



**A Descriptive Analysis of Notifiable Gastrointestinal Illness  
in the Northwest Territories, Canada, 1991-2008**

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**Title:**

A Descriptive Analysis of Notifiable Gastrointestinal Illness in the Northwest Territories,  
Canada, 1991-2008

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## ABSTRACT

**Objectives:** To describe the demographic, temporal and spatial distribution of reported enteric, food- and waterborne diseases in the Northwest Territories (NWT) from January 1991 through December 2008.

**Design:** Descriptive analysis of 708 reported cases of enteric, food- and waterborne diseases extracted from the Northwest Territories Communicable Disease Registry (NWT CDR).

**Setting:** Primary, secondary and tertiary health care centres across all 33 communities of the Northwest Territories.

**Population:** NWT residents of all ages with confirmed enteric, food- and waterborne diseases reported to the NWT CDR from January 1991 through December 2008.

**Main Outcome Measure:** Laboratory-confirmed enteric, food- and waterborne diseases.

**Results:** Campylobacteriosis, giardiasis and salmonellosis were the most commonly identified types of enteric illness in the territory. There was an increased risk of infection from the late summer to autumn ( $p<0.01$ ). Higher rates of notifiable gastrointestinal illness (all 15 diseases/infections) were found in the 0 to 9 years age group and in males ( $p<0.01$ ). Similarly, rates of giardiasis were higher in the 0 to 9 years age group and in males ( $p<0.02$ ). A disproportionate burden of salmonellosis was found in people 60 years and older and in females ( $p<0.02$ ). Although not significant, the incidence of campylobacteriosis was greater in the 20 to 29 years age group and in males ( $p<0.07$ ). The health authority with the highest incidence of NGI was Yellowknife ( $p<0.01$ ) while for campylobacteriosis and salmonellosis it was Tlicho ( $p<0.01$ ) and for giardiasis, Sahtu region ( $p<0.01$ ). Overall, disease rates were higher in urban areas ( $p<0.01$ ). Contaminated eggs, poultry and untreated water were believed by health

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3 practitioners to be important sources of infection in cases of salmonellosis, campylobacteriosis  
4  
5 and giardiasis, respectively.  
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9 **Conclusion:** The general patterns of these findings suggest that environmental and behavioral  
10 risk factors played key roles in infection. Further research into potential individual and  
11 community-level risk factors is warranted.  
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## 15 16 17 **ARTICLE SUMMARY**

### 18 19 **Article Focus**

- 20  
21 • To date, there is very little baseline data on notifiable gastrointestinal illness (NGI)  
22 diseases in the Northwest Territories, where Aboriginal people constitute a majority of  
23 the population. The demographic, socio-cultural, and health conditions of northern  
24 Aboriginal people are markedly different from those of other Canadian populations.  
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31 • There is a clear need to identify demographic, geographical and temporal distributions  
32 and risk factors NGI in order to guide disease control strategies.  
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### 37 38 **Key Messages**

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40 • The annual average rate of NGI over the study period was 95.5 cases per 100,000 with  
41 increased risk in the 0 to 9 years age group and males.  
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45 • Reported rates of NGI declined from 1991 to 2008 however, seasonal peaks were  
46 observed in the spring and fall months.  
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51 • There was variability in the rates of NGI with higher notifications in the southern, urban  
52 areas compared to the northern, rural, remote areas of the territory suggesting the possible  
53 involvement of geographical risk factors and/or bias in the surveillance data.  
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## Strengths and Limitations

- The study provides a historical portrait of NGI as the Northwest Territories Communicable Disease Registry (NWT CDR) broadly covered the entire territory over 18 years, therefore allowing comparisons across communities and time periods.
- Due to under-reporting, the rates of infections reported in this study are likely underestimates of the true incidence of diseases and therefore, should be interpreted as reporting rates rather than as incidence rates.
- Suspected sources of infection are infrequently confirmed by microbiological testing therefore, the results regarding ‘suspected exposure’ must be viewed with caution and be thought of as hypotheses.

## BACKGROUND

Notifiable gastrointestinal illness (NGI) is an important global public health issue and a growing concern in northern, rural and remote populations of Canada. Many Aboriginal residents of the Northwest Territories (NWT) engage in traditional and subsistence activities (harvesting, processing, sharing and consumption of animals, fish and plants) as they have economic, dietary and socio-cultural importance.[1] Nonetheless, activities such as hunting, fishing and trapping as well as the traditional preparation, storage and consumption of wild game, seafood and untreated water can increase exposure to pathogenic agents in the environment.[2] Illness can result from the ingestion of micro-organisms in contaminated food or water, through contact with animals or other contaminated objects, and some infections can be further spread by person-to-person transmission.[3] Symptoms can include loss of appetite, abdominal cramps, diarrhea of variable severity, nausea, vomiting, and fever.[4] Estimates of the overall morbidity and identification of potential risk factors for NGI in NWT have not been previously published in the literature and hence, there is very little baseline data to inform policies and guide public health interventions in the territory. Using data elements extracted from cases of NGI in the Northwest Territories Disease Registry (NWT CDR), this study describes the demographic, temporal and spatial distribution of NGI in NWT from January 1991 through December 2008.

## METHODS

### Study Area

The NWT is located in northern Canada with a majority Aboriginal population (50.3%).[5] As of the 2006 Census, the population was 41,464, an increase of 11% from

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3 2001.[5] There are 33 officially recognized communities across 1,140,835 km<sup>2</sup> of land; the  
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5 smallest is Kakisa with 52 residents and the largest is Yellowknife with 18,700 residents.[6] The  
6  
7 NWT population density is 0.03 people per km<sup>2</sup>. There is a high proportion of children under 15  
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9 years of age (23.9%) and a low proportion of people over 65 years of age (4.7%).[6] The median  
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11 age for both sexes is 31 years; males comprise a majority of the population (51.2%).[6]  
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## 14 15 16 **Data Sources**

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19 Data on reported cases of enteric, food- and waterborne diseases for the period January  
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21 1991 through December 2008 were obtained from the NWT Communicable Disease Registry.  
22  
23 Ethics approval was obtained from the University of Guelph Research Ethics Board, the  
24  
25 Government of the Northwest Territories and the Aurora Research Institute.  
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30 The general procedures for notification remained consistent over the study period. Upon  
31  
32 symptomatic presentation of enteric, food- and waterborne disease/infections, health  
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34 practitioners send the patient's clinical specimen to the laboratory for confirmation and sero-  
35  
36 typing. The patient's demographic information, food and water histories are collected by the  
37  
38 health practitioner and manually-entered into the food and waterborne illness investigation form.  
39  
40 The form is submitted to the Population Health Division of the Government of the Northwest  
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42 Territories Department of Health and Social Services. Health practitioners and laboratories are  
43  
44 required to report patients with confirmed NGI to the Population Health Division within 24 hours  
45  
46 and this information is entered into the NWT Communicable Disease Registry.[7]  
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52 Case notification data, stripped of personal identifiers, were received for 15  
53  
54 diseases/infections and associated fields listed in Table 1; none of these fields was considered  
55  
56 mandatory at the time of notification. A geographical conversion database was used to assign  
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3 case-patients to their respective census subdivision (community), health and social services  
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5 health authority (HSSA) as well as assign them a status of rural or urban location; cases were  
6  
7 classified as urban if reported at a health center located in a community of at least 1,000 persons  
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9 and 400 persons / sq km, others were classified as rural.[5, 6]  
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### 12 13 **Data Quality Evaluation and Descriptive Analyses** 14

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16 Data quality evaluation involved manually checking data associated with each case for  
17  
18 completeness and internal consistency. Missing values were replaced with “unspecified”. The  
19  
20 numbers and percentages related to “unspecified” values were calculated for each field.  
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24 Population denominators for each year were obtained from the NWT Bureau of Statistics  
25  
26 and the mean annual age-specific rates of disease were calculated for the territory. The average  
27  
28 annual number of cases was calculated using the total number of notifications divided by 18  
29  
30 years. Data manipulation and statistical analyses were conducted in SPSS version 17 (SPSS Inc.,  
31  
32 Chicago, Illinois) and choropleth maps of disease rates by health authority were created in  
33  
34 ArcView GIS version 3.1 (ESRI, Redlands, California). Means and medians were used to  
35  
36 describe the data; medians were used when dealing with highly skewed distributions. A least  
37  
38 squares regression analysis was used to determine the rate of change over time. Fischer’s Exact  
39  
40 tests were used to determine statistical significance [ $p < 0.05$  (two-tailed)] for categorical  
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42 variables. Community level risk factors for NGI are reported elsewhere.[8]  
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## 49 **RESULTS** 50

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52 The percentages of missing or unspecified values for the 9 fields considered in the  
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54 analysis are also shown in Table 1.  
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3 From the 708 case-patients with notified enteric, food- and waterborne  
4 diseases/infections from all years, 458 (64.7%) had bacterial infections, 240 (33.9%) had  
5 parasitic infections and 10 (1.4%) had viral (hepatitis A) infections. The three largest  
6 contributors to the total number of notifications were giardiasis with 205 cases (29.0%),  
7 salmonellosis with 202 cases (28.5%) and campylobacteriosis with 175 cases (24.7%). Too few  
8 cases were attributed to other agents (<6% each) to draw inferences, therefore, the focus of the  
9 rest of this paper is on the three most commonly notified diseases.  
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21 The annual reported incidence rates of NGI (total and cause-specific for giardiasis,  
22 salmonellosis and campylobacteriosis) are shown in Figure 1. A least squares regression analysis  
23 indicated that the incidence of NGI decreased by 3.7 ( $p<0.01$ ) cases per 100,000 per year over  
24 the study period. Giardiasis and salmonellosis decreased by 1.7 ( $p<0.01$ ) and 1.2 ( $p<0.01$ ) cases  
25 per 100,000 per year, respectively, but there was no significant ( $p<0.13$ ) linear change in  
26 incidence of campylobacteriosis. A majority of campylobacteriosis (85.7%), giardiasis (62%),  
27 and salmonellosis (58.4%) cases were reported from health facilities in urban areas ( $p<0.01$ ).  
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38 The highest rates of NGI (128.5 cases per 100,000) were observed in the 0 to 9 years age  
39 group with 56% of cases occurring in males ( $p<0.01$ ). The highest rates of giardiasis (50.4 cases  
40 per 100,000) were also found in the 0 to 9 years age group with 57% of cases occurring in males  
41 ( $p<0.02$ ). The highest rates of salmonellosis (46.1 cases per 100,000) were found in the 60+  
42 years age group with 51% occurring in females ( $p<0.02$ ). Although not significant ( $p<0.07$ ), the  
43 highest rates of campylobacteriosis were observed in the 20 to 29 years age group for  
44 campylobacteriosis (28.2 cases per 100,000) with 53% of cases occurring in males.  
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3 Table 2 shows that the most frequently suspected vehicle for NGI was contaminated food  
4 (p<0.01). The probable source of giardiasis was most often attributed to untreated water whereas  
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6 for campylobacteriosis and salmonellosis it was poultry and eggs, respectively (p<0.01).  
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11 Figure 2 show that cases of NGI (p<0.01) and more specifically campylobacteriosis  
12 (p<0.01) and salmonellosis (p<0.04), occurred more frequently in the late summer and early fall.  
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14 Although not significant (p<0.07), giardiasis showed a similar trend on visual inspection of the  
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16 data.  
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21 As shown in Figure 3, the highest median annual incidence of NGI (118.0 cases per  
22 100,000) was observed in Yellowknife HSSA (p<0.01) whereas the lowest median annual  
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24 incidence (41.0 cases per 100,000) was found in Fort Smith HSSA (p<0.01). The highest  
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26 median annual incidence of campylobacteriosis (266.0 cases per 100,000) was found in Tlicho  
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28 (p<0.01) whereas the lowest median annual incidence (8.0 cases per 100,000) was found in  
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30 Dehcho (p<0.01). The highest median annual incidence of salmonellosis (35.1 cases per  
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32 100,000) was also found in Tlicho HSSA (p<0.01) however the lowest median annual incidence  
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34 (17.0 cases per 100,000) was found in Fort Smith HSSA (p<0.01). The highest median annual  
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36 incidence of giardiasis (38.1 cases per 100,000) was found in the Sahtu HSSA (p<0.01) whereas  
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38 the lowest median annual incidence (14.5 cases per 100,000) was found in Beaufort Delta HSSA  
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40 (p<0.01).  
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## 50 DISCUSSION

