucosa of the stomach and occasionally the small intestine, causing various degrees of inflammation (i.e., gastritis) (Dooley et al., 1989). It is a bacteria mainly transmitted between humans. Seventy percent (70%) of individuals harboring the bacteria (**carriers**) remain asymptomatic (Meurer & Bower, 2018). The remaining 30% of carriers can develop ulcers or chronic symptomatic inflammation of the stomach (Logan & Walker, 2001). The symptomatic carriers can exhibit gastric symptoms (mainly **dyspepsia**), weight loss, or loss of blood in the stool (fresh or digested such as **melena**). The vast majority of gastric and duodenal ulcers are associated with *H. pylori* (Logan & Walker, 2001). Chronic inflammation of the stomach caused by the presence of *H. pylori* is causally linked to the development of gastric cancer (adenocarcinoma or gastric mucosa lymphoma) in chronic carriers, although this remains a very rare event (Wroblewski et al., 2010). While *H. pylori* increases the risk of the above complications, it may also be associated with health benefits, including lower risk of esophageal reflux and protection against childhood asthma and related disorders (Cover & Blaser, 2009).

The only available data for this pathogen in Nunavik goes back to the 1992 survey which revealed that approximately 27% of pregnant Inuit women from Nunavik had antibodies (IgG) against *H. pylori* (Hodgins, 1997). The most important risk factors associated with *H. pylori* infections are overcrowding and a lack of modern sanitation infrastructure (Sethi et al., 2013).

The *Maastricht V/Florence Consensus Report* was elaborated some years ago and consisted of a “test and treat” strategy following uninvestigated dyspepsia, using non-invasive diagnostic methods (i.e., urea-breath test, serology or stool antigen test (SAT) (Malfertheiner et al., 2017). Recently, researchers dealing with *H. pylori* infections in Arctic Indigenous populations (including Inuit) have questioned the applicability of this approach in populations with such an elevated proportion of antibodies (i.e., high **seroprevalence**) (McMahon et al., 2016). Instead of testing all dyspeptic patients, a direct upper **endoscopy** is proposed for patients with a combination of dyspepsia and worrisome signs or symptoms (e.g., weight loss, fecal blood, anemia) as well as for those without worrisome symptoms but showing no improvement after administration of an acid reducing medication (proton-pump inhibitors or H2 blockers) (McMahon et al., 2016). When improvement with the acid-reducing approach is noticed, only the recurrence of clinical symptoms is followed.

Nunavik medical doctors are concerned by the increasing number of *H. pylori* infection cases and have sought formal expertise to assess the prevalence of this infection and the associated risk factors. This work can help to better inform management protocols.

3.6 OBJECTIVES

This thematic report focuses on zoonotic diseases and gastrointestinal illness in the population of Nunavik. The two main objectives are to describe the proportion of Nunavimmiut affected and to conduct exploratory bivariate analyses to identify factors associated with the following health outcomes:

- 2004 seroprevalence of antibodies against rabies and prevalence of animal bites;
- 2017 seroprevalence of antibodies against *Trichinella* sp., *Cryptosporidium* sp., *T. gondii;*
- 2004 and 2017 seroprevalence of antibodies against *H. pylori* and 2017 prevalence of an active infection (stool active infection);
- 2017 prevalence of acute gastrointestinal illness (AGI) and prolonged AGI episodes (3 days and more), median duration of an AGI and the presence of occult blood in stools.

4 METHODOLOGICAL ASPECTS

4.1 *QANUIPPITAA?* 2004 DATA COLLECTION

The methodological aspects of *Qanuippitaa?* 2004 are fully described in the *Qanuippitaa? How are we? Methodological Report* (Rochette & Blanchet, 2007). The 2004 archived serum was used and analyzed in 2017 with the objective of evaluating the risk of transmission of two pathogens of interest: rabies *Lyssavirus* and *H. pylori*.

4.1.1 Rabies *Lyssavirus* retrospective testing

The complete methodology for the cross-sectional rabies study is described elsewhere (Ducrocq, Proulx, Lévesque, et al., 2019). Briefly, in preparation for *Qanuilirpitaa?* 2017, 196 archived serum samples from 2004 participants were sent to the National Microbiology Laboratory based in Winnipeg in 2015. The laboratory tested them for the presence of rabies virus specific neutralizing antibodies using the fluorescent antibody virus neutralizing assay (Knowles et al., 2009). The participants were selected based on their 2004 declaration of handling terrestrial mammals (i.e., skinning, washing or cutting) more than ten times in the previous year (n = 107) and if they reported hunting more than once a week in spring (n = 95). Six participants were excluded because of a vaccination history recorded in the 1999-2004 Nunavik rabies vaccination registry.

4.12 *Helicobacter pylori* bacteria retrospective testing

Amongst the 303 participants of the 2004-2017 cohort, archived serum samples were available for 263 of them (86.8%) and were tested to estimate the seroprevalence of *H. pylori* infection in 2004.

4.2 *QANUILIRPITAA?* 2017 DATA COLLECTION

Because all other methodological aspects of *Qanuilirpitaa?* 2017 are fully described in the methodological report, only specific aspects related to this thematic report are covered in the following sections.

4.2.1 Questionnaire variables

Participants of *Qanuilirpitaa?* 2017 answered questions grouped in the following five questionnaires: the sociodemographic (SDQ), psychosocial (PSQ 1 and 2), physical health and food security (PHFSQ) and food frequency (FFQ) questionnaires. For this thematic report, only variables acting as potential risk or protection factors were studied.

The SDQ allowed information to be collected in order to classify participants according to sex, age group, community size, ecological region[3] ("Hudson Strait", "Hudson Bay" and "Ungava Bay"), education, income, employment and number of people living in the home (refer to the *Qanuilirpitaa?* 2017 thematic report "Sociodemographic Characteristics" for more information on these variables).

The PSQ contained information on the main water sources used during the summer and winter months (with five modalities: "municipal system (tap water/water tank at home)", "tap directly at the water plant", "bottled water", "from nearby lake, river or stream" and "melted snow, ice or iceberg"), the use of water treatments at home (boiling, filtering or other with two possible modalities: yes or no), the frequency of water tank cleaning (with five modalities: "in the last month", "in the last year", "about 2 years ago", "between 2 – 5 years ago" and "more than five years ago") (refer to the *Qanuilirpitaa?* 2017 thematic report "Housing and Drinking Water" for more information on these variables).

3. Hudson Strait communities: Ivujivik, Salluit, Kangiqsujuaq and Quaqtaq; Hudson Bay communities: Akulivik, Inukjuak, Puvirnituq, Umiujaq and Kuujjuarapik; Ungava Bay communities: Kangirsuk, Aupaluk, Tasiujaq, Kuujjuaq and Kangiqualujjuaq.

The PHFSQ contained questions pertaining to the frequency of hunting, fishing and seafood harvesting for each season (spring, summer, fall and winter) with four modalities: "never", "less than once a month", "1 to 3 days per month" and "once a week and more". The PHFSQ also contained questions on the number of "wild birds", "caribou or muskox", "fox, wolves or dogs" and "bear" prepared (skinning, washing, cutting, etc.) in the past 12 months with five modalities: "none", "1 – 2", "3 – 9", "10 – 29" and "more than 30". Lastly, the PHFSQ contained questions concerning interactions with wild or domestic animals, AGI and worrisome systemic symptoms potentially associated with *H. pylori* infection:

- "In the last 12 months, have you ever been bitten or scratched by: 1) a dog and 2) a wild animal (e.g., wolf, fox or bear)?"
- "In the past 30 days, did you experience any illness that included vomiting or diarrhea – excluding symptoms related to drugs, alcohol consumption, pregnancy and chronic illness?"
- "How many days did your episode of vomiting and/or diarrhea last?"
- "During the last six months, have you involuntarily lost weight and not gained it back? (Did you have to tighten your belt or do your clothes fit more loosely?)"
- "In the last six months, did you have very black stool (like coal tar) or have you ever seen blood in your stool?"

The FFQ contained questions on the frequency of consumption, in the last three months prior to the survey, of the following country food: marine mammals (beluga, seal and walrus), terrestrial mammals (caribou, polar bear and muskox), wild birds (ptarmigan/partridge and Canada/white goose), fish (lake trout, sea trout/brook trout/salmon, Arctic char, pike or walleye, other fish such as lake whitefish and sculpin) and "shellfish" (molluscs (mussels, scallops, clames, etc.) and urchins). Country food frequency consumption variables contained modalities: 1) "never or less than once a month"; 2) "1-3 times a month"; 3) "once a week"; 4) "2-6 times a week"; 5) "once a day"; 6) "2-3 times a day"; and 7) "4 times and more a day". Participants were also asked if they most often ate the following specific country food raw: beluga meat, seal meat, walrus meat/***igunak*** (fermented walrus), caribou meat, ptarmigan/partridge, goose and shellfish. If the country food was not eaten raw very often, it is expected that it was consumed in another form after being cooked, boiled, fried, etc. The question "Do you often eat this raw?" (hereinafter referred to as "mostly eaten raw") was not available for any of the fish species or for polar bear and muskox (refer to the *Qanuilirpitaa?* 2017 thematic report "Country and Market Foods Consumption and Nutritional Status" for more information on these variables). In keeping with usual practice in Nunavik, public health authorities recommend that bear and muskox meat be eaten well cooked. For bear, this precaution is well rooted in historical and contemporary cultural practices. Fish species are consumed very differently depending on the season. For example, Arctic char is mainly consumed raw while frozen or after being thawed during winter, whereas other fish such as pike, walleye, sculpin and lake whitefish are generally cooked.

4.2.2 Blood collection and laboratory analysis

Blood was collected by a trained nurse in ethylenediaminetetraacetic acid (EDTA) tubes, was left to rest at room temperature for a few minutes and was then centrifuged. Serum was collected, frozen at −20 °C and sent to laboratories for analysis on frozen or dry ice. For the rabies and *H. pylori* components, archived serum samples from the *Qanuippitaa?* 2004 survey were also analyzed. The presence of antibodies in the serum samples (serology), which indicates a past or current exposure to the zoonotic and gastrointestinal diseases under study, was identified with the following assays:

1) Platelia *H. pylori* IgG Assay™ to detect antibodies against *Helicobacter pylori* (Biorad, Marnes-la-Coquette, France) (Biorad, 2009). Serological results were available for 1 325 of the 1 326 participants of *Qanuilirpitaa?* 2017 as well as, retrospectively, in the 2004 serum of 263 participants of the 2004-2017 cohort. Serological testing was performed by the microbiology laboratory of the CIUSSS[4] du Saguenay—Lac-Saint-Jean – Hôpital de Chicoutimi;

2) Homemade enzyme-linked immunoenzymatic assays (ELISA) to measure antibodies (IgG) against *T. gondii, Trichinella* sp. and *Cryptosporidium* sp. (Gp45, p23 and Gp900 recombinant antigens involved in the adhesion of the parasites entering the enterocytes). Serological results were available for 1 325 of the 1 326 participants of *Qanuilirpitaa?* 2017 and produced by the National Reference Centre for Parasitology.

Thresholds for seropositivity for each of the aforementioned laboratory tests are described in Table 1, along with the expected longevity of immunity reported in the literature for each pathogen.

4. Integrated university health and social services centre.

Table 1 Interpretative criteria for serological testing

Pathogens	Thresholds for each criterion				Units[1]	Longevity of naturally acquired antibodies
	Negative	Equivocal	Positive low	Positive high		
Trichinella spp	< 0.25	0.25 to < 0.35	0.35 to < 1.20	≥ 1.20	OD	Lifelong immunity suspected (Capo & Despommier, 1996)
T. gondii	< 8	≥ 8 to < 11	≥ 11		UI/ml	Lifelong (Weiss & Dubey, 2009)
Cryptosporidium sp.	< 0.30	< 0.40	≥ 0.40		OD	Unknown (Borad & Ward, 2010)
H. pylori	≤ 0.90	0.91 – 1.09	≥ 1.10		ISR	15 years in 69% of an adult cohort of Alaskan Eskimos (Zhu et al., 2006)
Rabies *Lyssavirus*	< 0.5	–	≥ 0.5		UI/ml	Not applicable since it is considered a fatal disease

1. OD = Optical density; IU = International units; ISR = Immune status ratio, which is a calibrated optical density.

4.2.3 Stool collection and laboratory analysis

All *Qanuilirpitaa?* 2017 participants were invited to submit a stool sample in a plastic airtight container. Stools were stored at −20 °C and shipped frozen on dry ice to laboratories. Amplified IDEIA™ Hp StAR™ , a qualitative sandwich Enzyme Immuno-Assay, was performed on 100 µL of faeces according to the manufacturer's recommendations (Premier Platinum HpSA, Meridian Diagnostics, Cincinnati, USA) by the Laboratoire de biochimie of the Hôpital de Granby of the CIUSS de l'Estrie – Centre hospitalier universitaire (CHU) de Sherbrooke (OXOID Limited, 2019). This test allows detection of *H. pylori* antigens in stools, which confirms the presence of an active infection (stool active infection). Results for the *H. pylori* stool antigen test (SAT) were classified according to the following optical density thresholds: negative (OD < 0.15), **equivocal** (OD ≥ 0.15 and < 0.2) and positive (OD ≥ 0.2) (OXOID Limited, 2019). Following the recommendation of the Canadian Cancer Society, screening for occult blood in stools was performed with the Fecal Immunochemical Test (OC-Auto SENSOR DIANA iFOB, Polymedco, New York, USA) by the Laboratoire de dépistage du cancer colorectal of the CIUSSS de l'Estrie – CHU de Sherbrooke, only for participants aged 50 years and over who had submitted a stool sample (MSSS, 2019).