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52 The results of this study suggest that NGI is an important health problem in NWT and  
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54 that giardiasis, salmonellosis and campylobacteriosis account for the great majority (82.2%) of  
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56 reported NGI in NWT. The mean annual reported rate of these three enteric diseases in NWT  
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3 was 78.0 cases per 100,000, which is less than reported for Ontario (87.0 cases per 100,000) and  
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5 British Columbia (145.8 cases per 100,000) based on notifiable disease data from 1991 through  
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7 2008.[9] This suggests that NWT residents may be at decreased risk of infection or alternatively,  
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9 there may be a higher degree of under-reporting in the territory because of the relative paucity  
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11 and distance to available health services, facilities, and qualified health professionals;[10] further  
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13 investigation is required. Previous studies have shown that about 1 out of 313 (Ontario) to 350  
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15 (British Columbia) cases of acute gastrointestinal illness are captured by surveillance  
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17 systems.[11, 12] Using these adjustment factors from Ontario and British Columbia, we estimate  
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19 that between 182,748 and 204,282 cases of campylobacteriosis, giardiasis and salmonellosis,  
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21 collectively, may have occurred in NWT over the 18 years.[4, 13, 14] Reported rates of these  
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23 enteric diseases also declined over the study period, which is consistent with observed trends in  
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25 southern Canada and the USA and may be attributed to effective, ongoing efforts to improve  
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27 food and water quality.[15, 16]

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34 Spatial analysis revealed that the incidence of campylobacteriosis, giardiasis and  
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36 salmonellosis varied substantially between health authorities. Higher or lower-than-expected  
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38 rates in health authorities could be a result of disparities in the geographical distribution of risk  
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40 factors and behaviors,[17] suggesting that further studies on population-level risk factors are  
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42 warranted. Overall, NGI was reported more frequently in urban than rural areas, but the  
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44 underlying reasons could not be evaluated with the available data. In theory, higher reporting  
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46 rates in urban areas could reflect greater propensity for person-to-person transmission; however,  
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48 this is more commonly seen with organisms with human reservoirs.[18] Other possibilities  
49  
50 include greater reliance on store-purchased foods, community water systems or other population-  
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52 level risk factors. It is also possible that some infections were acquired in rural and remote areas  
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3 but were reported at health facilities in urban areas. We expected exposure to these  
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5 environmental or zoonotic pathogens to be more common in rural and remote areas, through  
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7 contact with animals, their feces, as well as contaminated surface water and raw foods compared  
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9 to urbanized areas.[19] Furthermore, higher disease rates could also be an artifact of differential  
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11 reporting of cases or methods of data collection. Several studies have demonstrated that higher  
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13 reporting rates in urban areas are often a function of the amount and type of available health  
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15 services than the occurrence of illness itself.[20-22]  
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20 Giardiasis was the most commonly reported infection in this study, reflecting its  
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22 importance as an enteric pathogen in the territory. In NWT, the mean annual reported rate of  
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24 giardiasis was 27.7 cases per 100,000. This was slightly more than reported in Ontario (19.4  
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26 cases per 100,000) and similar to British Columbia (27.4 cases per 100,000).[9] Giardiasis  
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28 commonly occurs through the ingestion of infective cysts found in contaminated water, food, or  
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30 infected persons by the fecal-oral route. The cysts can be present in contaminated wells and  
31  
32 water systems, particularly those sourced from surface water such as fresh water lakes and  
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34 streams. Person-to-person transmission also accounts for many *Giardia* infections and is usually  
35  
36 associated with poor hygiene and sanitation. In the Arctic, cysts of *Giardia* spp. have been found  
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38 in water, sewage and fecal samples of marine mammals harvested for food.[23] Our findings of  
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40 higher rates in infants and children in NWT could be related to reporting bias, poor hygiene,  
41  
42 more frequent exposure to communal facilities or recreational water, lack of protective  
43  
44 immunity, or a combination of factors.[24, 25] High rates in patients 30 to 39 year of age may  
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46 also be at least partially attributed to contact with infected children as parents or as caregivers,  
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48 and these persons are possibly more likely to seek medical care and therefore more likely to be  
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50 captured by the surveillance system.[26] The higher rate of giardiasis in males is unexplained,  
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3 but has also been noted in other studies.[27] In NWT, gender may act as a surrogate for true  
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5 causal variables related to exposure, such as the consumption of untreated surface water or  
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7 contaminated traditional foods, particularly while carrying out subsistence activities in northern  
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9 areas of NWT. Consistent with previous research, the incidence of giardiasis in this study was  
10  
11 higher in the late summer and autumn months, which may be related to greater environmental  
12  
13 exposure during leisure and subsistence activities, potentially greater likelihood of infectious  
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15 levels of cysts in water at this time of year, or exposure to contaminated recreational water that  
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17 favors indirect person-to-person transmission.[28]  
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24 Salmonellosis was the second most frequently reported enteric infection in NWT. The  
25  
26 mean annual rate for salmonellosis for NWT was 27.2 cases per 100,000 population, which is  
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28 higher than Ontario (23.4 cases per 100,000) and British Columbia (20.3 cases per 100,000).[9]  
29  
30 *Salmonella* infections are commonly acquired through consumption of contaminated food of  
31  
32 animal origin, mainly meat, poultry, eggs and milk, but also contaminated fruit and  
33  
34 vegetables.[29] In NWT, poultry/eggs were identified by those reporting illness as the most  
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36 probable sources of this infection. Other suspected food vehicles included pork, caribou, beef,  
37  
38 and fish/seafood; however, we do not know whether these vehicles were identified through  
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40 epidemiological investigation, follow-up microbiological testing, or speculation by the health  
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42 practitioner. Moreover, we do not know whether suspect foods were obtained through individual  
43  
44 subsistence activities, community freezers, or retail locations making it difficult to hypothesize  
45  
46 the source of microbial contamination; however, outbreaks of verotoxin-producing *Escherichia*  
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48 *coli* O157:H7 (fourth highest notification) in NWT have been attributed to frozen minced beef  
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50 and caribou obtained from grocery stores and homes.[30, 31] Higher observed rates of  
51  
52 salmonellosis in infants and children (0 to 9 years age group) and the elderly (60 years and over  
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3 age group) in this study have been noted in a previous study and may be related to lack of  
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5 protective immunity or other factors mentioned for giardiasis.[32] Higher rates of disease in  
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7 females are so far unexplained, but further research considering differences in food handling  
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9 practices and hygiene as well as the types of foods consumed, may indicate their role in apparent  
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11 gender differences.[33] Higher rates of infection in the late summer and autumn months may be  
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13 attributable to environmental and social factors. These may include higher ambient temperatures,  
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15 frequent travel as well as higher prevalences in food animal populations, centralized outdoor  
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17 meal preparation and consumption related to large social gatherings.[34, 35]  
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24 Campylobacteriosis was the third most frequently reported infection in NWT. The mean  
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26 annual incidence of campylobacteriosis in NWT was 23.5 cases per 100,000 population, which is  
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28 lower than Ontario (44.2 cases per 100,000) and British Columbia (55.2 cases per 100,000).[9]  
29  
30 Campylobacteriosis commonly occurs through the poor handling of raw poultry, and  
31  
32 consumption of undercooked poultry, unpasteurized milk and contaminated drinking water.  
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34 *Campylobacter* is also common in migratory birds and the consumption of fresh water from  
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36 surface contaminated with bird feces could be a seasonal driver of this disease in the North.[36]  
37  
38 In NWT, the predominant mode of transmission was believed to be foodborne; poultry, eggs,  
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40 pork, caribou, beef, and fish/seafood from unspecified sources, were once again identified as  
41  
42 probable exposures for infection. Incidence rates were highest in adults 20 to 49 years of age.  
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44 The relatively higher rates in young males noted in other studies have been thought to reflect  
45  
46 poor hygiene and food handling practices.[37] As with other studies on campylobacteriosis,  
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48 disease occurred more frequently in the late summer and autumn months.[38] Traditionally, in  
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50 northern communities, hunting activities and the collection of plants, berries, and bird's eggs as  
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52 well as the consumption of surface water occur more frequently during this time period.[39] The  
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3 reason for the apparently lower incidence in NWT compared to southern Canada is unknown.  
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5 *Campylobacter* are more susceptible to freezing than other bacteria, therefore it is tempting to  
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7 speculate that the colder northern climate may play a role in reducing exposure in food and  
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9 water.  
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13 This study demonstrates the usefulness of surveillance data to guide epidemiological  
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15 research and public health practice in Northern communities. Of the nine reporting fields in the  
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17 NWT Communicable Disease Registry, eight had less than 5% of data missing. To maximize the  
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19 usefulness of the data, however, it is important to improve the completeness and hence, the  
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21 quality of reported data for some fields. The field 'suspected exposure', unknown (missing) for  
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23 73.5% of the records, is a source of potential bias. Exposure information is frequently  
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25 ascertained through an interview or questionnaire, thus, it is difficult to assess the extent to  
26  
27 which recall or reporting bias has occurred and there are obvious limitations on the quality of  
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29 exposure data obtained in this fashion. In addition, suspected sources are infrequently confirmed  
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31 by microbiological testing, therefore, the results regarding the 'suspected exposure' must be  
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33 viewed with considerable caution.  
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41 In summary, the results of the study indicate that giardiasis, salmonellosis and  
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43 campylobacteriosis were the most important enteric diseases in NWT from 1991 through 2008,  
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45 and the incidence declined in later years of the study period. There was increased risk of NGI in  
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47 the late summer and early fall, in infants and children, males and urban residents. The  
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49 geographical distribution of case-patients varied by disease suggesting that environmental and  
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51 behavioral risk factors played key roles in infection and may provide opportunities for  
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53 prevention. For future study, multivariable regression and spatial analyses at the community  
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55 level are necessary for valid risk factor identification as well as for implementing specific and  
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3 geographically-appropriate risk reduction and control strategies. It is anticipated that this  
4 information will guide future research as well as the allocation of resources for prevention,  
5 promotion and control initiatives.  
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## 10 11 **COMPETING INTERESTS**

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14 None  
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## 16 17 **ACKNOWLEDGMENTS**

18  
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20  
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24 Environments.  
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## 30 31 **CONTRIBUTORSHIP**

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APA contributed to the manuscript through study design and planning, data collection, analysis and interpretation of results, drafting of manuscript and response to editorial comments and preparation of final manuscript for submission. JW, VLE, CF, RRS and SAM contributed to the manuscript through study design and planning, consultation on study progress, troubleshooting, data analysis and interpretation of results, reviewing and commenting on manuscript drafts. MS contributed to the manuscript through data collection, interpretation of results and reviewing and commenting on manuscript drafts.

## 52 53 54 55 56 57 58 59 60 **DATA SHARING**

The dataset may be requested from Population Health, Department of Health and Social Services, Government of the Northwest Territories ([www.hlthss.gov.nt.ca](http://www.hlthss.gov.nt.ca)).



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Table 1. Notifiable gastrointestinal illnesses (NGI) and associated percent missing or unspecified values, by field and disease, Northwest Territories, Canada, 1991-2008.

Notifiable Disease Report Form Fields - Percent Missing Values								
Disease / Agent (number of reported cases 1991-2008)	Age	Gender	Community	Health Unit	Report Date	Etiologic Agent	Subtype	Suspected exposure
Amoebiasis (n=10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0
Botulism (n=8)	0.0	0.0	0.0	0.0	0.0	0.0	12.5	25.0
Brucellosis (n=3)	0.0	0.0	0.0	33.3	0.0	0.0	66.7	66.7
Campylobacteriosis (n=175)	0.0	0.0	2.3	0.6	0.0	0.0	0.0	79.4
Cryptosporidiosis (n=18)	0.0	0.0	11.1	0.0	0.0	0.0	0.0	100.0
E. coli (VTEC) (n=40)	0.0	0.0	12.5	0.0	0.0	0.0	0.0	62.5
Food Poisoning (n=10)	0.0	0.0	0.0	0.0	0.0	0.0	100.0	10.0
Giardiasis	0.0	0.0	3.9	0.0	0.0	0.0	0.0	73.7

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4	<b>(n=205)</b>							
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6	<b>Hepatitis A</b>	0.0	0.0	10.0	0.0	0.0	0.0	90.0
7	<b>(n=10)</b>							
8								
9	<b>Listeriosis</b>	0.0	0.0	0.0	0.0	0.0	0.0	100.0
10	<b>(n=1)</b>							
11								
12	<b>Salmonellosis</b>	0.0	0.0	0.0	4.5	0.0	0.0	70.8
13	<b>(n=202)</b>							
14								
15	<b>Shigellosis</b>	0.0	0.0	0.0	0.0	0.0	0.0	83.3
16	<b>(n=12)</b>							
17								
18	<b>Tapeworm</b>	0.0	0.0	0.0	0.0	0.0	0.0	57.1
19	<b>(n=7)</b>							
20								
21	<b>Tularemia</b>	0.0	0.0	0.0	0.0	0.0	0.0	100.0
22	<b>(n=1)</b>							
23								
24	<b>Yersiniosis</b>	0.0	0.0	16.7	0.0	0.0	0.0	100.0
25	<b>(n=6)</b>							
26								
27	<b>Total NGI Cases</b>	<b>0.0</b>	<b>0.0</b>	<b>2.6</b>	<b>0.1</b>	<b>0.0</b>	<b>0.0</b>	<b>73.2</b>
28	<b>(n=708)</b>							
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Table 2. Percentage distribution of reported suspected sources of infection for notifiable gastrointestinal illness, campylobacteriosis, giardiasis and salmonellosis, Northwest Territories, Canada, 1991-2008.

Percent of cases attributed to suspected exposure				
Suspected Exposure (%)	NGI	Campylobacteriosis	Giardiasis	Salmonellosis
Beef	6.8	2.8	3.7	3.4
Caribou	6.3	2.8	5.6	5.1
Fish/Seafood	3.2	11.1	0.0	1.7
Muktuk (Whale)	1.6	0.0	0.0	0.0
Pork	4.7	2.8	0.0	13.6
Poultry/eggs	18.9	38.9	1.9	33.9
Seal	0.5	0.0	0.0	0.0



<b>Foodborne unknown</b>	28.4	41.7	5.6	37.3
<b>Untreated water</b>	27.9	0.0	81.5	0.0
<b>Waterborne unknown</b>	0.5	0.0	1.9	5.1
<b>Perinatal transmission</b>	0.5	0.0	0.0	0.0
<b>Person-to-person</b>	0.5	0.0	0.0	0.0

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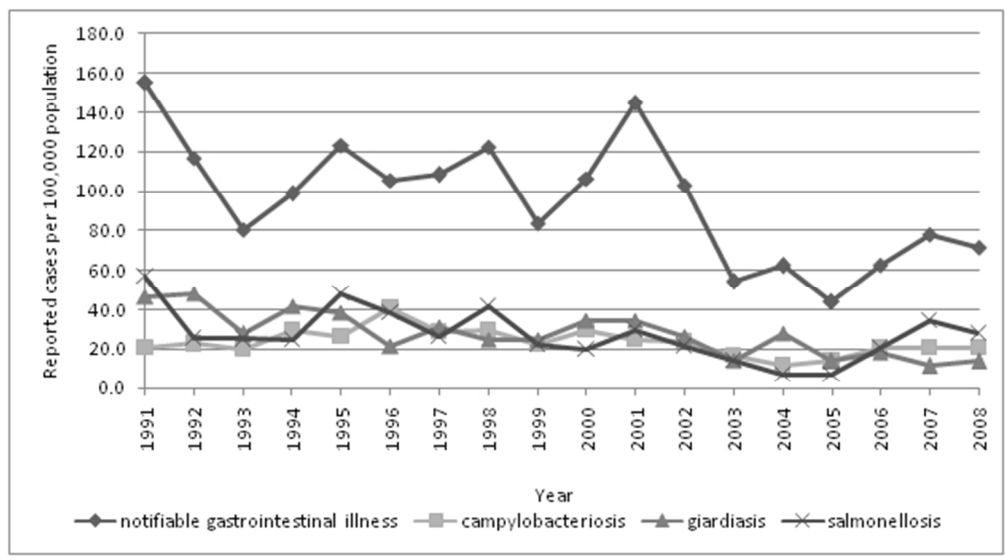


Figure 1. Annual incidence rates of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis). Northwest, Territories, Canada, 1991-2008. 166x93mm (96 x 96 DPI)

review only

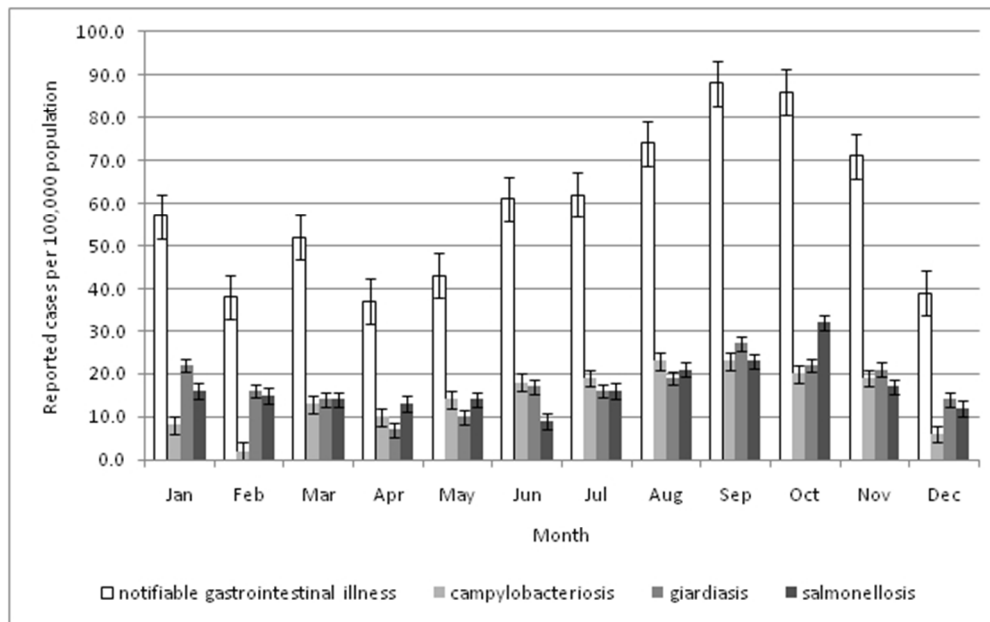


Figure 2. Incidence of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis) by month, Northwest Territories, Canada, 1991-2008.  
166x103mm (96 x 96 DPI)

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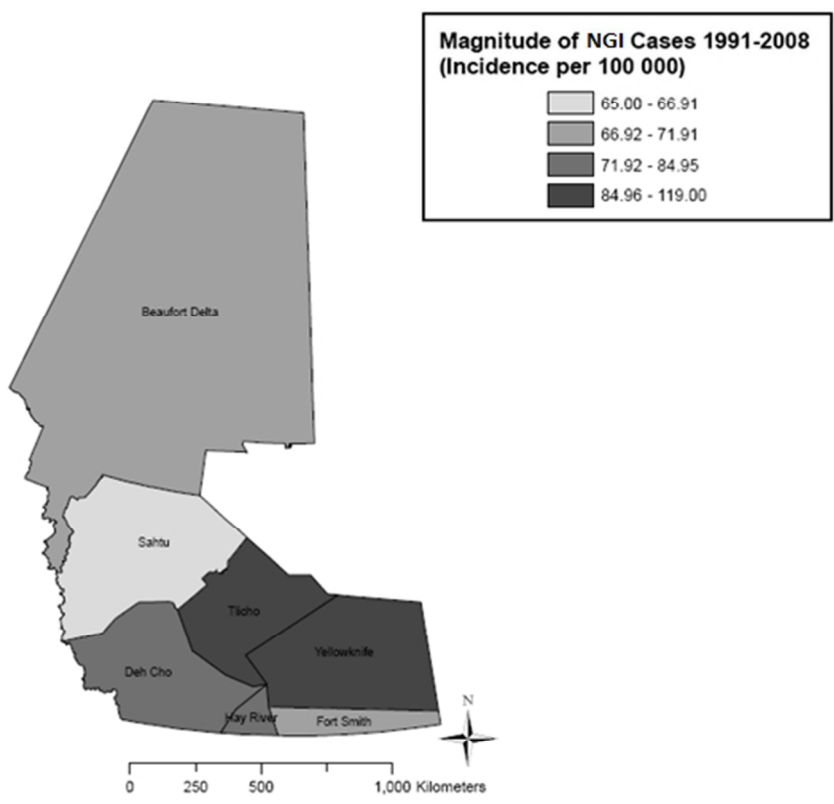


Figure 3. Map of incidence rates per 100,000 population by health authority for reported cases of notifiable gastrointestinal illness (NGI). Northwest Territories. 1991-2008. 166x141mm (96 x 96 DPI)

For peer review only

**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\***  
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5,6
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	N/A
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7
Bias	9	Describe any efforts to address potential sources of bias	10,14
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	7
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	N/A

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	N/A
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8,21
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8,9
		(b) Indicate number of participants with missing data for each variable of interest	7,21
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	N/A
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	N/A
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	N/A
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	9,10,14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10,14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9,10,14
Generalisability	21	Discuss the generalisability (external validity) of the study results	10
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).