4.2.4 Medical chart review

A review of the medical charts of 1 234 participants was performed during and after the 2017 health survey (Table 2). *H. pylori* diagnosis had occurred between November 1994 and March 2018 and only the non-weighted variables potentially associated with *H. pylori* infections are described here (Table 2).

Table 2 Variables potentially associated with *H. pylori* infection extracted from the 1 234 reviewed medical files

Potential *H. pylori* associated clinical diagnosis	Exclusions
Related gastric cancer or mucosa associated lymphoma tissue (MALT)	Oesophageal adenocarcinoma since it is more frequently associated with gastro-esophageal reflux disease (Rawla & Barsouk, 2019)
Infection (independently of diagnostic methods)	–
Gastritis	Gastritis associated with alcohol (n = 39), viruses (n = 3) or medication (n = 2) (e.g., non-steroidal anti-inflammatory agents)
Gastric or duodenal ulcers	–

4.3 STATISTICAL ANALYSES

4.3.1 Descriptive analyses

Weighted prevalences were computed for the following seven health outcomes: *Qanuilirpitaa?* 2017 seroprevalence of antibodies against *Trichinella* sp., *Cryptosporidium* sp., *T. gondii and H. pylori*; and *Qanuilirpitaa?* 2017 prevalence of self-reported animal bites or scratches, episodes of vomiting and diarrhea, and the presence of occult blood in stool samples. The weights corresponded to the inverse probabilities of participating in *Qanuilirpitaa?* 2017 based on village of origin, sex and age group as well as the laboratory or questionnaire response level. The sample was re-equilibrated in order to reflect the frequency of outcomes in the Nunavik population (Hamel et al., 2020). Non-weighted proportions were computed for five outcomes: *Qanuippitaa?* 2004 rabies *Lyssavirus* and *H. pylori* seroprevalence, *Qanuilirpitaa?* 2017 *H. pylori* active infection, *Qanuilirpitaa?* 2017 median duration of an AGI and prevalence of prolonged AGI. These outcomes were not weighted because they do not represent a random sample of Nunavik's population.

4.3.2 Creation of new variables

Some variables were recoded for the bivariate analyses detailed in Table 3. Using the SDQ, the age groups were reduced to "16-30", "31-49" and "≥ 50". Overcrowding was evaluated using the person-per-room index based on the number of people living in the house/number of bedrooms in the house +2 to account for the kitchen and living room (overcrowding was considered present if > 1 person per room and not present if ≤ 1 person per room) (refer to the *Qanuilirpitaa?* 2017 thematic report "Housing and Drinking Water" for more information).

Using the PHFSQ, a new binary variable was also created to document being bitten by a dog and/or a wild animal ("yes" or "no"). In addition, a binary variable reflecting the use ("yes" or "no") of at least one of the three water treatment options at home (boiling, filtering or other) was created. New modalities related to the principal sources of drinking water were created: 1) "municipal water" (grouping tap water/water tank at home/tap directly at the water plant); 2) "bottled water" and 3) "natural sources" (grouping nearby lakes, rivers or streams, melted snow, ice or icebergs). A new variable with three modalities was also created for the number of wild animals prepared (skinning, washing, cutting, etc.) in the past 12 months: "none", "between 1 – 9" and "≥ 10" (except for polar bear for which the last two modalities were grouped).

Using the FFQ, three types of variables were created using the initial seven modalities for consumption of country foods and the variable associated with specific country foods mostly eaten raw. First, a binary variable was created to classify the frequency consumption of each aforementioned country food item as: 1) "less than once a month" and 2) "once a month and more". Second, a mean consumption (as a continuous variable in times per month) was attributed to each of the following seven frequency categories: 0 = "never or less than once a month"; 2 = "between 1-3 times a month"; 4 = "once a week"; 16 = "between 2 and 6 times a week"; 30 = "once a day"; 75 = "between 2 and 3 times a day"; and 120 = "4 times a day and more". The values were then multiplied by the variable "mostly eaten raw": a value of "one" was attributed if mostly eaten raw and of "zero" if otherwise (this variable is not available for polar bear and fish species). The continuous frequencies were classified in two categories (low and high frequencies of consumption of country food, mostly raw, based on the median), creating the second country food associated variable. For *T. gondii*, a third variable was created to reflect the frequency of consumption for the following country food groups in the three months before the survey: marine mammals (beluga, walrus and seal meats) (polar bear was excluded since it is always cooked), terrestrial mammals (caribou and muskox), wild birds (ptarmigan/partridge and goose), fish (lake trout, sea trout/salmon, pike/walleye and other fish [lake whitefish and sculpin]). These group frequencies were classified as terciles (low, intermediate and high).

4.3.3 Bivariate analyses

In order to identify explanatory variables associated with each of the health outcomes, a literature review was performed to identify transmission pathways and variables that could influence each primary health outcome. The review was done during the planning phase of *Qanuilirpitaa?* 2017 to make sure that the questions would cover these topics. Table 3 describes all the specific explanatory variables retained for each of the primary and secondary health outcomes.

Table 3 Bivariate analyses between health outcomes and potential risk factors

Source	List of variables available for bivariate analysis	Health outcomes
SDQ	Sex, age group, ecological region, education, income and overcrowding	> *T. gondii* (LAB) > *Trichinella* sp. (LAB) > *H. pylori* (LAB) > *Cryptosporidium* sp. (LAB) > Animal bites or scratches (PHFSQ) > Acute gastrointestinal illness (PHFSQ) > Occult blood in stools (LAB)
PSQ	Water sources (summer and winter), water treatment and frequency of water tank cleaning	> *T. gondii* (LAB) > *H. pylori* (LAB) > Acute gastrointestinal illness (PHFSQ)
PHFSQ	Frequency of preparation (skinning, washing, cutting, etc.) of wild birds and, of terrestrial and marine mammals	> *Trichinella* sp. (LAB) (limited to preparation of marine mammals) > Animal bites or scratches (PHFSQ) (limited to preparation of fox, wolves and dogs) > *T. gondii* (LAB)
PHFSQ	*H. pylori* self-reported questions	> *H. pylori* (LAB)
FFQ	Annual consumption of country food groups, frequency of consumption of country food potentially harbouring the parasite, if country food is eaten mostly raw, and frequency of consumption of mostly raw meat	> *T. gondii* (LAB) > *Trichinella* sp. (LAB) (limited to consumption of marine mammals) > *Cryptosporidium* sp. (LAB)

LAB = laboratory results (serology or stool antigen test)

For bivariate analyses, all proportions were compared using a global chi-square (χ^2) test with a Satterwaithe correction which could suggest that at least one comparison was statistically significant if the variable had two modalities or more (Hamel et al., 2020). When crossing two variables, the weights associated with the variable with the most missing values were used. Only positive and negative test results were used for the bivariate analyses (equivocal or questionable results were excluded).

All data analyses for this thematic report were done using SAS software, Version 9.4 (SAS Institute Inc., Cary, NC, USA), and *p*-values are presented for statistical inference. All *p*-values ≤ 0.1 are highlighted in the tables; *p*-values below or equal to 0.05 were interpreted as "statistically significant" while *p*-values between 0.1 and 0.05 were classified as "marginally significant".

4.3.4 Comparison of *Helicobacter pylori* serological and stool antigen test results

For the *H. pylori* component, sensitivity and specificity values of serological testing were calculated using the stool antigen test (SAT) as the gold standard. All equivocal and undetermined tests were excluded from these calculations (n = 41).

4.3.5 Presentation of statistical results

In the presence of less than five participants for any outcome or explicative variable, the estimated proportions are not presented so as to avoid divulging confidential information (the letter "F" is used in the tables and figures). When one of the modalities of a variable received the letter "F", the *p*-value of the global χ^2 is not available (n.a.) in the tables. A coefficient of variation (CV) was calculated, representing the ratio of the standard deviation of a variable on its value. When the CV was less than or equal to 15%, the proportion is shown without any mention. If the CV was greater than 15%, distinctive signs are presented to avoid publishing estimates of fair to poor quality. The proportion should be interpreted with caution (*) when the CV lies between 15% and 25%, and it is shown for information only (**) when the CV is above 25%. For easier reading, tables and figures associated with only one outcome are presented in the text, while those covering multiple outcomes are presented in the appendices.

5 RESULTS

5.1 RABIES *LYSSAVIRUS* AND ANIMAL BITES OR SCRATCHES

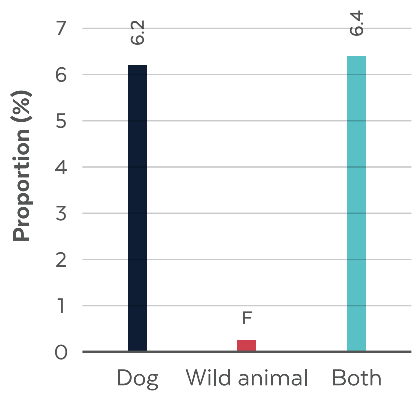
5.1.1 *Qanuippitaa?* 2004 antibodies against rabies *Lyssavirus*

Antibodies against rabies *Lyssavirus* above 0.5 IU/ml were detected in the serum of two participants who had previously been vaccinated but were not recorded in the 1999-2004 rabies immunization registry (Table 12, Appendix B). Thus, none of the non-vaccinated participants harboured neutralizing antibodies against rabies (Table 12, Appendix B). Based on these results, the determination of rabies virus serology was not conducted in *Qanuilirpitaa?* 2017.

5.1.2 *Qanuilirpitaa?* 2017 animal bites or scratches

The weighted proportion of Nunavik's 2017 population reporting a bite or a scratch from a dog or a wild animal (e.g., wolf, fox or bear) in the year preceding the survey was 6% (95% CI; 5 – 8). Almost all reported bites or scratches were attributed to dogs and to a much lesser extent, to wild animals (Figure 1).

Figure 1 Proportion of the population aged 16 years and over reporting an animal bite or scratch in the year prior to the *Qanuilirpitaa?* 2017 survey



NOTE:
F: This value is not displayed since some categories have less than 5 respondents.

The bivariate analyses with sociodemographic variables revealed that the proportion of the population reporting an animal bite or scratch varied according to sex, age group and ecological region (Table 13, Appendix B). Men declared more often being bitten or scratched by animals (8%) compared to women (5%) ($p = 0.02$). Higher frequencies of bites or scratches were reported in the 16 to 30 year age group (9%), followed by the 31 to 49 year (6%*) and the 50 and over age groups (2%**) ($p < 0.0001$). A greater proportion of the Ungava Bay population (9%) reported bites or scratches, followed by the populations of Hudson Bay (5%) and Hudson Strait (4%) ($p = 0.04$).

5.2 *TRICHINELLA NATIVA*

The weighted prevalence of antibodies against the parasite *Trichinella* sp. in Nunavik's 2017 population was 3%* (95% CI; 2 – 4) (Table 12, Appendix B). Age group and ecological region were associated with *Trichinella* sp. seroprevalence (Table 13, Appendix B). Seroprevalence increased with age but this association was marginally significant (*p* = 0.09). It was highest among Nunavimmiut aged 50 years and over (6%**) compared to younger individuals (2%**). Antibodies against *Trichinella* sp. were more prevalent in the Hudson Bay (5%**) population, followed by the population of Hudson Strait (2%**), while the small proportion of seropositive population living in Ungava Bay (F) did not allow the *p*-value to be presented.

Associations with the consumption of specific country foods were explored as these animal species can harbour the parasite. Seroprevalence of antibodies against *Trichinella* sp. was higher among Nunavimmiut reporting eating seal meat mostly raw, with a marginal *p*-value (Table 4).

Table 4 *Trichinella* sp. seroprevalence across marine mammal consumption variables

Country food meat	Frequency of eating mostly raw		Mostly eaten raw		Frequency of consumption	
	Below the median	Above the median	No	Yes	Below the median	Above the median
Beluga	2.7*	2.1**	2.7**	2.0**	2.7**	2.1**
p-value	0.6		0.5		0.7	
Walrus	2.6*	F	2.6**	F	2.6**	F
p-value	n.a.		n.a.		n.a.	
Seal	2.6**	2.4**	1.5**	3.7**	2.6**	2.4**
p-value	0.8		**0.07**		0.8	
Polar bear	–	–	–	–	2.5**	F
p-value	–		–		n.a.	

NOTE:
The questions related to "if the country food was mostly eaten raw" were not asked for polar bear, which explains the presence of "–" in this table. Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**). F: This value is not displayed since some categories have less than 5 respondents; n.a. = the *p*-value is not displayed. All p-values ≤ 0.1 are highlighted.

The frequency of preparing marine mammals or bears (polar and black) according to *Trichinella* sp. seroprevalence could not be presented because some categories have less than 5 respondents (Table 5).

Table 5 *Trichinella* sp. seroprevalence across marine mammal preparation frequencies

In the past 12 months, how many of the following animals did you prepare (skinning, washing, cutting, etc.) ?	*Trichinella* sp. seroprevalence
Bears (polar and black)	
None	2.9*
One and more	F
p-value	n.a.
Sea mammals (seals, whales, walrus)	
None	2.4**
Between 1 – 9	3.9**
10 and more	F
p-value	n.a.

NOTE:
Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**). F: This value is not displayed since some categories have less than 5 respondents; n.a. = the *p*-value is not displayed. All p-values ≤ 0.1 are highlighted.

5.3 *CRYPTOSPORIDIUM* SP.

The weighted prevalence of antibodies against *Cryptosporidium* sp. in Nunavik's 2017 population was 6% (95% CI; 5 – 8) (Table 12, Appendix B). Sex, age group, ecological region and income were associated with this outcome (Table 13, Appendix B). Seroprevalence was higher in men (8%*) compared to women (5%) but this result was marginally significant ($p = 0.07$). Prevalence of antibodies increased with age: 4%* in the 16 to 30 age group, 8%* in the 31 to 49 age group and 11%* in the 50 and over age group ($p = 0.001$). Higher seroprevalence was observed in Ungava Bay (12%*) compared to Hudson Bay (4%**) and Hudson Strait (3%**) ($p = 0.0001$). Finally, seroprevalence was also associated with income levels: $40 000 or more (10%*) compared to $20 000 – $40 000 (7%**) and < $20 000 (5%*) ($p = 0.04$).

Some associations were observed between the seroprevalence of *Cryptosporidium* sp. and country food consumption variables (Table 6). All seal meat consumption variables, the consumption frequency of sea trout/brook trout/salmon as well as consuming shellfish mostly raw, were positively associated with *Cryptosporidium* sp. seroprevalence, but some of these associations were marginally significant. *Cryptosporidium* sp. seroprevalence was lower for people eating more frequently goose and shellfish (Table 6).

Table 6 *Cryptosporidium* sp. seroprevalence according to various country foods

Country food meat	Frequency of eating mostly raw[a]		Mostly eaten raw[a]		Frequency of consumption	
	Below the median	Above the median	No	Yes	Below the median	Above the median
Beluga	6.9*	7.0**	6.4	7.9	6.9*	7.0**
p-value	1.0		0.5		1.0	
Walrus	5.5	8.7**	6.6	8.7**	6.7	9.4**
p-value	0.6		0.5		0.6	
Seal	5.5	10.4*	5.5*	8.8*	5.5**	8.7*
p-value	**0.07**		**0.08**		**0.07**	
Polar bear	–	–	–	–	7.2	F
p-value	–		–		n.a.	
Caribou	7.5*	6.4*	5.8**	7.2	7.6	6.4
p-value	0.6		0.5		0.5	
Muskox	–	–	–	–	6.7	14.9
p-value	–		–		0.2	
Ptarmigan/partridge	7.1	6.7	6.6*	7.6*	7.1	6.7*
p-value	0.8		0.6		0.8	
Goose	8.3	3.4**	7.4	F	8.0	3.5*
p-value	**0.005**		n.a.		**0.01**	
Lake trout	–	–	–	–	6.0*	7.8*
p-value	–		–		0.3	
Sea trout/brook trout/salmon	–	–	–	–	5.6*	9.2*
p-value	–		–		**0.07**	
Arctic char	–	–	–	–	9.4*	5.9
p-value	–		–		0.3	
Pike or walleye	–	–	–	–	6.9	F
p-value	–		–		n.a.	
Other fish	–	–	–	–	6.5*	8.2*
p-value	–		–		0.4	
Shellfish	7.4*	4.3*	4.3**	8.6*	7.5*	3.9
p-value	**0.09**		**0.02**		**0.04**	

[a] The questions related to "if the country food was mostly eaten raw" were not asked for polar bear, muskox and fish, which explains the presence of "–" in this table.

NOTE:

Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**). F: This value is not displayed since some categories have less than 5 respondents; n.a. = the *p*-value is not displayed. All *p*-values ≤ 0.1 are highlighted.

5.4 *TOXOPLASMA GONDII*

The weighted prevalence of antibodies against *Toxoplasma gondii* in Nunavik's population was 42% (95% CI; 40 – 44) (Table 12, Appendix B). Seroprevalence varied according to sex, age group, ecological region, education and income (Table 13, Appendix B). Seroprevalence was higher in women (45%) compared to men (40%) ($p = 0.04$) and in the 50 and over age group (78%) compared to the 31 to 49 (51%) and 16 to 30 (18%) age groups ($p < 0.0001$). Antibodies against the parasite were also more frequently observed in the population of Hudson Bay (56%) followed by that of Ungava Bay (36%) and Hudson Strait (27%) ($p < 0.0001$). Seroprevalence was higher among individuals with an elementary education (63%) compared to those with a secondary (39%) or post-secondary education (41%) ($p = 0.0002$). Finally, antibody prevalence was higher in the two upper income categories ($20 000 – $40 000 and ≥$40 000 ~ 47%) compared to the lower one (< $20 000 = 37%) ($p = 0.01$).

As for potential water-related risk factors, *T. gondii* seroprevalence varied according to the main source of drinking water in summer ($p = 0.002$) and in winter ($p = 0.001$) (Table 14, Appendix B). It was lower in Nunavimmiut drinking bottled water compared to those drinking water from the municipal system ($p_{summer} = 0.0008$ and $p_{winter} = 0.0004$) as well as from natural sources ($p_{summer} = 0.0001$ and $p_{winter} = 0.0004$). Seroprevalence was similar between Nunavimmiut drinking water from the municipal system and from natural sources ($p_{summer} = 0.4$ and $p_{winter} = 0.3$). Water treatment at the point of use (boiling, filtration) and frequency of water tank cleaning were not associated with *T. gondii* seroprevalence (Table 14, Appendix B).

Multiple variables were examined with regard to the potential risk factors associated with the consumption of country foods. *T. gondii* seroprevalence increased, from the low to the high terciles of annual consumption of fish; however, no statistically significant associations were observed for any other country food group (Table 7).

Table 7 *Toxoplasma gondii* **seroprevalence according to terciles of monthly consumption of country food groups**

Country food groups	Frequency terciles of monthly consumption		
	Low	Intermediate	High
Marine mammals (beluga, walrus and seals)	43.0	40.5	41.8
p-value		0.8	
Terrestrial mammals (caribou and muskox)	44.2	38.9	40.5
p-value		0.4	
Wild birds (ptarmigan/partridge and goose)	39.0	45.8	44.1
p-value		0.2	
Fish (lake trout, sea trout/salmon, Arctic char, pike/walleye and other fish)	36.7	42.5	48.2
p-value		**0.01**	
Shellfish (molluscs (mussels/scallops/clams) and urchins)	42.5	41.5	41.3
p-value		1.0	

NOTE:
Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**). All *p*-values ≤ 0.1 are highlighted.

The population reporting eating walrus, seal, seal liver, caribou, ptarmigan/partridge and shellfish mostly raw had a significantly higher seroprevalence for *T. gondii* (Table 8). Nunavimmiut consuming walrus, seal liver, lake trout, pike or walleye and other fish above the monthly median frequency presented a higher seroprevalence as well. Seroprevalence was also higher in those eating walrus and seal liver mostly raw above the monthly median frequency.

Table 8 *Toxoplasma gondii* seroprevalence according to country food variables

Country food meat	Frequency of eating mostly raw[a]		Mostly eaten raw[a]		Frequency of consumption	
	Below the median	Above the median	No	Yes	Below the median	Above the median
Beluga	43.7	39.1	41.9	42.3	43.7	39.1
p-value	0.2		0.9		0.2	
Walrus	41.2	50.3	39.6	54.6	41.2	50.3
p-value	**0.1**		**0.002**		**0.1**	
Seal	41.8	42.2	32.0	54.9	41.8	42.2
p-value	0.9		**< 0.0001**		0.9	
Seal liver	38.4	50.0	32.8	53.1	38.4	50.0
p-value	**0.002**		**< 0.0001**		**0.02**	
Polar bear	–	–	–	–	41.9	45.7
p-value	–		–		0.7	
Caribou	41.6	42.5	29.2	45.4	43.4	40.7
p-value	0.8		**< 0.0001**		0.4	
Muskox	–	–	–	–	42.4	31.5
p-value	–		–		0.2	
Ptarmigan/partridge	40.2	44.7	32.1	58.3	40.2	44.7
p-value	0.2		**< 0.0001**		0.2	
Goose	42.0	42.1*	42.3	37.8	41.9	42.2
p-value	1.0		0.5		0.9	
Lake trout	–	–	–	–	39.4	44.5
p-value	–		–		**0.1**	
Sea trout/brook trout/ salmon	–	–	–	–	43.7	39.2
p-value	–		–		0.2	
Arctic char	–	–	–	–	40.2	44.7
p-value	–		–		0.2	
Pike or walleye	–	–	–	–	40.7	62.6
p-value	–		–		**0.009**	
Other fish	–	–	–	–	36.2	56.9
p-value	–		–		**< 0.0001**	
Shellfish	41.6	44.7	32.2	48.0	42.0	41.2
p-value	0.5		**< 0.0001**		1.0	

[a] The questions related to "if the country food was mostly eaten raw" were not asked for polar bear, muskox and fish, which explains the presence of "–" in this table.

NOTE:
Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**). F: This value is not displayed since some categories have less than 5 respondents; n.a. = the *p*-value is not displayed. All *p*-values ≤ 0.1 are highlighted.

As for frequencies of preparation of wild animals, the population reporting preparing 10 and more wild birds in the past 12 months had a higher seroprevalence than those reporting preparing fewer wild birds (Table 9).

No association was observed between the frequency of preparation of terrestrial mammals (caribou and muskox), carnivores (fox, wolves and dogs), bears and sea mammals and *T. gondii* seroprevalence.

Table 9 *Toxoplasma gondii* seroprevalence according to the frequency of handling animals

In the past 12 months, how many of the following animals did you prepare (skinning, washing, cutting, etc.)?	Toxoplasma gondii seroprevalence (%)
Wild birds	
None	36.6
Between 1 – 9	45.1
10 and more	47.3
p-value	**0.01**
Caribou and muskox	
None	41.7
Between 1 – 9	43.3
10 and more	43.2
p-value	0.9
Fox, wolves and dogs	
None	41.9
Between 1 – 9	48.0
10 and more	39.8**
p-value	0.4
Bears (polar and black)	
None	43.2
One and more[a]	34.8*
p-value	0.2
Sea mammals (whale, beluga, walrus and seal)	
None	43.2
Between 1 – 9	42.2
10 and more	36.1*
p-value	0.7

[a] The “between 1 – 9” and “10 and more” results were merged together.

NOTE:

Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**). F: This value is not displayed since some categories have less than 5 respondents; n.a. = the *p*-value is not displayed. All *p*-values ≤ 0.1 are highlighted.

5.5 *HELICOBACTER PYLORI*, MEDICAL REVIEW AND GASTROINTESTINAL SIGNS AND SYMPTOMS

5.5.1 Occult fecal blood, self-reported weight loss and blood in stools

For the population aged ≥ 50 years, the weighted prevalence of occult blood in stools was 13% (95% CI; 8 – 19) (Table 12, Appendix B). These participants were referred to health services for a medical follow-up. Among the sociodemographic variables, the presence of occult blood was only marginally associated with education level (Table 13, Appendix B). Individuals with an elementary education (13%) or who had attended but not completed secondary school (15%) had higher seroprevalences than those who had completed secondary school or higher (4.0%) ($p = 0.09$).

The weighted proportions of Nunavimmiut aged 16 and over self-reporting an involuntary weight loss in the last six months and the presence of blood in stools (fresh or digested) were 22% and 12% respectively (results not shown). A higher proportion of Nunavimmiut with fecal occult blood in their stool self-reported observing fresh or digested blood in their stool (27%) compared to those without fecal occult blood (12%) but this association was not significant ($p = 0.2$) (results not shown).

5.5.2 *Qanuilirpitaa?* 2017 stool antigen test for active infection

The non-weighted prevalence of *H. pylori* active infection (based on the SAT) was 70% (95% CI; 67 – 73) (Table 12, Appendix B). The sociodemographic variables associated with this outcome were age group, community size, ecological region and household overcrowding (Table 13, Appendix B). The prevalence of active infection was higher in the 31 to 49 age group (78%) compared to the 50 and over age group (59%) ($p < 0.0001$) as well as in large communities (74%) compared to small ones (67%) ($p = 0.04$). The association with ecological region was marginally significant (75% for Hudson Bay, 70% for Hudson Strait and 67% for Ungava Bay; $p = 0.1$). The bacteria were more often detected in people living in overcrowded households (76%) compared to those living in households not classified as overcrowded (68%) ($p = 0.05$).

The prevalence of *H. pylori* active infection was greater in Nunavimmiut drinking water mainly from bottled water in winter (82%) compared to those drinking mainly from natural sources (63%), but this association was marginally significant ($p = 0.07$). Those reporting that their water tank had been cleaned more than two years prior to the survey had higher seroprevalence (88%) compared to those reporting that their tank had been cleaned in the previous month (65%) ($p = 0.01$) (Table 14, Appendix B). No other water-related potential risk factors were associated with this outcome.

Self-reported involuntary weight loss or self-reported presence of blood in stools (fresh or digested) was not associated with *H. pylori* SAT prevalence, while the presence of occult blood was marginally associated with *the presence of an* active infection (Table 10). The unweighted prevalence of *H. pylori* in stools was lower for Nunavimmiut suffering from anemia (66%) than for those without anemia (76%) ($p = 0.03$) (results not shown). When broken down by type of anemia, the prevalence of active infection was lower in those with unexplained anemia (64%) compared to those without it (75%), but the *p*-value was marginally significant ($p = 0.1$) (results not shown). Iron deficiency anemia and anemia of chronic inflammation were not associated with active infection (results not shown).