**A Descriptive Analysis of Notifiable Gastrointestinal Illness  
in the Northwest Territories, Canada, 1991-2008**

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2011-000732.R1
Article Type:	Research
Date Submitted by the Author:	02-Apr-2012
Complete List of Authors:	Pardhan-Ali, Aliya; University of Guelph, Department Population Medicine, Ontario Veterinary College Wilson, Jeff; Novometrix Research Inc., Edge, Victoria; University of Guelph, Department of Population Medicine, Ontario Veterinary College Furgal, Chris; Trent University, Department of Indigenous Environmental Studies Reid-Smith, Richard; University of Guelph, Department of Population Medicine, Ontario Veterinary College Santos, Maria; Government of the Northwest Territories, Department of Health and Social Services McEwen, Scott; University of Guelph, Department of Population Medicine, Ontario Veterinary College
<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Infectious diseases
Keywords:	Gastrointestinal infections < GASTROENTEROLOGY, Epidemiology < INFECTIOUS DISEASES, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Public health < INFECTIOUS DISEASES

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1 **Title:**

2 A Descriptive Analysis of Notifiable Gastrointestinal Illness in the Northwest Territories,  
3 Canada, 1991-2008

4 **Authors:**

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18 **Medical Subject Headings-Key Words:**

19 Gastrointestinal illness, Foodborne Diseases, Minority Health, Population Surveillance

20 **Word count:** 4448



21 **ABSTRACT**

22 **Objectives:** To describe the major characteristics of reported Notifiable Gastrointestinal Illness  
23 (NGI) data in the Northwest Territories (NWT) from January 1991 through December 2008.

24 **Design:** Descriptive analysis of 708 reported cases of NGI extracted from the Northwest  
25 Territories Communicable Disease Registry (NWT CDR).

26 **Setting:** Primary, secondary and tertiary health care centres across all 33 communities of  
27 NWT.

28 **Population:** NWT residents of all ages with confirmed NGI reported to the NWT CDR from  
29 January 1991 through December 2008.

30 **Main Outcome Measure:** Laboratory-confirmed NGI, with a particular emphasis on  
31 campylobacteriosis, giardiasis, and salmonellosis.

32 **Results:** Campylobacteriosis, giardiasis and salmonellosis were the most commonly identified  
33 types of NGI in the territory. Seasonal peaks for all three diseases were observed in late summer

34 to autumn ( $p<0.01$ ). Higher rates of NGI (all 15 diseases/infections) were found in the 0 to 9

35 years age group and in males ( $p<0.01$ ). Similarly, rates of giardiasis were higher in the 0 to 9

36 years age group and in males ( $p<0.02$ ). A disproportionate burden of salmonellosis was found in

37 people 60 years and older and in females ( $p<0.02$ ). Although not significant, the incidence of

38 campylobacteriosis was greater in the 20 to 29 years age group and in males ( $p<0.07$ ). The

39 health authority with the highest incidence of NGI was Yellowknife ( $p<0.01$ ) while for

40 salmonellosis and campylobacteriosis it was Tlicho ( $p<0.01$ ) and for giardiasis, the Sahtu region

41 ( $p<0.01$ ). Overall, disease rates were higher in urban areas ( $p<0.01$ ).

**Comment [TA1]:**

**Reviewer 2:** In the abstract you indicate higher increased risk in late summer/fall but in key messages (and paper) you indicate seasonal peaks in spring and fall months. Please clarify and ensure consistent messaging.

APA: It is seasonal peaks. Please see corrections in lines 33-34.

Contaminated eggs, poultry and untreated water were believed by health practitioners to be important sources of infection in cases of salmonellosis, campylobacteriosis and giardiasis, respectively.

**Conclusion:** The general patterns of these findings suggest that environmental and behavioral risk factors played key roles in infection. Further research into potential individual and community-level risk factors is warranted.

## ARTICLE SUMMARY

### Article Focus

- To date, there is very little baseline data on notifiable gastrointestinal illness (NGI) diseases in the Northwest Territories (NWT), where Aboriginal people constitute a majority of the population. The demographic, socio-cultural, and health conditions of northern Aboriginal people are markedly different from those of other Canadian populations.

- There is a clear need to identify the major characteristics of reported NGI in order to generate hypotheses, guide future studies, and help public health officials target resources, interventions or increased surveillance to areas of greatest need in NWT.

### Key Messages

- The annual average rate of NGI over the study period was 95.5 cases per 100,000 with increased risk in the 0 to 9 years age group and males.
- Reported rates of NGI declined from 1991 to 2008 however, seasonal peaks were observed in the spring and fall months.

#### Comment [TA2]:

Reviewer 1: The authors aim to describe demographical characteristics, temporal and spatial distribution and risk factors of reported enteric, food- and waterborne diseases. However, this very simple descriptive analysis is not sufficient to address the research questions. The reviewer would suggest to add further spatial and temporal analyses based on the available data.

APA: I agree with you. This article does not fully address the research question; therefore, I have revised my research question as well as the objectives (please see lines 22-23, 55-57 and 117-122) so that it accurately reflects the contents of the paper. The aim of this paper was to provide an overview of the major characteristics of NGI over the 18 years. I have done a very technical paper on spatial, temporal and spatio-temporal analysis but I have submitted it to the International Journal of Health Geographics. However, I have added to the results (Please see Table 2, Figures 5, 6 and 7) and expanded on the discussion (Please see lines 234-257, 266-270, 348-364, and 374-400) to strengthen the interpretation and conclusions (also suggested by Reviewer 2).

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9 63 • There was variability in the rates of NGI with higher notifications in the southern, urban  
10 64 areas compared to the northern, rural/remote areas of the territory suggesting the possible  
11 65 involvement of geographical risk factors and/or bias in the surveillance data.  
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15 66 **Strengths and Limitations**

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17 67 • The study provides a historical portrait of NGI as the Northwest Territories  
18 68 Communicable Disease Registry (NWT CDR) broadly covered the entire territory over  
19 69 18 years, therefore allowing comparisons across communities and time periods.  
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23 70 • Due to under-reporting, the rates of infections reported in this study are likely  
24 71 underestimates of the true incidence of diseases and therefore, should be interpreted as  
25 72 reporting rates rather than as incidence rates.  
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30 73 • Suspected sources of infection are infrequently confirmed by microbiological testing  
31 74 therefore, the results regarding 'suspected exposure' must be viewed with caution and be  
32 75 thought of as hypotheses.  
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9 76 **BACKGROUND**

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11 Notifiable gastrointestinal illness (NGI) is an important global public health issue and a  
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13 growing concern in the Northwest Territories, where Aboriginal people constitute a majority of  
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15 the population.[1]. The Aboriginal population of NWT maintains strong ties to the environment,  
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17 continually adapting and learning to use available resources to provide food and other  
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19 necessities, sustain livelihoods, and reinforce social relations.[2] Foods obtained by harvesting,  
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21 hunting, fishing and trapping are referred to as traditional or country foods. About 40 to 60% of  
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23 NWT residents living in small communities rely on country food for most (at least 75%) of their  
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25 meat and fish.[3] This percentage has remained nearly the same for the past 10 years.[3]

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28 Country foods in NWT vary by geographic area, season, climate and availability and  
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30 include items such as Caribou, Moose, Ducks, Geese, Seals, Hare, Grouse, Ptarmigan, Lake  
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32 Trout, Char, Inconnu, White Fish, Pike, and Burbot.[4, 5] Due to the harsh climate, animal  
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34 products are the staple, and fresh vegetables and fruits provide additional nutrients when  
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36 available. During the short summers, items such as blueberries, cranberries, blackberries and  
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38 cloudberries are gathered, both for eating fresh and for drying or freezing to eat during the  
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40 winter.[4] The consumption of untreated water from lakes, creeks, and rivers in the summer or  
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42 from melted ice or snow in winter and spring is also common practice during subsistence  
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44 activities.[6]

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46 A well-balanced diet is primarily achieved by consuming muscle meat and other parts of  
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48 the animals (raw or with minimal processing) such as the stomach, liver and fat which contain  
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50 iron, calcium and a range of vitamins.[7] Common Traditional meats are also an excellent  
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52 source of protein and lower in fat compared to meats eaten in southern Canada. Seal and whale

Comment [TA3]:

Reviewer 2: In the first few sentences you lead into the fact that the population of the NWT (specifically Aboriginal) may engage in tradition activities but the way they are currently described does not appear unique. Is it possible to provide more specific examples of the harvesting, processing, consumption, economic, dietary issues that this population faces?

APA: Please see lines 79-106.

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9 98 are a good source of omega-3 fatty acids which help reduce the risk of chronic conditions such as  
10 99 cardiovascular disease.[7] Although the traditional diet is nutritious, it is also very high in  
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12 100 calories. High caloric intake is an adaptation feature that enables the northern residents to keep  
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14 101 warm through the long, frigid winters.[5]

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17 102 Sharing food is a key element of the Aboriginal culture in NWT. Traditionally, when  
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19 103 hunters return with fresh game or fish, it is distributed according to social rules [2]. Meals are  
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21 104 communal and fresh, uncooked animal-derived foods are first given out to people who are  
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23 105 feeling cold or hungry, then to the community, and the remaining portion is shared within the  
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25 106 household. The distribution of raw meats can occur several times in a week.[2]

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28 107 Activities such as hunting, fishing and trapping as well as the traditional preparation,  
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30 108 storage and consumption of wild game, seafood and untreated water can increase exposure to  
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32 109 pathogenic agents in the environment.[8] Illness can result from the ingestion of micro-  
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34 110 organisms in contaminated food or water, through contact with animals or other contaminated  
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36 111 objects, and some infections can be further spread by person-to-person transmission.[9]  
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38 112 Symptoms can include loss of appetite, abdominal cramps, diarrhea of variable severity, nausea,  
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40 113 vomiting, and fever.[10] Estimates of the overall morbidity and identification of potential risk  
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42 114 factors for NGI in NWT have not been previously published in the literature and hence, there is  
43  
44 115 very little baseline data to inform policies and guide public health interventions in the territory.  
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46 116 Using data elements extracted from cases of NGI in the Northwest Territories Disease Registry  
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48 117 (NWT CDR), this study provides a descriptive analysis of reported NGI in NWT from January  
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50 118 1991 through December 2008. At the time of writing, the surveillance system for NGI was going  
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52 119 through a review process and the human resources structure was in a phase of organizational

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9 120 change; therefore, the findings of this study should be considered with respect to the surveillance  
10 121 system in place during the study period. This study can also provide a baseline against which the  
11 122 performance of the new process can be measured.