Table 10 *Helicobacter pylori* **infection and laboratory results according to potential consequences**

Potential consequences of *H. pylori* infection	*H. pylori* SAT (non-weighted)			*H. pylori* serology (weighted)		
	Positive	Negative	*p*-value	Sero-positive	Sero-negative	*p*-value
Self-reported questions						
Involuntary weight loss	21.6	23.0	0.7	23.6	19.8	**0.1**
Presence of black stools or blood in stools	12.4	14.3	0.5	13.1	13.0	1.0
Laboratory results						
Occult blood in stools	18.6**	7.6**	**0.07**	13.6**	9.2**	0.4

NOTE:
Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**). All *p*-values ≤ 0.1 are highlighted.

5.5.3 *Qanuilirpitaa?* 2017 and *Qanuippitaa?* 2004 serological results

The *Qanuilirpitaa?* 2017 weighted seroprevalence for *H. pylori* was 73% (95% CI; 70 – 75), while the non-weighted seroprevalence in 2004 among the 2004-2017 cohort participants was 80% (95% CI; 75 – 84) (Table 12, Appendix B). Among the 2004 – 2017 cohort participants, nearly 70% of those who were **seropositive** in 2004 were also positive in 2017, while half of the 2004 **seronegative** participants had become positive by 2017 (Table 15, Appendix B). The mean yearly cumulative incidence of seroconversion against *H. pylori* based on this cohort is estimated at 4%. Approximately 25% of participants who were seropositive in 2004 were seronegative in 2017 (Table 15, Appendix B).

The sociodemographic variables associated with the 2017 weighted seroprevalence were sex, age group, community size, ecological region, education and household overcrowding (Table 13, Appendix B). Higher *H. pylori* seroprevalence was observed in men (78%) compared to women (68%) ($p < 0.0001$) and in Nunavimmiut aged 16 to 49 (78%) compared to those aged 50 and over (57%) ($p < 0.0001$). A positive seroprevalence for *H. pylori* was more frequently observed in large communities (75%) compared to small ones (69%) ($p = 0.03$) and in the population of Hudson Bay (76%) followed by that of Hudson Strait (71%) and Ungava Bay (69%) ($p = 0.02$). Those who had attended but not completed secondary school (75%) had a higher seroprevalence than those who had completed secondary school or higher (71%) or had an elementary education (62%) ($p = 0.1$). Seroprevalence was also higher in the population living in overcrowded dwellings (77%) compared to those who did not live in such dwellings (71%), but this result was marginally significant ($p = 0.06$) (Table 13, Appendix B).

Seroprevalence was higher in Nunavimmiut drinking from bottled water (84%) compared to those drinking from natural sources (69%) in winter (nearby lake, river or stream, melted snow, ice or iceberg) ($p = 0.04$) (Table 14, Appendix B). Seroprevalence for *H. pylori* antibodies was higher in those who reported that their water tank had been cleaned more than two years prior to the survey (81%) compared to those reporting that their tank had been cleaned in the previous month (70%), but this result was marginally significant ($p = 0.07$) (Table 14, Appendix B).

As for the potential consequences of *H. pylori* infection, the presence of self-reported black stools or blood in stools was not associated with *H. pylori* status, while seroprevalence was higher in those self-reporting involuntary weight loss (Table 10). Prevalence of antibodies against *H. pylori* was similar between Nunavimmiut suffering from anemia (72%) and those without it (73%) ($p = 0.9$) (results not shown). When broken down by type of anemia, seroprevalence was higher in individuals with iron deficiency anemia (83%) compared to those without it (76%), but this association was marginally significant ($p = 0.06$) (results not shown). Anemia caused by chronic inflammation and unexplained anemia were not associated with *H. pylori* seroprevalence (results not shown).

5.5.4 Non-weighted comparisons between stool antigen and serological testing

Using the SAT as the "gold standard", the sensitivity and specificity values associated with detection of IgG against *H. pylori* in Nunavik's population were 0.85 and 0.67, respectively, while the positive and negative predictive values of serology compared to the SAT were 0.86 and 0.66, respectively (Table 16).

5.5.5 Medical review

The medical chart reviews revealed that the unweighted proportion of the population with at least one prior diagnosis of *H. pylori* infection was 28%. No gastric carcinoma or mucosa-associated lymphoid tissue (MALT) associated lymphoma was reported in the medical charts. The overall unweighted proportion of the population with a history of gastritis and of gastric/duodenal ulcers in their medical file was 11% and 2%*, respectively. Most of these diagnoses were concomitant with a history of *H. pylori* infection in the medical files (Table 11). A greater proportion of 2017 participants with *H. pylori* positive results (by serology and SAT) did not have a history of infection compiled in their medical files (Table 11).

Table 11 Non-weighted proportion of the population with a medical history of *H. pylori* infection, gastritis and gastric or duodenal ulcer

Variables documented in the medical file review	Gastritis in the medical file review	Gastric or duodenal ulcers in the medical file review	2004 *H. pylori* seroprevalence	2017 *H. pylori* seroprevalence	2017 *H. pylori* prevalence with SAT
History of *H. pylori* infection	28.2	6.6*	80.4	62.9	52.1
No history of *H. pylori* infection	5.4	0.9**	83.0	75.6	76.4
p-value	**< 0.0001**	**< 0.0001**	0.6	**< 0.0001**	**< 0.0001**

NOTE:
Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**). All *p*-values ≤ 0.1 are highlighted.

5.6 SELF-REPORTED ACUTE GASTROINTESTINAL ILLNESS (AGI)

The weighted proportion of the population who reported being afflicted by an episode of vomiting and/or diarrhea in the 30 days before the survey was 12% (95% CI; 10 – 14), excluding symptoms related to drugs, alcohol consumption, pregnancy and chronic illness (Table 12, Appendix B). Episodes of vomiting or diarrhea had a non-weighted median duration of 1.4 days with a range varying from one to 30 days.

In the bivariate analysis with sociodemographic variables, AGI was associated only with age groups (Table 13, Appendix B). Prevalence was higher in the 31 to 49 age group (17%) followed by the 50 and over (11%) and 16 to 30 (9%) age groups (p = 0.01) (Table 13, Appendix B). Self-reporting an episode of diarrhea and/or vomiting in the 30 days before the survey did not vary according to any of the other sociodemographic and drinking water-related potential risk factors (Tables 13 and 14, Appendix B).

Of the sample of participants self-declaring AGI, the non-weighted prevalence of those experiencing vomiting and/or diarrhea for 3 days or more, was 35% (95% CI; 28 – 43) (Table 12, Appendix B). Prolonged AGI was associated with education, with the prevalence being higher in Nunavimmiut who had attended but not completed secondary school (41%) compared to those with an elementary school education (23%) or who had completed secondary school or higher (19%) (p = 0.05) (Table 13, Appendix B).

6 DISCUSSION

6.1 RABIES *LYSSAVIRUS* AND ANIMAL BITES OR SCRATCHES

The present report documents for the first time animal bites and the risk of harbouring antibodies against the rabies virus in the region. These results provide human and animal health authorities with important insight for managing these issues. Dogs are responsible for almost all animal bites or scratches occurring in Nunavik and the prevalence observed in Nunavimmiut aged 16 years and over (6%) is two-fold greater than that reported among Quebecers in 2010, i.e. 3% (AMVQ, 2010). Because a decreasing age group gradient was observed in the 2017 survey and bites are known to occur more frequently in children in the region (Aenishaenslin et al., 2014), the prevalence of dog bites estimated from *Qanuilirpitaa?* 2017 probably underestimates the occurrence in Nunavimmiut of all ages.

Dogs have been intrinsically tied to the Inuit culture because they have served for hunting, transportation and security for many centuries (MacRury, 1991). However, most economic activities offered by dog teams have now been replaced by modern technology (e.g., motorized vehicles and firearms). Despite this reality, Inuit still maintain a particular symbolic relationship with dogs, and traditional management of dog populations still occurs, potentially explaining the higher incidence of dog bites observed in Nunavik compared to that further south (Aenishaenslin et al., 2018; Lévesque, 2018). Comparisons of animal bites with *Qanuippitaa?* 2004 are not possible as this outcome was not evaluated at that time.

Besides the age trend, other studies have also observed a predominance of bites in men (Holzer et al., 2019). Most dog teams in Nunavik are owned and cared for by men (J. Ducrocq, Pers. Comm, 2020), which may increase their risk of bites or scratches. There is no systematic recording of the number of dogs living in Nunavik. However, MAPAQ rabies vaccination records suggest that the dog population on the Ungava coast is larger than that on the Hudson coast[5] (Aenishaenslin et al., 2014), which potentially explains the increased frequency of dog bites observed in the Ungava Bay (ecological region) communities. Dogs in Nunavik are mostly unneutered and the presence of sexual hormones might explain the more aggressive behaviours observed in intact animals compared to sterilized ones (D'Onise et al., 2017). Dogs that live in packs are also considered more dangerous than those acting alone and group attacks are more susceptible to cause more severe injuries (Kneafsey & Condon, 1995; Raghavan, 2008).

Moreover, dog bites are a public health issue in Nunavik because of the geographical endemicity of rabies in wildlife (Nadin-Davis et al., 2012). Although bites by dogs are reported more frequently than those caused by wild animals, the risk of being exposed to a rabid animal is inversely correlated (Government of Canada, 2018). Wild animals (fox and wolves) were submitted for rabies testing (39%) less often than dogs (61%), but most of the positive results were associated with wild animals (77%) compared to dogs (23%) (Aenishaenslin et al., 2018). Hence, even though very few bites or scratches were caused by wild carnivores, Nunavimmiut who hunt, trap or handle these species are still at increased risk of being in contact with rabid animals.

Our study that aimed specifically at evaluating if it was possible for Nunavimmiut who hunt, trap or handle wild animals to harbour neutralizing antibodies against rabies without demonstrating any compatible clinical signs, did not support this hypothesis. (Ducrocq, Proulx, Lévesque, et al., 2019). Antibodies were observed in the retrospective serums of only two 2004 participants. However, a review of their medical history confirmed that they had received rabies vaccinations prior to 2004, thus explaining the presence of titers above the 0.5 UI/ml threshold. These prior vaccinations were not contained in Nunavik's rabies immunization registry. Additional information on this project can be found in the scientific article entitled

5. This information is based on the two administrative regions (Ungava and Hudson coasts).

"Assessment of naturally acquired neutralizing antibodies against rabies *Lyssavirus* in a subset of Nunavik's Inuit population considered most at risk of being exposed to rabid animals" (Ducrocq, Proulx, Lévesque, et al., 2019). The results of this specific study did not support searching subsequently for rabies neutralizing antibodies in *Qanuilirpitaa?* 2017. Although rabies is fatal for humans, it is preventable. Avoiding contacts with the saliva of potentially rabid animals, basic hygiene measures, dog vaccination and rapidly available post-exposure prophylaxis remain the cornerstone of rabies prevention for Nunavik communities.

6.2 *TRICHINELLA NATIVA*

Neutralizing antibodies for *Trichinella* sp. were mainly observed among older Nunavimmiut, in the residents of the Hudson Bay ecological region and in people consuming seal meat mostly raw. As for the consumption of walrus meat, the main historical source of the parasite in Nunavik, no association was observed with *Trichinella* sp. seroprevalence.

Although a very small proportion of Nunavimmiut had neutralizing antibodies against *Trichinella* sp. in 2017 (3%), the proportion was greater than that estimated in *Qanuippitaa?* 2004 (≤ 1%) (Messier et al., 2012). Two outbreaks of human trichinellosis were reported in Nunavik recently, i.e., in 2013 and in 2016; they affected mostly residents of the Hudson Bay ecological region (J.-F. Proulx, 2013, 2016). Although neither of the two epidemiological investigations succeeded in confirming the origin of the parasite, two hypotheses were retained. The hypothetical source for the 2013 outbreak was the consumption of insufficiently cooked polar bear, which had been stored frozen and was mistaken for another type of meat when transformed and distributed (Ducrocq, Proulx, Simard, et al., 2019). In 2016, seal meat consumption was hypothesized as the cause of the outbreak (J.-F. Proulx, 2016). Although there is no better way to identify the source of a parasite than to detect it directly in food consumed during an outbreak, the serological results of *Qanuilirpitaa?* 2017 support the hypothesis of a link between seal meat consumption and trichinellosis. The greater seroprevalence observed in the population of Hudson Bay compared to that of the other regions most likely reflects the persistence of antibodies caused by the last two outbreaks (2013 and 2016), with the two communities most affected being Inukjuak and Umiujaq (J.-F. Proulx, 2013, 2016).

Walruses (*Odobenus rosmarus rosmarus*) harvested from the population of Hudson Bay are more often infected with *T. nativa* than those of Hudson Strait and Ungava Bay (Martinez-Levasseur et al., 2020). This could also explain why Nunavimmiut in this region are more at risk of exposure. However, the last outbreak related to walrus in Nunavik occurred in 1997 (J.-F. Proulx. Pers. Comm. 2020). In the current survey, the consumption of walrus was not associated with an increase of *Trichinella* sp. seroprevalence. This result tends to suggest that the Nunavik Trichinellosis Prevention Program is effective in reducing the risk of contracting trichinellosis from walrus.

With regard to seal meat as a potential source of *T. nativa*, exposure of seals to this parasite is not well documented in the Arctic, but it seems to be rare. Forbes (2000) has reported an overall seroprevalence of < 1% (0 – 2%; min – max) when including ringed seals and bearded seals collected from 1950 to 1983.

It cannot be ruled out that a confusion bias (residual or seasonal) is present in the results of *Qanuilirpitaa?* 2017. Indeed, the data collection period may have influenced food consumption and the associations observed. The three-month period covered by the food questionnaire likely favoured seal meat, which is mainly consumed during the summer, at the expense of walrus and polar bear meats, the main expected sources. Walrus and polar bear meat are mainly consumed in fall/winter and winter, respectively.

Multivariate regression models are needed to confirm the associations observed with the bivariate analysis. Grouping data from both the *Qanuippitaa?* 2004 and *Qanuilirpitaa?* 2017 health surveys could be explored to increase their statistical power and identify the main drivers of infection in Nunavik. In any case, the results of *Qanuilirpitaa?* 2017 in connection with seal meat will have to be validated by the detection of *T. nativa* in local seal species. A project with ringed seal is currently under way at the Nunavik Research Centre based in Kuujjuaq (G. Gouin, Pers. Comm.) and the results will help to confirm or deny the presence of a real risk of exposure to this parasite for Nunavimmiut. This information will help the NRBHSS to evaluate potential risks associated with seal meat consumption and, eventually, to determine if prevention measures are needed.

6.3 *CRYPTOSPORIDIUM* SP.

With a seroprevalence of 6%, harbouring antibodies against *Cryptosporidium* sp. can also be considered a rare occurrence in Nunavik. This proportion probably reflects in part the immunity against *Cryptosporidium* sp. of most individuals aged 16 years and over that were affected by the 2013-2014 *Cryptosporidium hominis* outbreak, the first ever reported in Nunavik. If this proves to be true, it would also suggest that antibodies against this parasite have persisted for at least three to four years.

Qanuilirpitaa? 2017 revealed that the population of Ungava Bay had been mostly exposed to this parasite, followed by the populations of the Hudson Bay and Hudson Strait regions; however, the precision level of these estimates is low. Antibodies against this parasite were also more often observed in men compared to women and in those aged 50 years and over. Some of the associations observed with sociodemographic variables and outcomes are in agreement with those observed during the 2013-2014 outbreak, except in the case of sex and ecological region.

The results of *Qanuilirpitaa?* 2017 in regards to age reflect the fact that cryptosporidiosis usually affects older adults (≥ 75 years) (CDC, 2020). Serological results suggest that many affected adults did not seek medical attention during the 2013-2014 outbreak or that the parasite might have circulated historically and gone undetected in the past. Because cryptosporidiosis is considered a self-limiting disease in immune-competent individuals and few participants were aged 75 years and over, the 2013–2014 outbreak potentially captured only the most vulnerable age group populations (i.e., children under the age of 5) (Thivierge et al., 2016). Since these children were still under the minimal age threshold (i.e., 16 years of age) for participating in the 2017 survey, it was not possible to estimate their past exposure levels.

The proportion of men affected during the 2013-2014 outbreak was also higher (56.9%) than that for women (43.1%) (Thivierge et al., 2016). The scientific literature is not clear as to whether the risk of contracting cryptosporidiosis is higher in men compared to women. It is possible that some risk factors such as the rate of person-to-person contact (household overcrowding or type of employment), drinking water habits, contacts with animals and carcasses as well as sanitation and hygiene measures might explain this sex difference in Nunavik.

With 60.8% of cases, the Hudson coast was the administrative region most affected during the 2013-2014 outbreak (Thivierge et al., 2016). This is contradictory to the *Qanuilirpitaa?* 2017 results, which indicate that Ungava Bay ecological region was the most affected region. Again, this suggests that either many Nunavimmiut did not seek medical attention or they had been exposed historically to the parasite.

The geographical and age-related discrepancies could also be related to infections caused by other genospecies of *Cryptosporidium*. Even though the 2013-2014 outbreak was caused by a strain of the parasite (*Cryptosporidium hominis*) transmitted between humans, animals harbouring other species (i.e., *Cryptosporidium parvum*) could have contributed to some of these past exposures (Iqbal et al., 2015). In *Qanuilirpitaa?* 2017, seal, fish[6] and shellfish were associated with *Cryptosporidium* sp. seroprevalence, suggesting potential alternative sources of infection. The presence of *Cryptosporidium* sp. in these country foods is documented in the literature (Certad et al., 2015; Dixon et al., 2008; Santín et al., 2005; Zhou et al., 2004).

The contradictions between *Qanuilirpitaa?* 2017 and the 2013-2014 outbreak could also be related to under-reporting since different diagnosis methods were used. The method applied in *Qanuilirpitaa?* 2017 consisted in detecting IgG immunoglobulins against four epitopes, making it possible to detect any past exposure to numerous species of *Cryptosporidium*. On the other hand, the method used during the 2013–2014 outbreak involved detecting oocysts by microscopy and only confirmed the presence of an active infection (Thivierge et al., 2016).

While *Cryptosporidium* was the leading passively identified enteric pathogen in Nunavik in the 2013-2014 outbreak, no active infections were identified in a recent 2-year prospective project (2016-2018) among the 73 children attending the childcare centre in Kuujjuaq with follow-ups at 4-month intervals using multiplex molecular testing. During this same time period, there were ~2 cases detected by passive surveillance in all of Nunavik (Yansouni *et al.* manuscript in preparation). Multivariate analysis needs to be carried out to disentangle the influence of all the potential variables associated with the seroprevalence of antibodies against *Cryptosporidium* sp.

6.4 *TOXOPLASMA GONDII*

Toxoplasma gondii seroprevalence decreased from 60% to 42% during the 13 years separating the two Nunavik health surveys, suggesting that the risk of exposure also decreased (Messier et al., 2009). As in 2004, seroprevalence was associated with sex, age group, region, education and income in the present survey. Women, people aged 50 years and over, Hudson Bay residents and Nunavimmiut with higher education and lower income levels harboured antibodies more frequently than other individuals. In addition, the seroprevalence associated with the modalities of each of these variables decreased from 2004 to 2017. On the one hand, the proportion of seronegative women increased from 2004 to 2017, which means that a greater proportion of women were going into pregnancy without protective toxoplasmosis antibodies.

6. The group composed of sea trout, brook trout and salmon.

On the other hand, the decrease in *T. gondii* seroprevalence in the population as a whole most likely means that Nunavimmiut are less exposed to the pathogen.

Keeping in mind the transversal design of the present survey, which does not allow conclusions to be drawn with respect to cause and effect relationships, as well as the fact that exposure to the pathogen could have occured at any time during a person's lifetime, the results of *Qanuilirpitaa?* 2017 support the hypothesis that drinking potentially contaminated water containing oocysts may be a transmission pathway of *T. gondii* in Nunavik. Similar water-related risk factors were also associated with *T. gondii* seroprevalence in 2004. Drinking mostly bottled water is a potential protective factor compared to drinking water mostly from natural sources or the municipal system; this was noticed in both surveys for the main sources of drinking water used in both summer and winter. However, we cannot exclude the possibility of confounding effects. Approximately 7% of Nunavik's 2017 population used bottled water as their primary source of water while ~11% drew water from natural sources (lakes, rivers, streams, snow, ice and icebergs); however the majority of Nunavimmiut were drinking water from municipal systems (82%) (*Qanuilirpitaa?* 2017 thematic report "Housing and Drinking Water"). The historical presence of chlorination in most municipal water treatment systems might explain the similar seroprevalences encountered in participants drinking from municipal and natural sources since chlorination does not inactivate *T. gondii* (Wainwright et al., 2007). However, since 2010, most municipalities[7] have implemented more effective treatments such as ultraviolet (UV) light disinfection (Ladouceur. Pers. Comm), a method that inactivates some enteric protozoans like *Giardia* sp. and *Cryptosporidium* sp. and probably *T. gondii* if it were to be inadvertently present in a municipal water source (Dumètre et al., 2008; Ware et al., 2010).

In contrast to the results of the 2004 survey, seroprevalence in 2017 did not vary according to the use of water treatment at home (e.g., boiling, filtering) or water tank cleaning frequency. Since 82% of the 2017 population drank water from the municipal system (tap water, water tank or directly at the water plant) and all water tanks were filled with water from that system, it is possible that the gradual implementation of UV disinfection at the municipal level might explain the discrepancy between the two surveys.

The results of *Qanuilirpitaa?* 2017 also suggest that *T. gondii* could be acquired from different country foods that are consumed mostly raw and that potentially harbour the parasite (i.e., walrus, seal, caribou, ptarmigan/partridge, fish[8] and shellfish). *Qanuilirpitaa?* 2017 cannot identify which local country foods may contribute the most to *T. gondii* food-borne exposure, but some of its results are similar to those of other human studies. In the *Qanuippitaa?* 2004 survey, seroprevalence increased according to each tercile of consumption of marine mammals, fish and feathered game. However, in the multivariate analysis, statistical significance was maintained only with the seal meat and wild birds variables (Messier et al., 2009). In a small case-control study of 22 Inuit women conducted in Nunavik in the 1980s, eating caribou more than once a month was significantly associated with seroconversion during pregnancy (McDonald et al., 1990). While *T. gondii* genetic material was not detected in blue mussels from Nunavik, it has been detected in shellfish elsewhere in the world due to the fact that they filter water to feed (Putignani et al., 2011; Zhang et al., 2014). Eating oysters, clams and mussels is a risk factor associated with seroprevalence in other human populations (Jones et al., 2009; Wilking et al., 2016).

The gold standard for confirming that animals are competent biological hosts capable of causing infection in humans is to feed laboratory animals (mice or cats) tissues naturally contaminated with *T. gondii*. In reality, with this approach, few intermediate hosts (especially Arctic wildlife and fish) suspected of harbouring *T. gondii* have been proven to be "competent biological hosts" (Peng et al., 2011). As for Arctic species, only laboratory-inoculated seal meat was infective to cats (Forbes et al., 2009). Because these bioassays are expensive and time-consuming, human risk is often evaluated by alternative methods such as molecular testing of animals and serologies (Leclair & Doidge, 2001).

A recent project testing 121 sampled fish from Nunavik with molecular techniques resulted in 12% of them testing positive: Atlantic salmon (27%), brook trout (17%), Arctic char (12%) and one sculpin (no DNA was found in lake whitefish and pike but greater sample sizes are needed to support this potential absence) (Reiling & Dixon, 2019). Even if methods reducing cross-contamination are used, the possibility of such contamination cannot be excluded as the parasite is present on the skin and gills as well as within the gastrointestinal system (Marino et al., 2019). Genetic material related to *T. gondii* has also been detected in various Arctic animals such as rock ptarmigan (4%), geese (including Canada, snow, lesser snow and

7. Exceptionally in Kuujjuarapik, groundwater distributed to houses through a municipal network should be considered less vulnerable to contamination.

8. Lake trout, pike or walleye and other fish.

Ross's geese) (6-35%), ungulates such as caribou and muskox (5-37%), Arctic fox (44%), lynx (25%), wolverine (42%), wolf (19%) and black bear (37%) (Bachand et al., 2019; Reiling & Dixon, 2019). In contrast, none of the tissues from 27 walrus (tongue), 61 seals (heart, liver and diaphragm) and 161 ptarmigan (brain and heart) sampled in Nunavik tested positive (Bachand et al., 2019). The estimated burden of *T. gondii* found in the tissue of geese sampled in Nunavik, combined with minimal infectious doses and amounts consumed, suggests a risk for consumers of raw geese (Bachand et al., 2019). That being said, *Qanuilirpitaa?* 2017 informs us that the risk concerns a small proportion of Nunavimmiut (6%). Antibodies against *T. gondii* were also detected in seals, caribou, geese and ptarmigan from Nunavik suggesting that these species have been previously exposed to *T. gondii* (Bachand et al., 2019; Leclair & Doidge, 2001; McDonald et al., 1990).

In *Qanuilirpitaa?* 2017, *T. gondii*, seroprevalence was also higher in people preparing wild birds carcasses compared to those who never did. This variable could reflect the risk associated with handling goose given that the parasite has already been detected in these species.

In Nunavik, the aim of understanding the main transmission pathways of *T. gondii* is essentially to decrease the risk of toxoplasmosis in the most vulnerable population, i.e., that composed of seronegative pregnant women (the risk is mainly for their future child) and individuals with compromised immune systems. Toxoplasmosis in immune-competent individuals generally goes unnoticed. In Nunavik, pregnant seronegative women are generally encouraged to eat fish for nutritional and cultural reasons, regardless of the preparation method used. The scientific literature about *T. gondii* in fish and its potential role in aquatic transmission cycles has appeared very recently. This brings light to the pertinence of reviewing this recommendation, taking into consideration the importance of country food and the risk of congenital toxoplasmosis despite serological follow-ups of seronegative pregnant women. Proper cooking or freezing of any animal tissues, as well as wearing gloves when handling animal carcasses should be considered in counselling seronegative pregnant women and immunocompromised individuals.

In the absence of science-based evidence using the gold-standard approach for proving which animals are biologically competent hosts that can cause infection in humans, the presence of DNA in animal tissues should be considered more robust data than the bivariate results outlined in this thematic report. Nevertheless, results outlined in this report support the presence of a combined water- and food-borne transmission pathway.

6.5 *HELICOBACTER PYLORI*

This is the first large-scale evaluation of the prevalence of *H. pylori* active infection in Nunavik. As suspected by Nunavik doctors, the 2017 proportion is very high (70%), although it reflects the rates observed in other comparable communities (> 50%) (Goodman et al., 2008; Jones et al., 2012). This situation seems to have been stable since 2004. The proportions are elevated compared to what is observed in non-Indigenous Canadian populations (~20 to 30%) owing to the differential distribution of risk factors and treatment protocols among them (Naja et al., 2007; Thomson et al., 2003). Such a high prevalence of *H. pylori* infection, coupled with a lack of compliance with antibiotherapy, antibioresistance and high re-infection rates, highlight the importance of moving from standard guidelines, such as the Maastricht guidelines, for routine management of *H. pylori* infections towards specific recommendations adapted to Nunavik realities focusing on symptomatic patients (McMahon et al., 2016). From a clinical perspective, stool antigen testing or urea breath tests documenting active infections should be used rather than serology as a diagnostic tool for confirming *H. pylori* infection in Nunavik.