## 16 123 METHODS

### 18 124 Study Area

20 125 The NWT is located in northern Canada with a majority Aboriginal population  
21 126 (50.3%).<sup>[11]</sup> As of the 2006 Census, the population was 41,464, an increase of 11% from  
22 127 2001.<sup>[3]</sup> There are 33 officially recognized communities across 1,140,835 km<sup>2</sup> of land; the  
23 128 smallest is Kakisa with 52 residents and the largest is Yellowknife with 18,700 residents.<sup>[12]</sup>  
24 129 The NWT population density is 0.03 people per km<sup>2</sup>. There is a high proportion of children  
25 130 under 15 years of age (23.9%) and a low proportion of people over 65 years of age (4.7%).<sup>[12]</sup>  
26 131 The median age for both sexes is 31 years; males comprise a majority of the population  
27 132 (51.2%).<sup>[12]</sup>

### 36 133 Data Sources

38 134 Data on reported cases of NGI for the period January 1991 through December 2008 were  
39 135 obtained from the NWT Communicable Disease Registry. Reported NGI is an umbrella term for  
40 136 fifteen enteric, food- and waterborne conditions that were reportable under the NWT Public  
41 137 Health Act during the study period: amoebiasis, botulism, brucellosis, campylobacteriosis,  
42 138 cryptosporidiosis, infection with *Escherichia coli*, food poisoning, giardiasis, hepatitis A,  
43 139 listeriosis, salmonellosis, shigellosis, tapeworm, tularemia, and yersiniosis. Ethics approval was  
44 140 obtained from the University of Guelph Research Ethics Board, the Government of the  
45 141 Northwest Territories, and the Aurora Research Institute.

**Comment [TA4]:** Throughout the paper you switch between "notifiable gastrointestinal illness (NGI) and "cases of enteric, food- and waterborne diseases". I recommend you select one of these terms and use it consistently throughout the manuscript. If they are 2 distinct terms then they should be clearly defined previously to using the terms.

APA: I have selected NGI and clearly defined it in lines 135-139.

**Comment [TA5]:**  
Reviewer 2: The diseases are listed in the tables but it might be easier for the reader to have them presented/listed in the first paragraph of the data sources as a reference point.

APA: Please see lines 135-139.

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9 142 The NWT Communicable Disease Manual provides guidelines to assist public health  
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11 143 practitioners with decision making about specific situations, and to support consistency of  
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13 144 territorial public health practice;<sup>[13]</sup> therefore the general procedures for notification remained  
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15 145 consistent over the study period. Upon symptomatic presentation of NGI as described in the  
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17 146 Manual, health practitioners send the patient's clinical specimen to the laboratory for  
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19 147 confirmation and sero-typing. The patient's demographic information, food and water histories  
20  
21 148 are collected by the health practitioner and manually-entered into the food and waterborne illness  
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23 149 investigation form. The paper form is submitted to the Population Health Division of the  
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25 150 Government of the Northwest Territories Department of Health and Social Services. Health  
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27 151 practitioners and laboratories are required to report patients with confirmed NGI to the  
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29 152 Population Health Division within 24 hours. Once the paper form is received, disease registry  
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31 153 officers at the territorial level collate, verify, enter, and disseminate illness investigation data  
32  
33 154 electronically through the Integrated Public Health Information System (i-PHIS) for inclusion  
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35 155 into the NWT CDR and the National Notifiable Disease database at the Public Health Agency of  
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37 156 Canada.<sup>[13]</sup>

38 157 Case notification data, stripped of personal identifiers, were received for 15  
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40 158 diseases/infections and associated fields listed in Table 1; none of these fields was considered  
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42 159 mandatory at the time of notification. A geographical conversion database was used to assign  
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44 160 case-patients to their respective census subdivision (community), health and social services  
45  
46 161 health authority (HSSA) as well as assign them a status of rural or urban location; cases were  
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48 162 classified as urban if reported at a health center located in a community of at least 1,000 persons  
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50 163 and 400 persons / sq km, others were classified as rural.<sup>[3, 12]</sup>

**Comment [TA6]:**

Reviewer 2: In the procedures for notification: what is the definition of symptomatic presentation? Is there a standard practice? Is it a number of symptoms, a single symptom? Does the practitioner have discretion on what is sent for testing or are their standard guidelines? If there are guidelines for testing please state; if there are not then the procedures may be consistent but the variation from practitioner to practitioner may be significant which may warrant further discussion.

APA: Please see lines 142-145.

**Comment [TA7]:** Reviewer 2: Is the illness investigation form entered into the disease registry or is this information maintained only on paper forms and required you to re-enter or extract it from another system?

APA: Please see lines 152-156.

## 164 Data Quality Evaluation and Descriptive Analyses

165 Data quality evaluation involved manually checking data associated with each case for  
166 completeness and internal consistency. Missing values were replaced with “unspecified”. The  
167 numbers and percentages related to “unspecified” values were calculated for each field.

168 Population denominators for each year were obtained from the NWT Bureau of Statistics  
169 and the mean annual age-specific rates of disease were calculated for the territory. The average  
170 annual number of cases was calculated using the total number of notifications divided by 18  
171 years. Data manipulation and statistical analyses were conducted in SPSS version 17 (SPSS Inc.,  
172 Chicago, Illinois) and choropleth maps of disease rates by health authority were created in  
173 ArcView GIS version 3.1 (ESRI, Redlands, California). Means and medians were used to  
174 describe the data; medians were used when dealing with highly skewed distributions. A least  
175 squares regression analysis was used to determine the rate of change over time. Fischer’s Exact  
176 tests were used to determine statistical significance [ $p < 0.05$  (two-tailed)] for categorical  
177 variables. Community level risk factors for NGI are reported elsewhere.[14]

## 178 RESULTS

179 The percentages of missing or unspecified values for the 9 fields considered in the  
180 analysis are also shown in [Table 1](#).

181 From the 708 case-patients with NGI from all years, 458 (64.7%) had bacterial infections,  
182 240 (33.9%) had parasitic infections and 10 (1.4%) had viral (hepatitis A) infections. The three  
183 largest contributors to the total number of notifications were giardiasis with 205 cases (29.0%),  
184 salmonellosis with 202 cases (28.5%) and campylobacteriosis with 175 cases (24.7%). Too few

### Comment [TA8]:

Reviewer 2: What were the cases of illness for “food poisoning”?

Typically a term like this would suggest that no known agent was identified but it is not missing data according to Table 1. If the pathogen is known is there a reason why they were not included under the appropriate pathogen for analysis vs. a general category?

APA: Food poisoning includes 5 cases of clostridium and 5 cases of bacillus. Infections from these agents are not notifiable in NWT unless they are from food poisoning. I have added a footnote in Table 1.



185 cases were attributed to other agents (<6% each) to draw inferences, therefore, the focus of the  
 186 rest of this paper is on the three most commonly notified diseases.

187 **The** annual reported incidence rates of NGI (total and cause-specific for giardiasis,  
 188 salmonellosis and campylobacteriosis) are shown in Figure 1. A least squares regression analysis  
 189 indicated that the incidence of NGI decreased by 3.7 ( $p<0.01$ ) cases per 100,000 per year over  
 190 the study period. Giardiasis and salmonellosis decreased by 1.7 ( $p<0.01$ ) and 1.2 ( $p<0.01$ ) cases  
 191 per 100,000 per year, respectively, but there was no significant ( $p<0.13$ ) linear change in  
 192 incidence of campylobacteriosis. A majority of campylobacteriosis (85.7%), giardiasis (62%),  
 193 and salmonellosis (58.4%) cases were reported from health facilities in urban areas ( $p<0.01$ ).

194 **The** average annual incidence of NGI (total and cause-specific for giardiasis,  
 195 salmonellosis and campylobacteriosis) by age-group are shown in **Figure 2**. The highest rates of  
 196 NGI (128.5 cases per 100,000) were observed in the 0 to 9 years age group with 56% of cases  
 197 occurring in males ( $p<0.01$ ). The highest rates of giardiasis (50.4 cases per 100,000) were also  
 198 found in the 0 to 9 years age group with 57% of cases occurring in males ( $p<0.02$ ). The highest  
 199 rates of salmonellosis (46.1 cases per 100,000) were found in the 60+ years age group with 51%  
 200 occurring in females ( $p<0.02$ ). Although not significant ( $p<0.07$ ), the highest rates of  
 201 campylobacteriosis were observed in the 20 to 29 years age group for campylobacteriosis (28.2  
 202 cases per 100,000) with 53% of cases occurring in males.

203 Table 2 shows that the most frequently suspected vehicle for NGI was contaminated food  
 204 ( $p<0.01$ ). The probable source of giardiasis was most often attributed to untreated water whereas  
 205 for campylobacteriosis and salmonellosis it was poultry and eggs, respectively ( $p<0.01$ ).

**Comment [TA9]:**

Reviewer 2: In the incidence over time graph there is a large spike in NGI in 2001 and incidence drops after that and remains low. I expected a comment on this in the discussion. Was there a change that led to this decrease?

APA: Please see lines 259-261

**Comment [TA10]:**

Reviewer 2: You state the highest rates for each disease by age group but do not present the incidence in the other age ranges. It is hard to assess how much higher the rates were for the age groups you have specified. Is there a way to provide an indication of the magnitude?

APA: Please see Figure 2

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9 206 Figure 3 show that cases of NGI ( $p<0.01$ ) and more specifically campylobacteriosis  
10 207 ( $p<0.01$ ) and salmonellosis ( $p<0.04$ ), occurred more frequently in the late summer and early fall.  
11 208 Although not significant ( $p<0.07$ ), giardiasis showed a similar trend on visual inspection of the  
12 209 data.

13 210 As shown in Figure 4, the highest median annual incidence of NGI (118.0 cases per  
14 211 100,000) was observed in Yellowknife HSSA ( $p<0.01$ ) whereas the lowest median annual  
15 212 incidence (41.0 cases per 100,000) was found in Fort Smith HSSA ( $p<0.01$ ). Figure 5 shows  
16 213 that the highest median annual incidence of campylobacteriosis (265.5 cases per 100,000) was  
17 214 found in Tlicho ( $p<0.01$ ) whereas the lowest median annual incidence (0.0 cases per 100,000)  
18 215 was found in Beaufort Delta, Dehcho, Fort Smith, and Sahtu HSSAs ( $p<0.01$ ). Figure 6 shows  
19 216 the highest median annual incidence of salmonellosis (35.0 cases per 100,000) was also found in  
20 217 Tlicho HSSA ( $p<0.01$ ) however the lowest median annual incidence (0.0 cases per 100,000) was  
21 218 found in Fort Smith, Hay River, and Sahtu HSSAs ( $p<0.01$ ). Figure 7 shows highest median  
22 219 annual incidence of giardiasis (38.0 cases per 100,000) was found in the Sahtu HSSA ( $p<0.01$ )  
23 220 whereas the lowest median annual incidence (0.0 cases per 100,000) was found in Tlicho HSSA  
24 221 ( $p<0.01$ ).

## 222 DISCUSSION

223 The results of this study suggest that NGI is an important health problem in NWT and  
224 that giardiasis, salmonellosis and campylobacteriosis account for the great majority (82.2%) of  
225 reported NGI in NWT. The mean annual reported rate of these three enteric diseases in NWT  
226 was 78.0 cases per 100,000, which is less than reported for Ontario (87.0 cases per 100,000) and  
227 British Columbia (145.8 cases per 100,000) based on notifiable disease data from 1991 through

### Comment [TA11]:

Reviewer 2: For the description of incidence by geography I wonder if there is an easier way to present this data to help inform the reader. I naturally wanted to determine if there were any that were consistently high or low and ended up making a table for myself. You have shown NGI in Figure 3, did you consider visually representing the other diseases?

APA: I think you were referring to Figure 4. The other disease are represented in Figures 5, 6, and 7.

### Comment [TA12]:

Reviewer 2: Is there a reason why you compared this data to ON and BC?

APA: I was interested in making a north-south comparison. Please see lines 228-230.

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9 228 2008.[9] This may suggest that compared to some southern areas as of Canada, NWT residents  
10 229 may be at decreased risk of infection or alternatively, there may be a higher degree of under-  
11 230 reporting in the territory;[15, 16] further investigation is required. Previous studies have shown  
12 231 that about 1 out of 313 (Ontario) to 350 (British Columbia) cases of acute gastrointestinal illness  
13 232 are captured by surveillance systems.[17, 18] Using these adjustment factors from Ontario and  
14 233 British Columbia, we estimate that between 182,748 and 204,282 cases of campylobacteriosis,  
15 234 giardiasis and salmonellosis, collectively, may have occurred in NWT over the 18 years.[10, 11,  
16 235 19] Several explanations for under-reporting have been proposed, such as cases not presenting to  
17 236 medical facilities, health workers not submitting clinical samples to laboratories, laboratory test  
18 237 sensitivity issues, absence or delay of reporting from local to territorial health authorities.  
19 238 Patients may not seek medical attention because symptoms are mild and self-limiting, they may  
20 239 be too ill to travel, or they may prefer to seek treatment from local healers.[19] These tendencies  
21 240 are exacerbated in rural/remote communities of NWT due to the relative paucity of available  
22 241 health services, facilities, and health professionals. Increased distances to health facilities and  
23 242 transportation problems further aggravate other barriers to accessing the health systems in  
24 243 rural/remote settings in northern communities.[15, 16] There are no data addressing possible  
25 244 geographical reporting biases in NWT; therefore, research to characterize and quantify reporting  
26 245 bias in the NWT CDR is needed. Reduction of under-reporting and differential reporting (if it  
27 246 does exist) would require increased awareness of community health practitioners about the  
28 247 potential usefulness of surveillance data and therefore, the need to improve their quality.

29 248 In NWT, seasonal peaks over the study period may have been attributed to social  
30 249 environmental factors such as higher ambient temperatures, frequent travel for subsistence  
31 250 activities, centralized outdoor meal preparation as well as the consumption of country foods and  
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**Comment [TA13]:**

Reviewer 2: Ideally I would like for more of the discussion to focus on what your findings mean for this unique population. For Salmonella, Giardia and Campylobacter you spend time discussing each pathogen and findings separately but it reads somewhat repetitive at times and it would be interesting for the readers to also have comment on the impacts and specific risks or consideration for the population of the NWT.

APA: I tried to rephrase a little so that it wouldn't sound repetitive. I have added to the discussion. Please see:

-Lines 235-258  
-Lines 267-271  
-Lines 349-365  
-Lines 375-401

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9 251 surface water.[4, 6, 20-23] Therefore, control strategies, such as regular, coordinated public  
10 252 education and communication about known risk factors of the disease (e.g., drinking  
11 253 contaminated water, safe food preparation) would therefore need to be targeted during these  
12 254 seasons. Such public health programs need to take into account the wide geographic distribution  
13 255 of these communities, their cultural diversity and the number of languages used [24].  
14 256 Community-oriented media such as local television and radio, have proven to be successful  
15 257 methods of reaching rural/remote populations by providing a forum for which health issues can  
16 258 be identified and discussed thus, increasing general awareness.[25-27]

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24 259 Fluctuations in rates of NGI over the 18 years are likely to be explained, at least in part,  
25 260 by random variation due to small number of cases. The peaks in 1995 and 2001 also coincide  
26 261 with known outbreaks of salmonellosis and cryptosporidiosis, respectively.[28] The incidence of  
27 262 NGI however, declined over the last few years of the study period (since 2002), which is  
28 263 consistent with observed trends in southern Canada and the USA. The decline may attributed to  
29 264 effective, ongoing efforts to improve food and water quality or an artifact of diagnostic  
30 265 procedures, reporting practices or changes in population demographics.[29, 30] The extent to  
31 266 which these factors may have contributed to a decrease in incidence is unknown but it is an  
32 267 important topic for future research. This trend however, is not consistent with the theory of  
33 268 temperature-driven increases of enteric disease related to climate change;[31-32] unless the  
34 269 decline would have been steeper without it. The use of statistical techniques to correlate NGI  
35 270 data with weather events and climate variables would allow the impact of these factors on human  
36 271 health to be examined and better understood in a northern context.

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49 272 Spatial analysis revealed that the incidence of campylobacteriosis, giardiasis and  
50 273 salmonellosis varied substantially between health authorities. Higher or lower-than-expected  
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274 rates in health authorities could be a result of disparities in the geographical distribution of risk  
 275 factors and behaviors,[33] suggesting that further studies on population-level risk factors are  
 276 warranted. Overall, NGI was reported more frequently in urban than rural areas, but the  
 277 underlying reasons could not be evaluated with the available data. In theory, higher reporting  
 278 rates in urban areas could reflect greater propensity for person-to-person transmission; however,  
 279 this is more commonly seen with organisms with human reservoirs.[34] Other possibilities  
 280 include greater accessibility, affordability and/or reliance on store-purchased foods, restaurant  
 281 meals, and foreign travel as well as other population-level risk factors such as community water  
 282 systems.[35] It is also possible that some infections were acquired in rural/remote areas of NWT  
 283 but were reported at health facilities in urban areas.[36] We expected exposure to these  
 284 environmental or zoonotic pathogens to be more common in rural/remote areas, through contact  
 285 with animals, their feces, as well as contaminated surface water and raw foods compared to  
 286 urbanized areas.[37] Furthermore, higher disease rates could also be an artifact of differential  
 287 reporting of cases or methods of data collection that vary by area or practitioners. Several studies  
 288 have demonstrated that higher reporting rates in urban areas are often a function of the amount  
 289 and type of available health services, rather than the occurrence of illness itself.[38-40]

291         Giardiasis was the most commonly reported infection in this study, reflecting its  
 292 importance as an enteric pathogen in the territory. Giardiasis commonly occurs through the  
 293 ingestion of infective cysts found in contaminated water, food, or infected persons by the fecal-  
 294 oral route. The cysts can be present in contaminated wells and water systems, particularly those  
 295 sourced from surface water such as fresh water lakes and streams. Person-to-person transmission  
 296 also accounts for many *Giardia* infections and is usually associated with poor hygiene and

**Comment [TA14]:**

Reviewer 2: Some studies in other jurisdictions have also identified higher rates of enteric illness in urban settings. Some hypothesis of this has been due to travel related illness. Did you explore either of these or would the inclusion of travel have any impact on your findings?

APA: Please see lines 276-283

**Comment [TA15]:**

Reviewer 2: On page 11 you state that higher disease rates could be an artefact of differential reporting or data collection. In the methods you state the procedure was consistent over time. Are you suggesting changes between areas/practitioners vs. time please clarify?

APA: Please see lines 286-287.

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9 297 sanitation. In the Arctic, cysts of *Giardia* spp. have been found in water, sewage and fecal  
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11 298 samples of marine mammals harvested for food.[23] Our findings of higher rates in infants and  
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13 299 children in NWT could be related to reporting bias, poor hygiene, more frequent exposure to  
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15 300 communal facilities or recreational water, lack of protective immunity, or a combination of  
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17 301 factors.[41, 42] High rates in patients 30 to 39 year of age may also be at least partially attributed  
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19 302 to contact with infected children as parents or as caregivers, and these persons are possibly more  
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21 303 likely to seek medical care and therefore more likely to be captured by the surveillance  
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23 304 system.[43] The higher rate of giardiasis in males is unexplained, but has also been noted in  
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25 305 other studies.[44] In NWT, gender may act as a surrogate for true causal variables related to  
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27 306 exposure, such as the consumption of untreated surface water or contaminated traditional foods,  
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29 307 particularly while carrying out subsistence activities in northern areas of NWT. Consistent with  
30  
31 308 previous research, the incidence of giardiasis in this study was higher in the late summer and  
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33 309 autumn months, which may be related to greater environmental exposure during leisure and  
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35 310 subsistence activities, potentially greater likelihood of infectious levels of cysts in water at this  
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37 311 time of year, or exposure to contaminated recreational water that favors indirect person-to-person  
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39 312 transmission.[45]

40 313 Salmonellosis, the second most frequently reported enteric infection, is commonly  
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42 314 acquired through consumption of contaminated food of animal origin, mainly meat, poultry, eggs  
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44 315 and milk, but also contaminated fruit and vegetables.[36] In NWT, poultry/eggs were identified  
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46 316 by those reporting illness as the most probable sources of this infection. Other suspected food  
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48 317 vehicles included pork, caribou, beef, and fish/seafood; however, we do not know whether these  
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50 318 vehicles were identified through epidemiological investigation, follow-up microbiological  
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52 319 testing, or speculation by the health practitioner. Moreover, we do not know whether suspect

**Comment [TA16]:**

Reviewer 2: On page 13 you note lack of protective immunity related to age differences. Could you include a reference for this or expand on this further?

APA: I am referring to protection induced by natural exposure. Please see reference 41.