Despite the high prevalence of *H. pylori* active infection and antibodies in Nunavik's population, no cases of gastric cancer or MALT lymphoma were observed throughout the medical file review of the 2017 participants. Moreover, the prevalence of potential consequences of *H. pylori* infection such as gastritis and/or ulcers were 12% and 3%*, respectively. Globally, close to 30% of the population had a history of *H. pylori* infection in their medical file. Surprisingly, those who did not have a history of *H. pylori* infection in their medical file were slightly more likely to be seropositive or SAT positive. This could reflect the fact that many infected participants do not have clinical symptoms and do not seek medical attention even in the presence of an active infection. Alternatively, this condition might be underdiagnosed by health professionals. Half of the individuals that were infected in 2017 had received a previous medical diagnosis of *H. pylori*, suggesting the presence of a chronic infection or re-infection.

The presence of occult fecal blood can suggest the presence of a gastric or duodenal ulcer associated with *H. pylori* infection. According to *Qanuilirpitaa?* 2017, elders with a positive *H. pylori* SAT seemed more prone to have occult blood in their stools, but the precision of the bivariate estimate was marginally significant and needs further exploration. Anemia could also be a consequence of gastric or duodenal ulcers associated with *H. pylori* infection. While the bivariate analysis between *H. pylori* seroprevalence and iron-deficiency anemia produced a marginally significant *p*-value, this needs to be further explored.

As for the potential risk factors identified by *Qanuilirpitaa?* 2017, they are very similar to those observed in other Indigenous or developing communities. Nunavik's population is growing faster than the number of housing units needed to adequately accommodate everyone. Hence, household overcrowding and bed sharing are reported to increase the risk of exposure to *H. pylori* through increased person-to-person contacts, since the bacteria is present in dental plaque and saliva (Kim et al., 2000). Concerning sex differences, *H. pylori* infections are slightly more prevalent in adult men than adult women and this phenomenon seems to be observed inconsistently from one study to another (de Martel & Parsonnet, 2006). Finally, the results of *H. pylori* active infection and seroprevalence according to age group are quite different from those observed in other studies where these proportions increase with life years (Fagan-Garcia et al., 2019). In contrast, the *Qanuilirpitaa?* 2017 survey revealed an inverse trend, where older participants seem to be less likely to be infected. Treatment of active infection, spontaneous clearance of *H. pylori* and acquired immunity may also play a role in this trend (Luzza et al., 2014).

6.6 SELF-REPORTED ACUTE GASTROINTESTINAL ILLNESS (AGI)

A similar proportion of the population self-reported AGI in 2017 (12%) and in 2004 (10%). Prolonged AGI episodes (3 days or more) also appeared to be similar between both Nunavik surveys (35% in 2017 and 39% in 2004, among those who declared an AGI episode).

The *Qanuilirpitaa?* weighted 30-day point prevalence (12%) is lower than that reported in a study conducted in two Nunavut communities (15-17%, reflecting a non-weighted 28-day point prevalence) (Harper et al., 2015). However, the authors of the Nunavut study stratified their results by season since variations are known to occur depending on the pathogen involved (Mounts et al., 2000). Globally, an increased incidence of AGI episodes is reported in spring, following the melting of snow (Ghazani et al., 2018). Hence, the 2017 self-reported prevalence of AGI might be lower since *Qanuilirpitaa?* was held in late summer/early fall when AGI is likely to be less frequent than in spring.

As for the potential risk factors associated with AGI, in 2017 age group was the only factor associated with this outcome, with the 31 to 49 age group presenting a higher prevalence. In 2004, both younger (0 to 4 years of age) and older generations reported AGI more often (Messier et al., 2007). In 2004, administrative regions (Hudson coast < Ungava coast) and the frequency of water tank cleaning were associated with the occurrence of AGI episodes.

Different gastrointestinal pathogens may circulate in Nunavik, creating specific patterns that are difficult to compare across time and space. The 2017 self-reported prevalence of AGI (12%) is slightly higher than the 28-day point prevalence reported at the Canadian level (8.5%) during the 2014-2015 Foodbook Survey (Thomas et al., 2017). Both studies had very comparable case definitions. It is possible that the shorter retrospective period of 28 days in the Canadian study explained in part the lower prevalence documented compared to the present survey, in which a period of 30 days was used.

6.7 STRENGTHS AND LIMITATIONS

The main strength of *Qanuilirpitaa?* 2017 is the sample size and the use of advanced statistical methodologies to estimate most outcomes at the population level and to identify potential risk factors. On the other hand, the main limitation of the present thematic report is associated with the fact that the statistical analyses are limited to bivariate analyses. That being said, a number of other common strengths and limitations can be associated with the zoonotic and gastrointestinal disease components of this thematic report.

Qanuilirpitaa? 2017 has made it possible to estimate the proportion of Nunavik's population with prior exposure to five zoonotic or gastrointestinal pathogens (Rabies *Lyssavirus*, *Trichinella* sp., *Cryptosporidium* sp., *T. gondii* and *H. pylori*), thanks to the detection of neutralizing IgG antibodies. Antibodies are produced by immune cells (B-cell lymphocytes) following a primary infection and normally decrease over time in the absence of re-exposure (Janeway et al., 2001). A proportion of the B-cells will retain a "memory" of the antigens they were presented to, thus preventing re-infection. Hence, the presence of circulating antibodies reflects a prior primary infection, but not the moment in time when the infection occurred and whether it was the result of re-exposure. In addition, the absence of circulating antibodies cannot be a guarantee that a person has never been exposed to the pathogen. In fact, it can reflect a true absence of exposure as it can also mean that antibodies have decreased under the seropositivity threshold, suggesting the absence of re-exposure to the pathogen. Re-exposure to a pathogen in a person's lifetime is not expected to be frequent with rare diseases such as trichinellosis in Nunavik. Conversely, re-exposure to a pathogen is expected to occur more frequently with very common pathogens such as *T. gondii*, given that cysts are detected in many local country foods that are consumed mostly raw. Misclassification of participants according to serological outcomes might have occurred since tests are not perfect (sensitivity and specificity values under 100%). The serological results obtained using the 2004 serums must be interpreted with caution since 13 years of freezing has probably led to a degradation of antibodies and thus underestimation of prevalences. This was observed in our attempt to calibrate the 2004 and 2017 *T. gondii* serological titers.

In total, four country food consumption variables, each of which has inherent strengths and limitations, were explored in a number of the bivariate analyses. Multiple strategies to regroup the initial seven modalities were explored because missing data were observed in the higher consumption frequencies for most country foods. Grouping these frequencies into a binary variable ("never or less than once a month" and "once a month and more") removes all the details related to the frequency of consumption. In addition, the 2017 FFQ covered food habits in the last three months prior to the survey, creating a potential seasonal bias in the participants' responses.

The variables evaluating if country foods were "eaten mostly raw" were more often identified as risk factors for *Trichinella* sp., *Cryptosporidium* sp. and *T. gondii,* and these results are scientifically compatible with the transmission cycles of these pathogens in Nunavik. The main limitation related to these variables is that no definition of "mostly" and "raw" was associated with the question "Do you often eat this raw?". Did participants interpret "raw" as referring only to freshly harvested country food or did they include meat that had been previously frozen? This clarification is important for two zoonotic diseases as some freezing regimens (e.g., 3 days at −20 °C) can destroy *T. gondii* cysts while *T. nativa* is cold resistant. Country food is frozen frequently in Nunavik either naturally during traditional activities performed during winter or when it is stored in a freezer for future consumption.

The variables that group similar animal species (e.g., marine and terrestrial mammals, wild birds, fish and shellfish) have the advantage of identifying potential environments that serve as the main source of infection. Conversely, their main limitation is that they do not reveal which country food is involved. Finally, the creation of a variable that measures the frequency with which country food is eaten mostly raw was judged the best way to reflect the risk of acquiring a zoonotic disease. A person may eat infected country food very often, but the risk of acquiring a parasite is greatly reduced if a method and a regimen destroying the parasite is used. Because these variables were created with two original FFQ questions (frequency of country food consumption multiplied by eaten mostly raw or not), their strengths and limitations have already been covered.

Finally, another limitation that may be discussed and that applies to the 2017 survey as a whole is the low participant contact rate and the potential selection bias associated with that. A selection bias also occurred in relation to the participants who submitted stool samples (*H. pylori*) since they differed in relation to sex, ecological region and community size. However, it should be possible to limit this selection bias by adjusting for these variables in multivariate models.

7 CONCLUSION

The *Qanuilirpitaa?* 2017 Health Survey has made it possible to estimate the burden of certain zoonotic and gastrointestinal diseases in Nunavik's population and to document important information for local human and animal health authorities. The results of this thematic report cover only the microbiological and parasitological risks associated with specific pathogens that can be found in local country foods or the environment. However, it is of the utmost importance that readers factor in all the health benefits associated with the vital nutriments, cultural values and practices associated with country-food harvesting and consumption, as these subjects are not covered in this report.

Globally, *Qanuilirpitaa?* 2017 has made it possible to document that trichinellosis, cryptosporidiosis and animal bites do not often affect (< 10%) Nunavik's population and that *Toxoplasma gondii* (~40%) seroprevalence has declined since 2004. Finally, as expected from the literature and by Nunavik health professionals, *H. pylori* active infection is present in ~70% of the population. However, this situation seems to have been stable since 2004.

In addition to evaluating the burden of these diseases, this thematic report provides an insight on the risk factors potentially associated with each outcome. More specifically, the 2017 survey reveals that:

- Animal bites or scratches were mostly caused by dogs and more likely to occur in men, Nunavimmiut aged 16 to 30 and residents of the Ungava Bay ecological region.
- Past exposure to *Trichinella* sp. was more prevalent in Nunavimmiut aged 50 and over, residents of the Hudson Bay ecological region and people who ate seal meat mostly raw.
- Past exposure to *Cryptosporidium* sp. was more likely in men, Nunavimmiut aged 50 and over, residents of the Ungava Bay ecological region and people with a higher income. Certain country food may have been a source of exposure (including seal and shellfish).
- Past exposure to *T. gondii* was more prevalent in women, Nunavimmiut aged 50 and over, residents of the Hudson Bay ecological region and people with a lower education level and a higher income. Seroprevalence was higher in Nunavimmiut drinking water from natural and municipal water sources, preparing more wild birds carcasses and reporting the consumption of country food (walrus, seal, caribou, ptarmigan/partridge, fish and shellfish).
- Active *H. pylori* infection was positively associated with Nunavimmiut aged 31 to 49, large community size, the Hudson coast ecological region, drinking from natural water sources in winter and household overcrowding.

However, additional analyses will be needed in order to understand the complex interactions between these potential risk factors and the different outcomes.

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APPENDIX A
QUESTIONNAIRES

ᐊᕕᑦᑐᓯᒪᔪᖅ 5. [6] ᐆᒪᔪᒧᑦ ᑮᔭᐅᓂᖅ ᖅᑭᓯᑦᑕᐅᓂᖅ

ᐊᐱᕐᓱᑎᐅᓚᖓᓕᕐᒥᔪᑦ ᐃᓅᑉ ᖃᓄᐃᙱᓯᐊᕐᓂᖓᓄᓚᖓᔪᑦ ᐆᒪᔪᖃᕐᓂᒧᓗ.

SECTION 5.
[6] Zoonosis

The following questions refer to human health and interactions with animals.

1. ᐊᓂᒍᖅᑐᓂᑦ ᑕᖅᑭᓂᑦ 12ᓂᑦ, ᑮᔭᐅᓐᓂᖅᑮᑦ ᑭᓯᑦᑕᐅᓯᑎᓗᓐᓃᑦ ᐅᒧᖓ:

ᐊ) ᖅᑭᒻᒥᒃ?

- ◯ 1- ᐋ
- ◯ 2- ᐊᐅᑲ
- ◯ 99- ᖃᐅᔨᒪᙱᑐᖅ-ᑭᐅᙱᑐᖅ-ᑭᐅᒍᒪᙱᑐᖅ

ᐸ) ᐆᒪᔪᒧᑦ (ᐊᒪᕈᖅ, ᑎᕆᒐᓐᓂᐊᖅ ᐊᑦᓴᓗᒧᓗᓐᓃᑦ ᓇᓄᕐᒧᓗᓐᓃᑦ)?

- ◯ 1- ᐋ
- ◯ 2- ᐊᐅᑲ
- ◯ 99- ᖃᐅᔨᒪᙱᑐᖅ-ᑭᐅᙱᑐᖅ-ᑭᐅᒍᒪᙱᑐᖅ

1. <u>In the last 12 months</u>, have you ever been bitten or scratched by:

a) A dog?

- ◯ 1- Yes
- ◯ 2- No
- ◯ 99- DK/NR/R

b) A wild animal (wolf, fox or bear)?

- ◯ 1- Yes
- ◯ 2- No
- ◯ 99- DK/NR/R

8. <u>ᐊᓂᒍᖅᑐᓂᑦ ᑕᖅᑭᓂᑦ 12ᓂᑦ</u>, ᖃᑦᔫᑦ ᑖᒃᑯᐊ ᐊᓪᓚᔨᒪᔪᐃᑦ ᐆᒪᔪᐃᑦ ᐋᑦᑐᓂᖅᑲᑎᑦ, ᓴᓗᒻᒪᓴᓂᖅ, ᓇᑲᑎᕆᓂᑦ, ᐊᓯᖏᓪᓗ.?