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9 320 foods were obtained through individual subsistence activities, community freezers, or retail  
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11 321 locations making it difficult to hypothesize the source of microbial contamination; however,  
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13 322 outbreaks of verotoxin-producing *Escherichia coli* O157:H7 (fourth highest notification) in  
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15 323 NWT have been attributed to frozen minced beef and caribou obtained from grocery stores and  
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17 324 homes.[46, 47] Higher observed rates of salmonellosis in infants and children (0 to 9 years age  
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19 325 group) and the elderly (60 years and over age group) in this study have been noted in a previous  
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21 326 study and may be related to lack of protective immunity or other factors mentioned for  
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23 327 giardiasis.[41, 48, 49] Higher rates of disease in females are so far unexplained, but further  
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25 328 research considering differences in food handling practices and hygiene as well as the types of  
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27 329 foods consumed, may indicate their role in apparent gender differences.[50] Higher rates of  
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29 330 infection in the late summer and autumn months may be attributable to environmental and social  
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31 331 factors. These may include higher ambient temperatures, frequent travel as well as higher  
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33 332 prevalences in food animal populations, centralized outdoor meal preparation and consumption  
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35 333 related to large social gatherings.[20, 51]

36 334       Campylobacteriosis, the third most frequently reported infection, commonly occurs  
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38 335 through the poor handling of raw poultry, and consumption of undercooked poultry,  
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40 336 unpasteurized milk and contaminated drinking water. *Campylobacter* is also common in  
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42 337 migratory birds and the consumption of fresh water from surface contaminated with bird feces  
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44 338 could be a seasonal driver of this disease in the North.[52] In NWT, the predominant mode of  
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46 339 transmission was believed to be foodborne; poultry, eggs, pork, caribou, beef, and fish/seafood  
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48 340 from unspecified sources, were once again identified as probable exposures for infection.  
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50 341 Incidence rates were highest in adults 20 to 49 years of age. The relatively higher rates in young  
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52 342 males noted in other studies have been thought to reflect poor hygiene and food handling

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9 343 practices.[53] As with other studies on campylobacteriosis, disease occurred more frequently in  
10 344 the late summer and autumn months.[54] Traditionally, in northern communities, hunting  
11 345 activities and the collection of plants, berries, and bird's eggs as well as the consumption of  
12 346 surface water occur more frequently during this time period.[4]. *Campylobacter* however, are  
13 347 more susceptible to freezing than other bacteria, therefore it is tempting to speculate that the  
14 348 colder northern climate may play a role in reducing exposure in food and water.

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20 349 *Cryptosporidium* infections in humans may be from either human or animal origin, and  
21  
22 350 no attempts were made to differentiate among strains in this study. The apparent low incidence  
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24 351 of pathogens such as *Cryptosporidium* (2.4 cases per 100,000) in NWT may be due to the lack of  
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26 352 exposure to agricultural animals in the North.[55] Domestic livestock, including beef and dairy  
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28 353 cattle as well as sheep are often perceived to be the leading environmental source of waterborne  
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30 354 pathogens,[56] although contamination from human sewage also occurs. Animals shed oocysts  
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32 355 through manure contributing to the *Cryptosporidium* load of drinking water sources [57].  
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34 356 Several studies have shown that concentrations of *Cryptosporidium* are significantly higher in  
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36 357 agricultural rather than non-agricultural watersheds.[58, 59] The role of wildlife as a source of  
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38 358 *Cryptosporidium* is less clear in published literature. A study conducted over a 4-year period in  
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40 359 northern Alaska found that the prevalence of *Cryptosporidium* spp. in fecal samples of marine  
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42 360 mammals from subsistence hunts was highest in Ringed Seals (22.6%) followed by Right  
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44 361 Whales (24.5%) and Bowhead Whales (5.1%).[60] A study in Nunavik (Quebec, Canada) also  
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46 362 found a prevalence of 9% in fecal samples of Ringed Seals.[61] These studies suggest that some  
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48 363 animals used in traditional foods may be reservoirs for the disease in the north. In this study,  
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50 364 Caribou, Muktuk, and Seal were also suspected sources of infection for 8.4% of NGI cases;  
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52 365 therefore, further evaluations of environmental risk factors in NWT are warranted.



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9 366 This study demonstrates the usefulness of surveillance data to guide epidemiological  
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11 367 research and public health practice in Northern communities. Of the nine reporting fields in the  
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13 368 NWT Communicable Disease Registry, eight had less than 5% of data missing; however, the  
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15 369 field 'suspected exposure', unknown (missing) for 73.5% of the records, is a source of potential  
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17 370 bias. Exposure information is frequently ascertained through an interview or questionnaire, thus,  
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19 371 it is difficult to assess the extent to which recall or reporting bias has occurred and there are  
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21 372 obvious limitations on the quality of exposure data obtained in this fashion. In addition,  
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23 373 suspected sources are infrequently confirmed by microbiological testing, therefore, the results  
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25 374 regarding the 'suspected exposure' must be viewed with considerable caution and can be thought  
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27 375 of as hypotheses. For the data to be useful, particularly for risk factor identification, it is essential  
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29 376 that the completeness of fields and hence, quality be improved. From 1991 to 2008, there were  
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31 377 no mandatory fields enforced by the GNWT. Due to the contextual challenges of conducting  
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33 378 surveillance in northern, rural/remote communities, the NWT CDR is based around the minimum  
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35 379 data set concept, where the focus is on collecting the most essential data fields; however, these  
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37 380 fields must be standardized and sufficiently detailed to support the delivery, planning and  
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39 381 monitoring of public health initiatives. Although issues related to data quality are not unique to  
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41 382 surveillance systems serving northern, rural/remote areas, they may be exacerbated when the  
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43 383 systems serve sparse populations and have inadequate infrastructure, human and financial  
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45 384 resources.[62] The implementation of electronic-based platforms for reporting have been shown  
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47 385 to improve data quality and completeness in low-resource settings.[63,64]

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47 386 Published knowledge on surveillance in rural/remote areas is sparse; as a result, very little  
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49 387 has been recommended in terms of cohesive and effective approaches to enhance surveillance in  
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51 388 these communities. The gap in the literature suggests that the development of a comprehensive

**Comment [TA17]:** Reviewer 2: You state the limitation related to suspected source. Do you have any recommendations on how this data could be improved or should this data be used for analysis?

APA: Please see lines 375-385.

**Comment [TA18]:**  
Reviewer 2: Do you have any other recommendations (more specific) about how this data could be improved or used? Did this analysis lead to any changes in surveillance in the NWT? Was this data used for any further programs or shared with the community?

APA: Please see lines 386-407.

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9 389 public health surveillance system for rural/remote communities, which takes into account local  
10 390 realities and needs, is a priority area for research; however, this will require a collaborative effort  
11 391 from stakeholders, partners and knowledge-users of the system. Suggestions for moving forward  
12 392 include a collaborative design of suitable data elements, data collection protocols, data quality  
13 393 assurance, research and evaluation training, and procedures for confidential data entry and  
14 394 transfer. The existing literature recommends several strategies to augment insufficient data from  
15 395 traditional health surveillance. Andresen et al. (2004) suggest methodological approaches such as  
16 396 aggregation, spatial smoothing, small area estimation and exact statistics.[65] Sentinel  
17 397 surveillance, population-based sample surveys, community-based observations, and syndromic  
18 398 surveillance can also be used as surrogates for more widespread surveillance.[65,66] The  
19 399 capacity to generate high quality surveillance data in northern, rural/remote populations, such as  
20 400 those in NWT, may exist if innovative, informal and population-specific approaches are  
21 401 considered and applied to public health surveillance.

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34 402 In 2011, the Department of Health and Social Services (DHSS), GNWT, introduced a  
35 403 new electronic tool to improve surveillance for NGI. The application, called DHSS Tools, is a  
36 404 restricted-access site which includes a case reporting module (environmental health - food and  
37 405 waterborne illness investigation) that can be used by community public health officers, disease  
38 406 consultants, epidemiologists and environmental health officers to ensure better communication,  
39 407 follow-up, decision-making, and completeness of information.

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44 408 In summary, the results of the study indicate that giardiasis, salmonellosis and  
45 409 campylobacteriosis were the most important enteric diseases in NWT from 1991 through 2008,  
46 410 and the incidence declined in later years of the study period. There was increased risk of NGI in  
47 411 the late summer and early fall, in infants and children, males and urban residents. The

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9 412 geographical distribution of case-patients varied by disease suggesting that environmental and  
10 413 behavioral risk factors played key roles in infection and may provide opportunities for  
11 414 prevention. For future study, multivariable regression and spatial analyses at the community  
12 415 level are necessary for valid risk factor identification as well as for implementing specific and  
13 416 geographically-appropriate risk reduction and control strategies. It is anticipated that this  
14 417 information will guide future research as well as the allocation of resources for prevention,  
15 418 promotion and control initiatives.

#### 22 419 **COMPETING INTERESTS**

23 420 None

#### 28 421 **ACKNOWLEDGMENTS**

29 422 The authors gratefully acknowledge the Government of the Northwest Territories Health  
30 423 and Social Services Department and Bureau of Statistics for providing the data to complete this  
31 424 study. This work was supported by Nasivvik Centre for Inuit Health and Changing  
32 425 Environments.

#### 38 426 **CONTRIBUTORSHIP**

39 427 APA contributed to the manuscript through study design and planning, data collection,  
40 428 analysis and interpretation of results, drafting of manuscript and response to editorial comments  
41 429 and preparation of final manuscript for submission. JW, VLE, CF, RRS and SAM contributed to  
42 430 the manuscript through study design and planning, consultation on study progress,  
43 431 troubleshooting, data analysis and interpretation of results, reviewing and commenting on

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432 manuscript drafts. MS contributed to the manuscript through data collection, interpretation of  
433 results and reviewing and commenting on manuscript drafts.

434 **DATA SHARING**

435 The dataset may be requested from Population Health, Department of Health and Social  
436 Services, Government of the Northwest Territories ([www.hltss.gov.nt.ca](http://www.hltss.gov.nt.ca)).

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Table 1. Notifiable gastrointestinal illnesses (NGI) and associated percent missing or unspecified values, by field and disease, Northwest Territories, Canada, 1991-2008.

Notifiable Disease Report Form Fields - Percent Missing Values								
Disease / Agent (number of reported cases 1991-2008)	Age	Gender	Community	Health Unit	Report Date	Etiologic Agent	Subtype	Suspected exposure
Amoebiasis (n=10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0
Botulism (n=8)	0.0	0.0	0.0	0.0	0.0	0.0	12.5	25.0
Brucellosis (n=3)	0.0	0.0	0.0	33.3	0.0	0.0	66.7	66.7
Campylobacteriosis (n=175)	0.0	0.0	2.3	0.6	0.0	0.0	0.0	79.4
Cryptosporidiosis (n=18)	0.0	0.0	11.1	0.0	0.0	0.0	0.0	100.0
E. coli (VTEC) (n=40)	0.0	0.0	12.5	0.0	0.0	0.0	0.0	62.5

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<b>Food Poisoning*</b> <b>(n=10)</b>	0.0	0.0	0.0	0.0	0.0	0.0	100.0	10.0
<b>Giardiasis</b> <b>(n=205)</b>	0.0	0.0	3.9	0.0	0.0	0.0	0.0	73.7
<b>Hepatitis A</b> <b>(n=10)</b>	0.0	0.0	10.0	0.0	0.0	0.0	0.0	90.0
<b>Listeriosis</b> <b>(n=1)</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
<b>Salmonellosis</b> <b>(n=202)</b>	0.0	0.0	0.0	4.5	0.0	0.0	0.0	70.8
<b>Shigellosis</b> <b>(n=12)</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3
<b>Tapeworm</b> <b>(n=7)</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.1
<b>Tularemia</b> <b>(n=1)</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
<b>Yersiniosis</b> <b>(n=6)</b>	0.0	0.0	16.7	0.0	0.0	0.0	0.0	100.0
<b>Total NGI Cases</b> <b>(n=708)</b>	<b>0.0</b>	<b>0.0</b>	<b>2.6</b>	<b>0.1</b>	<b>0.0</b>	<b>0.0</b>	<b>1.8</b>	<b>73.2</b>

\* Includes 5 cases due to clostridium and 5 cases due to bacillus. Infections from these agents are not notifiable unless they are from food poisoning.