7. <u>In the past 12 months</u>, how many of the following animals did you prepare such as skinning, washing, cutting, etc.?

		None ᐱᑦᖃᙱᑐᖅ	1 - 2	3 - 9	10 - 29	More than 30 30 ᐅᖓᑖᓂ	DK/NR/R
ᐊ) ᖁᐸᓄᐊᑦ	a) Wild Birds	◯1	◯2	◯3	◯4	◯5	◯99
ᐸ) ᑐᑦᑐᒃ ᐅᒥᒻᒪᓗᓐᓃᑦ	b) Caribou or muskox	◯1	◯2	◯3	◯4	◯5	◯99
ᑕ) ᑎᕆᒐᓐᓂᐊᖅ, ᐊᒪᕈᐃᑦ ᖅᑭᒻᒦᓗᓐᓃᑦ	c) Fox, wolves or dogs	◯1	◯2	◯3	◯4	◯5	◯99
ᑲ) ᐊᑦᓴᒃ ᓇᓄᖅ	d) Bear	◯1	◯2	◯3	◯4	◯5	◯99
ᒐ) ᐃᒪᕐᒥᐅᑕᑦ ᐆᒪᔪᐃᑦ (ᐳᐃᔩᑦ, ᕿᓚᓗᒐᑦ, ᐁᕕᖅ)	e) Sea mammals (seals, whales, walrus)	◯1	◯2	◯3	◯4	◯5	◯99

In the last 3 months, how often on average do you eat this food?

Country foods		Never or less than once a month	1-3 times a month	Once a week	2-6 times a week	Once a day	2-3 times a day	4 times and more a day
Marine mammals								
Beluga	1. Dried meat (nikku)							
	2. Meat 2.1 Do you often eat this raw? ◯ Yes ◯ No							
	3. Misirak/Ursuk (blubber only)							
	4. Mattaaq (skin and blubber)							
Seal	5. Meat (fresh, cooked, frozen) 5.1 Do you often eat this raw? ◯ Yes ◯ No							
	6. Misirak/Ursuk (blubber only)							
	7. [8] Liver 7.1 Do you often eat this raw? ◯ Yes ◯ No							
8. [9] Walrus meat, igunak 8.1 Do you often eat this raw? ◯ Yes ◯ No								
Game Animals and Birds								
Caribou	9. [10] Dried meat (nikku)							
	10. [11] Meat 10.1 Do you often eat this raw? ◯ Yes ◯ No							
11. [12] Polar bear								
12. [13] Muskox								
13. [14] Ptarmigan, partridge 13.1 Do you often eat this raw? ◯ Yes ◯ No								

Country foods	Never or less than once a month	1-3 times a month	Once a week	2-6 times a week	Once a day	2-3 times a day	4 times and more a day
14. [15] Goose (Canada or white goose) 14.1 Do you often eat this raw? ◯ Yes ◯ No							
15. [16] Eggs of game bird 15.1 Which ones do you usually eat? (check all that apply) ◯ Duck ◯ Geese ◯ Murre/Seagulls							
Fish and seafood							
16. [17] Dried fish (nikku, pitsik) 16.1 Which ones do you usually eat? (check all that apply) ◯ Char ◯ Brook trout ◯ Lake trout ◯ Other							
17. [18] Lake trout (fresh, cooked or frozen, NOT dried)							
18. [19] Brook or sea trout, or salmon (fresh, cooked, canned or frozen, NOT dried)							
19. [20] Arctic char (fresh, cooked or frozen, NOT dried)							
20. [21] Pike or walleye							
21. [22] Other fish, e.g. Lake whitefish (Coregone), Sculpin (Ugly fish)							
22. [23] Mollusks (Mussels, scallops, clams, etc.) and urchins 22.1 Do you often eat this raw? ◯ Yes ◯ No							
23. [24] Seaweed (kuanniq, qirquak, etc.)							

4. [7] ᐅᐱᕐᖕᓛᖕᒍᓚᐅᔪᒥ (ᐊᐅᔾᔭᐅᓚᐅᔪᒥ), ᓇᑭᑦ ᐱᓯᒪᔪᒥᒃ ᐃᒥᕐᑲᑦᑕᓚᐅᔪᕕᓯᕙ

- 1- ᓄᓇᓕᐅᑉ ᐃᒪᕐᑲᕐᑎᓯᒍᑎᖕᒐ (ᑯᕕᔪᒥ ᐃᒪᖅ/ ᐃᒪᕐᑲᐅᑎᒥ ᐊᓂᕐᕋᓂ)
- 2- ᐃᒥᕐᑕᕕᒻᒥ ᐃᒥᕐᑕᓯᒍ
- 3- ᐳᓪᓚᐅᔭᓂᑦ ᐃᒪᖅ
- 4- ᑕᓯᕐᒥ ᕐᑲᓂᑦᑐᒥ, ᑰᒻᒥ ᑰᒐᕐᒥᓗᓐᓃᑦ
- 5- ᐊᓂᐅᒥᒃ ᐊᐅᑦᑐᕕᓂᕐᒥᒃ; ᓯᑯᒥᒃ ᐱᕐᑲᓗᔭᒥᓗᓐᓃᑦ
- 99- ᕐᑲᐅᔨᒪᖕᖕᒋᑐᖅ/ᑭᐅᖕᖕᒋᑐᖅ/ᑭᐅᒍᒪᖕᖕᒋᑐᖅ

4. [7] <u>In the last summer</u>, what was the main source of drinking water in your home?

- 1- Municipal system (tap water/water tank at home)
- 2- Tap directly at the water plant
- 3- Bottled water
- 4- From nearby lake, river or stream
- 5- Melted snow, ice or iceberg
- 99- DK/NR/R

5. [8] ᐅᑭᐅᖕᒍᓚᐅᔪᒥ, ᓇᑭᑦ ᐱᓯᒪᔪᒥᒃ ᐃᒥᕐᑲᑦᑕᓚᐅᔪᕕᓯᕙ

- 1- ᓄᓇᓕᐅᑉ ᐃᒪᕐᑲᕐᑎᓯᒍᑎᖕᒐ (ᑯᕕᔪᒥ ᐃᒪᖅ/ ᐃᒪᕐᑲᐅᑎᒥ ᐊᓂᕐᕋᓂ)
- 2- ᐃᒥᕐᑕᕕᒻᒥ ᐃᒥᕐᑕᓯᒍ
- 3- ᐳᓪᓚᐅᔭᓂᑦ ᐃᒪᖅ
- 4- ᑕᓯᕐᒥ ᕐᑲᓂᑦᑐᒥ, ᑰᒻᒥ ᑰᒐᕐᒥᓗᓐᓃᑦ
- 5- ᐊᓂᐅᒥᒃ ᐊᐅᑦᑐᕕᓂᕐᒥᒃ; ᓯᑯᒥᒃ ᐱᕐᑲᓗᔭᒥᓗᓐᓃᑦ
- 99- ᕐᑲᐅᔨᒪᖕᖕᒋᑐᖅ/ᑭᐅᖕᖕᒋᑐᖅ/ᑭᐅᒍᒪᖕᖕᒋᑐᖅ

5. [8] <u>In the last winter</u>, what was the main source of drinking water in your home?

- 1- Municipal system (tap water/water tank at home)
- 2- Tap directly at the water plant
- 3- Bottled water
- 4- From nearby lake, river or stream
- 5- Melted snow, ice or iceberg
- 99- DK/NR/R

7. [10] ᐊᓂᕐᕋᒥ, ᐃᒪᕐᒥᒃ ᓴᓗᒻᒪᓵᖕᒍᕕᑦ ᓇᓪᓕᑐᐃᓐᓇᖕᒋᓐᓂᑦ ᐅᑯᓂᖕᒐ ᐊᑐᕐᓯᑎᑦᐯ

7. [10] At home, do you treat the water you drink by any of the following methods?

		Yes ᐋ	No ᐊᐅᑲ	DK/NR/R
ᐊ) ᑎᕐᑎᑦᑎᓯᒍ	a) Boiling	1	2	99
ᐸ) ᐃᒪᕐᒥᒃ ᓴᓗᒻᒪᓴᒍᑎᒍᑦ (ᐳᕆᑕ, ᐊᐅᓛᓗᒃ ᐊᑦᔨᐸᓯᖕᒐᓂᓗᓐᓃᑦ)	b) Filtering (Brita, charcoal or similar)	1	2	99
ᑕ) ᐊᓯᖕᒋᓐᓂᑦ ᓴᓗᒻᒪᓴᒍᑎᖕᒋᓐᓂᑦ	c) Other type of treatment	1	2	99

8. [11] ᐃᒪᖃᐅᑎᓖ ᐊᓂᕐᕋᓂ?

- 1- ᐋ
- 2- ᐊᐅᑲ ᐁᒥᑦ ᑭᖑᓪᓕᖕᒥᓐᓂᑐᓄᑦ ᐊᕕᑦᑐᓯᒪᔭᓂ
- 99- ᖃᐅᔨᒪᙱᑦᑐᖅ/ᑭᐅᙱᑦᑐᖅ/ᑭᐅᔪᒪᙱᑦᑐᖅ ᐁᒥᑦ ᑭᖑᓪᓕᖕᒥᓐᓂᑐᓄᑦ ᐊᕕᑦᑐᓯᒪᔭᓂ

ᐊ) [11A] ᐊᓂᕐᕋᓂ, ᐃᒪᖃᐅᑎᒃ ᖃᖓ ᑭᖑᓪᓛᒥ ᓴᓗᒻᒪᓴᖅᑕᕕᓂᖅ?

- 1- ᑕᖅᑭᐅᓚᐅᖅᑐᒥ
- 2- ᐊᕐᕌᓂ
- 3- ᐊᕐᕌᓂᑦᓴᖅ
- 4- ᐊᕐᕋᒍᐃᑦ 2-5 ᒐᓚᓐᓂ
- 5- ᐊᕐᕌᒍᐃᑦ 5 ᐅᖓᑖᓂ
- 99- ᖃᐅᔨᒪᙱᑦᑐᖅ/ᑭᐅᙱᑦᑐᖅ/ᑭᐅᔪᒪᙱᑦᑐᖅ

8. [11] Is there a water tank in your house?

- 1- Yes
- 2- No Go to the next block
- 99- DK/NR/R Go to the next block

a) [11A] In your home, when was the water tank cleaned the last time?

- 1- In the last month
- 2- In the last year
- 3- About 2 years ago
- 4- Between 2-5 years ago
- 5- More than five years ago
- 99- DK/NR/R

ᐊᕕᑦᑐᓯᒪᔪᖅ 6. [7] ᐊᕐᑭᐊᕈᓕᓇᓂᖅ ᐃᓇᓗᐊᕐᓗᓂᖅ

ᐊᐱᕐᔪᑎᐅᓚᖓᓕᕐᒥᔪᑦ ᐊᕐᑭᐊᕈᓕᓇᓂᕐᑐᓕᖓᔪᑦ ᐃᓇᓗᐊᕐᓗᓂᕐᑐᓗ ᐋᓐᓂᐊᓃᑦ.

1. ᐊᓂᒍᕐᑐᓂᑦ ᑕᕐᕿᓂᑦ 6ᓂᑦ, ᓴᓗᓯᒪᕖᑦ ᓴᓗᓚᔨᓐᓇ ᕐᑯᐃᑦᑎᐅᒥᒋᐊᓪᓚᓇᕐᓗ? (ᑕᑦᓯᑲᕐᑲᑦᑕᓇᐊᕐᑲᔨᓐᓂᕐᕿᑦ ᐅᕝᕙᓗᓐᓃᑦ ᐊᓐᓄᕿᑎᑦ ᐊᖕᒋᒋᓕᐅᒥᕙᑎᑦ?)
   - 1- ᐋ
   - 2- ᐊᐅᑲ
   - 99- ᕐᑲᐅᔨᒪᙱᑦᑐᖅ-ᑭᐅᙱᑦᑐᖅ-ᑭᐅᔪᒪᙱᑦᑐᖅ

2. ᐊᓂᒍᕐᑐᓂᑦ ᑕᕐᕿᓂᑦ 6ᓂᑦ, ᐊᓇᕐᓂᕐᕿᑦ ᕐᑭᕐᓂᑕᓪᓚᓇᒥᒃ (ᐃᓪᓗᑉ ᕐᑯᓛᑦᓴᔭᖕᒪᑕ ᓂᐱᑎᕈᑎᖕᒪᑎᑐᑦ) ᐅᕝᕙᓗᓐᓃᑦ ᐊᐅᒻᒥᒃ ᑕᑯᓚᐅᕐᓯᒪᕖᑦ ᐊᓇᕐᑕᐃᓂ?
   - 1- ᐋ
   - 2- ᐊᐅᑲ
   - 99- ᕐᑲᐅᔨᒪᙱᑦᑐᖅ-ᑭᐅᙱᑦᑐᖅ-ᑭᐅᔪᒪᙱᑦᑐᖅ

3. ᐊᓂᒍᕐᑐᓂᑦ ᐅᓪᓗᓂᑦ 30ᓂᑦ, ᕐᑲᓂᒪᓐᓂᕐᕿᑦ ᒥᓇᐊᕐᑲᑦᑕᔪᑎᑦ ᐃᑎᑦᑕᔪᑎᓗᓐᓃᑦ? - ᐃᓚᐅᙱᑎᓪᓗᒍ ᐋᖕᒪᔩᓐᓇᕐᑐᕐᑐᓯᒪᔪᓄᑦ ᐊᑑᑎᔭᐅᔩᑦ, ᐃᒥᐊᓗᑦᓯᒪᔪᓄᑦ, ᐱᐊᕋᑦᓴᓕᓐᓄᑦ (ᓄᑕᕋᑦᓴᓕᓐᓄᑦ) ᐋᓐᓂᐊᒍᑎᐅᖕᒋᓐᓇᓕᒫᕐᑐᓴᔭᐅᒐᓂᓗ?
   - 1- ᐋ ᐁᒋᑦ ᑎᒥᐅᑉ ᕐᑲᓄᐃᓕᖕᒐᓂᖕᒐᓄᑦ-ᐊᕕᑦᑐᓯᒪᔪᖅ 6 ᐊᐱᕐᓯᑎᒃ 4ᒧᑦ
   - 2- ᐊᐅᑲ ᐁᒋᑦ ᑎᒥᐅᑉ ᕐᑲᓄᐃᓕᖕᒐᓂᖕᒐᓄᑦ-ᐊᕕᑦᑐᓯᒪᔪᖅ 7ᒧᑦ. ᐆᒪᔪᕐᓂᐊᓂᖅ ᐃᕐᑲᓪᓕᐊᓂᕐᒧᓗ
   - 99- ᕐᑲᐅᔨᒪᙱᑦᑐᖅ-ᑭᐅᙱᑦᑐᖅ-ᑭᐅᔪᒪᙱᑦᑐᖅ ᐁᒋᑦ ᑎᒥᐅᑉ ᕐᑲᓄᐃᓕᖕᒐᓂᖕᒐᓄᑦ-ᐊᕕᑦᑐᓯᒪᔪᖅ 7ᒧᑦ. ᐆᒪᔪᕐᓂᐊᓂᖅ ᐃᕐᑲᓪᓕᐊᓂᕐᒧᓗ

4. ᕐᑲᑦᓯᓂᑦ ᐅᓪᓗᓂᑦ ᒥᓇᐊᕐᑲᑦᑕᓂᕐᕿᑦ ᐊᒻᒪᓗ/ᐅᕝᕙᓗᓐᓃᑦ ᐃᑎᑦᑕᔪᑎᑦ ᑭᖑᓪᓕᕖᒥ?

   ______ ᐅᓪᓗᐃᑦ

   - 99- ᕐᑲᐅᔨᒪᙱᑦᑐᖅ-ᑭᐅᙱᑦᑐᖅ-ᑭᐅᔪᒪᙱᑦᑐᖅ

SECTION 6.
[7] Gastro-intestinal illness

The following questions refer to common symptoms of stomach and intestinal illnesses.

1. <u>During the last six months</u>, have you involuntarily lost weight and not gained it back? (Did you have to tighten your belt or do your clothes fit more loosely?)
   - 1- Yes
   - 2- No
   - 99- DK/NR/R

2. <u>In the last six months</u>, did you have very black stool (like coal tar) or have you ever seen blood in your stool?
   - 1- Yes
   - 2- No
   - 99- DK/NR/R

3. <u>In the past 30 days</u>, did you experience any illness that included vomiting or diarrhea? – excluding symptoms related to drugs, alcohol consumption, pregnancy and chronic illness?
   - 1- Yes go to PHFS -Section 6 – Q4
   - 2- No go to PHFS -Section 7. Hunting and Fishing
   - 99- DK/NR/R go to PHFS -Section 7. Hunting and Fishing

4. How many days did your episode of vomiting and/or diarrhea last?

   ______ days

   - 99- DK/NR/R

APPENDIX B
SUPPLEMENTARY TABLES AND FIGURES

Table 12 Prevalence of zoonotic and gastrointestinal outcomes in the *Qanuippitaa?* 2004 and *Qanuilirpitaa?* 2017 health surveys

Health outcomes	Test results or questionnaire answer % (95% CI)		
	Positive/Yes	Negative/No	Equivocal
***Qanuippitaa?* 2004 non-weighted health outcomes**			
Rabies *Lyssavirus* serology[a]	0[1]	100	–
H. pylori serology	79.8 (74.5 – 84.3)	17.5 (13.3 – 22.6)	2.7 (1.3 – 5.5)**
***Qanuilirpitaa?* 2017 survey weighted health outcomes**			
Trichinella sp. serology	2.8 (1.9 – 4.2)*	94.8 (93.2 – 96.0)*	2.4 (1.6 – 3.6)*
Cryptosporidium sp. serology	6.3 (4.9 – 7.9)	87.6 (85.4 – 89.5)	6.2 (4.8 – 7.9)
Animal bite (domestic and wild animals)	6.4 (5.1 – 8.0)	93.6 (92.0 – 94.9)	–
Acute gastrointestinal illness (AGI)	12.2 (10.3 – 14.4)	87.8 (85.6 – 89.7)	–
Presence of occult blood in stools[b]	12.5 (8.1 – 18.7)	87.5 (81.3 – 91.9)[3]	–
T. gondii serology	42.0 (39.6 – 44.4)	56.9 (54.5 – 59.2)	1.1 (0.7 – 1.9)**
H. pylori serology	72.6 (70.0 – 75.0)	23.0 (20.6 – 25.5)	4.4 (3.5 – 5.7)
***Qanuilirpitaa?* 2017 survey non-weighted health outcomes**			
Prolonged AGI (≥ 3 days) among people who declared AGI	35.1 (27.9 – 43.0)	64.9 (57.0 – 72.1)	–
H. pylori stool antigen test (SAT)[c]	70.2 (66.7 – 73.4)	29.4 (26.2 – 32.8)	F

[a] Naturally acquired immunity against rabies was not detected in this study component because the two participants with positive serology had a history of vaccination.
[b] In participants aged 50 years and over.
[c] Four negative stool samples that were frozen are included in these results.

NOTE:
Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**).
F: This value is not displayed since some categories have less than 5 respondents.

Table 13 Prevalence of zoonotic and gastrointestinal outcomes according to sociodemographic variables, population aged 16 years and over, Nunavik, 2017

Sociodemographic variables	Weighted prevalence							Non-weighted prevalence	
	Trichinella sp. serology	*Cryptosporidium* sp. serology	*T. gondii* serology	*H. pylori* serology	Animal bite or scratches	Acute gastrointestinal illness (AGI)	Occult blood in stools[a]	*H. pylori* SAT[b]	Prolonged AGI[c]
Sex									
Women	2.3*	5.1	45.4	67.5	4.6	12.2	9.2**	70.0	36.3
Men	3.5**	8.2*	39.9	77.5	8.3	12.3	15.8**	71.4	34.6*
p-value	0.2	**0.07**	**0.04**	< **0.0001**	**0.02**	1.0	0.2	0.7	0.8
Age group									
16-30 years	2.0**	3.6*	17.9	77.6	9.4	9.1	–	72.8	41.1*
31-49 years	2.3**	7.8*	50.5	77.8	5.8*	17.2	–	78.4	33.3*
50 years and over	5.6**	11.0*	77.6	56.6	2.2**	10.7	12.6	59.3	31.7*
p-value	**0.09**	**0.001**	< **0.0001**	< **0.0001**	**< 0.0001**	**0.01**	–	< **0.0001**	0.6
Community size									
Large	3.1**	6.7*	41.7	75.4	6.9*	13.0	13.6**	73.9	35.7
Small	2.7**	6.8	43.9	68.7	6.0*	10.9	11.0**	67.1	35.7*
p-value	0.8	1.0	0.4	**0.03**	0.6	0.3	0.6	**0.04**	1.0
Ecological region									
Hudson Strait	2.4**	3.3**	27.3	70.5	4.2	12.4	14.9**	69.6	33.3*
Hudson Bay	5.1**	4.4**	56.1	76.3	5.4	11.0	13.7**	74.7	36.7*
Ungava Bay	F	12.0*	36.4	69.1	9.2	13.3	9.5**	67.3	36.1*
p-value	n.a.	**0.0001**	**< 0.0001**	**0.02**	**0.04**	0.6	0.6	**0.1**	0.9
Education									
Elementary	F	9.8**	63.2	62.1	6.8**	9.4	13.0**	62.9	23.1**
Secondary	2.7*	6.0*	39.4	74.7	6.5	12.5	14.9**	72.3	40.7
College and more	3.9**	9.2*	40.7	71.0	7.3**	12.4	4.0**	69.5	19.2**
p-value	n.a.	0.2	**0.0002**	**0.1**	1.0	0.5	**0.09**	0.3	**0.05**

Sociodemographic variables	Weighted prevalence							Non-weighted prevalence	
	Trichinella sp. serology	*Cryptosporidium* sp. serology	*T. gondii* serology	*H. pylori* serology	Animal bite or scratches	Acute gastrointestinal illness (AGI)	Occult blood in stools[a]	*H. pylori* SAT[b]	Prolonged AGI[c]
Income									
< $20 000	3.2*	4.5*	37.3	74.6	6.9*	10.4	15.4**	71.8	36.5*
$20 000 to $40 000	2.1**	7.2**	47.6	70.1	6.6**	10.7	6.9**	73.6	39.3*
> $40 000	2.2**	9.8*	46.6	70.8	5.9**	15.5	15.7**	68.1	27.9*
p-value	0.6	**0.04**	**0.01**	0.4	0.9	0.2	0.4	0.5	0.5
Household overcrowding									
Yes	10.3**	7.9**	41.5	77.0	5.7	10.3	20.0**	75.6	44.2*
No	12.9**	6.2**	43.1	70.7	6.8	12.9	11.3**	68.4	32.4
p-value	0.2	0.4	0.6	**0.06**	0.5	0.2	0.3	**0.05**	0.2

[a] In participants aged 50 years and over.
[b] Stool antigen test.
[c] Among the 126 participants with AGI.

NOTE:
Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**).
F: This value is not displayed since some categories have less than 5 respondents; n.a. the *p*-value is not displayed. 1 Stool antigen test. All *p*-values ≤ 0.1 are highlighted.

Table 14 Potential water-related risk factors associated with exposure to *Cryptosporidium* sp., *Toxoplasma gondii* and *Helicobacter pylori*

Potential water-related risk factors	2017 weighted seroprevalence (%)			2017 non-weighted prevalence (%)	2017 weighted prevalence (%)
	Cryptosporidium sp.	*T. gondii*	*H. pylori*	*H. pylori* stool antigen test (SAT)	AGI[a]
Water source in summer					
Bottled water	F	24.1*	79.0	77.3	9.4**
Municipal system (tap water/water tank at home) and tap directly at the water plant	7.1	44.3	75.3	77.3	12.3
Natural sources (from nearby lake, river or stream, melted snow, ice or iceberg)	4.6	48.7	78.6	65.0	12.9*
p-value	n.a.	**0.002**	0.6	0.3	0.7
Water source in winter					
Bottled water	F	21.3*	84.4	81.6	7.6**
Municipal system (tap water/water tank at home) and tap directly at the water plant	6.9**	44.2	76.3	71.1	12.4
Natural sources (from nearby lake, river or stream, melted snow, ice or iceberg	4.4	49.3	68.9	62.6	13.3
p-value	n.a.	**0.001**	**0.04**	**0.07**	0.3
Water treatment					
Yes	6.8	43.1	75.8	71.1	12.8
No	6.1*	41.2	76.2	69.6	10.5*
p-value	0.7	0.5	0.9	0.7	0.3
Water tank cleaning					
In the last month	5.5*	43.1	69.6	64.5	11.3*
In the last year	7.4*	45.5	77.0	73.6	11.1
About 2 years ago	9.3**	38.9	80.0	74.1	21.6*
More than 2 years ago	F	46.2	80.5	87.9	16.4**
p-value	n.a.	0.7	**0.07**	**0.01**	0.2

[a] Acute gastro-intestinal illness.
NOTE:
Results must be interpreted with caution when the CV is between 15-25% (*), and results are shown for information only when the CV is ≥ 25% (**).
F: This value is not displayed since some categories have less than 5 respondents; n.a. the *p*-value is not displayed.
All *p*-values ≤ 0.1 are highlighted.

Table 15 Comparison of *H. pylori* serological results for the 269 participants of the 2004-2017 cohort

Serological results with 2004 serum	Serological results with 2017 serum		
	Negative (%)	Positive (%)	Equivocal (%)
Negative	20 (43.5)	23 (50.0)	3 (6.5)
Positive	50 (24.3)	141 (68.5)	15 (7.3)
Equivocal	4 (23.5)	11 (64.7)	2 (11.8)

Table 16 Comparison of non-weighted *H. pylori* serological results compared to the stool antigen test (SAT) used as the gold standard

Serological results	Stool antigen test		
	Positive	Negative	Total
Seropositive	415	66	481
Seronegative	71	136	207
Total	486	202	688

Sensitivity

$$Sn = \frac{True\ positive}{(True\ positive + false\ negative)} = \frac{415}{486}$$

$$Sn = 0.85$$

Specificity

$$Sp = \frac{True\ negative}{(True\ negative + false\ positive)} = \frac{136}{202}$$

$$Sp = 0.67$$

Positive predictive value

$$PV+ = \frac{True\ positive}{(True\ positive + false\ positive)} = \frac{415}{481}$$

$$PPV = 0.86$$

Negative predictive value

$$PV- = \frac{True\ negative}{(True\ negative + false\ negative)} = \frac{136}{207}$$

$$PPV = 0.66$$

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