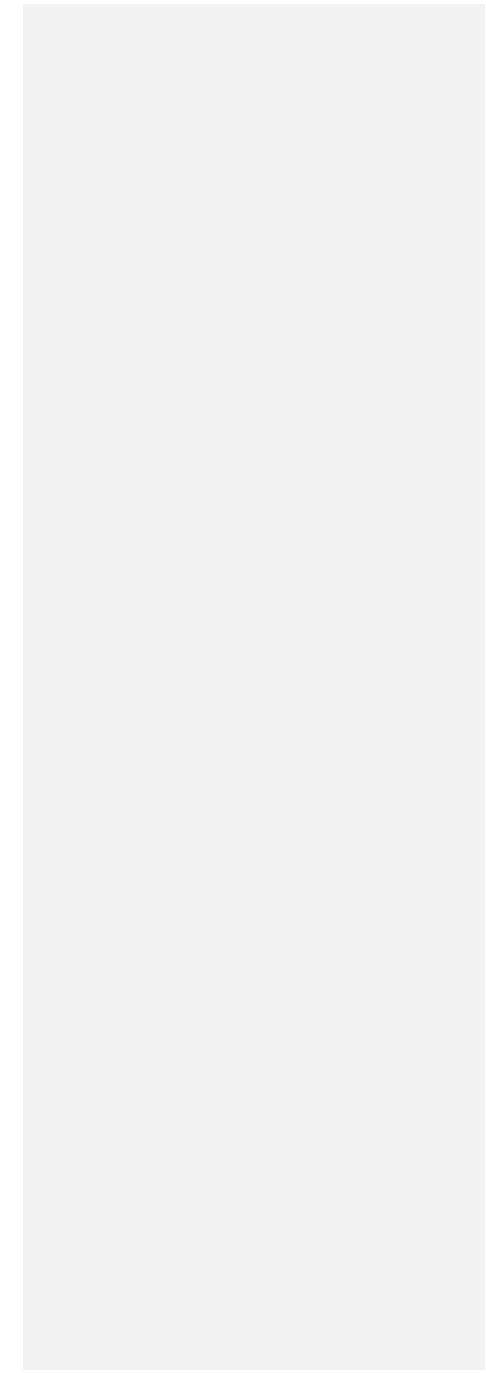
Table 2. Percentage distribution of reported suspected sources of infection for notifiable gastrointestinal illness, campylobacteriosis, giardiasis and salmonellosis, Northwest Territories, Canada, 1991-2008.

<b>Percent of cases attributed to suspected exposure</b>				
<b>Suspected Exposure (%)</b>	<b>NGI</b>	<b>Campylobacteriosis</b>	<b>Giardiasis</b>	<b>Salmonellosis</b>
<b>Beef</b>	6.8	2.8	3.7	3.4
<b>Caribou</b>	6.3	2.8	5.6	5.1
<b>Fish/Seafood</b>	3.2	11.1	0.0	1.7
<b>Muktuk (Whale)</b>	1.6	0.0	0.0	0.0
<b>Pork</b>	4.7	2.8	0.0	13.6
<b>Poultry/eggs</b>	18.9	38.9	1.9	33.9
<b>Seal</b>	0.5	0.0	0.0	0.0

<b>Foodborne unknown</b>	28.4	41.7	5.6	37.3
<b>Untreated water</b>	27.9	0.0	81.5	0.0
<b>Waterborne unknown</b>	0.5	0.0	1.9	5.1
<b>Perinatal transmission</b>	0.5	0.0	0.0	0.0
<b>Person-to-person</b>	0.5	0.0	0.0	0.0

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## FIGURES

**Figure 1:** Annual incidence rates of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis). Northwest Territories, Canada, 1991 to 2008.

**Figure 2:** Incidence of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis) by age-group, Northwest Territories, Canada, 1991 to 2008.

**Figure 3:** Incidence of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis) by month, Northwest Territories, Canada, 1991 to 2008.

**Figure 4:** Map of incidence rates per 100,000 population for reported cases of notifiable gastrointestinal illness (NGI). Northwest Territories. 1991 to 2008.

**Figure 5:** Map of incidence rates per 100,000 population for reported cases of campylobacteriosis. Northwest Territories. 1991 to 2008.

**Figure 6:** Map of incidence rates per 100,000 population for reported cases of salmonellosis. Northwest Territories. 1991 to 2008.

**Figure 7:** Map of incidence rates per 100,000 population for reported cases of giardiasis. Northwest Territories. 1991 to 2008.

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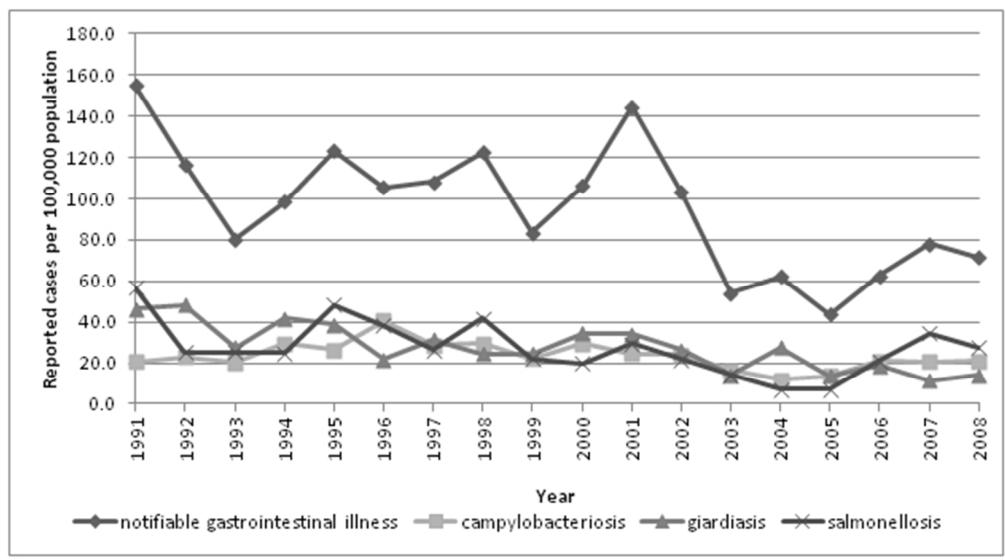


Figure 1 Annual incidence rates of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis). Northwest, Territories, Canada, 1991 to 2008  
166x92mm (96 x 96 DPI)

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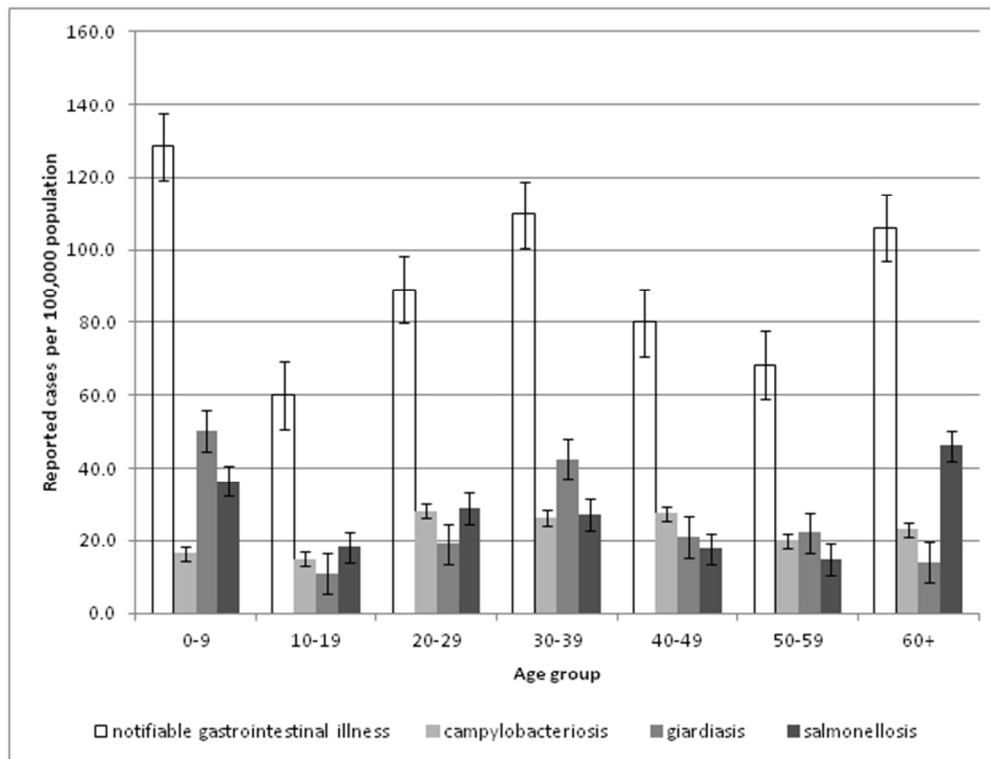


Figure 2 Incidence of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis) by age-group, Northwest Territories, Canada, 1991 to 2008  
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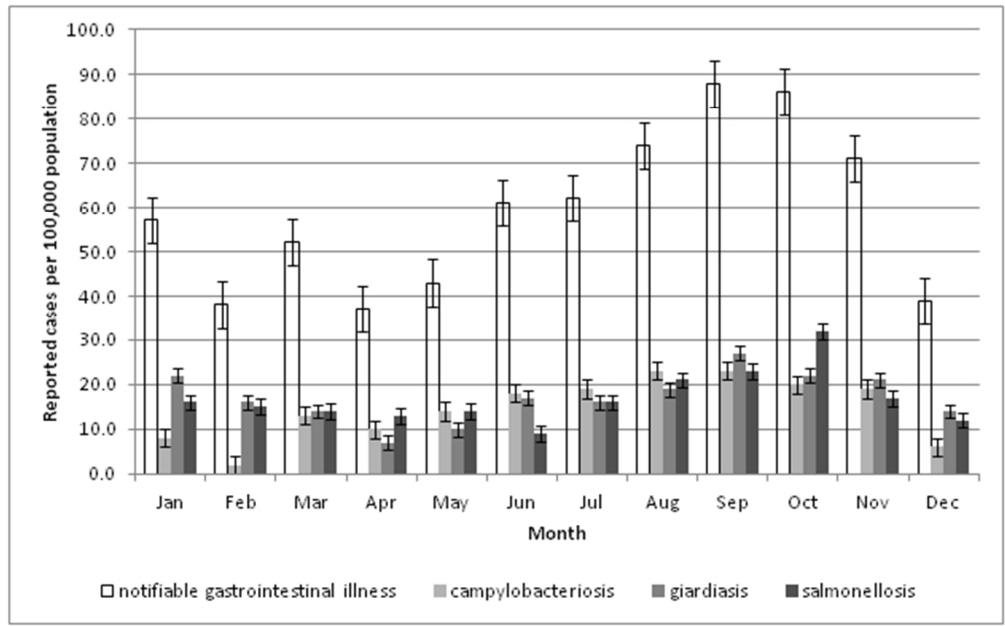


Figure 3 Incidence of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis) by month, Northwest Territories, Canada, 1991 to 2008  
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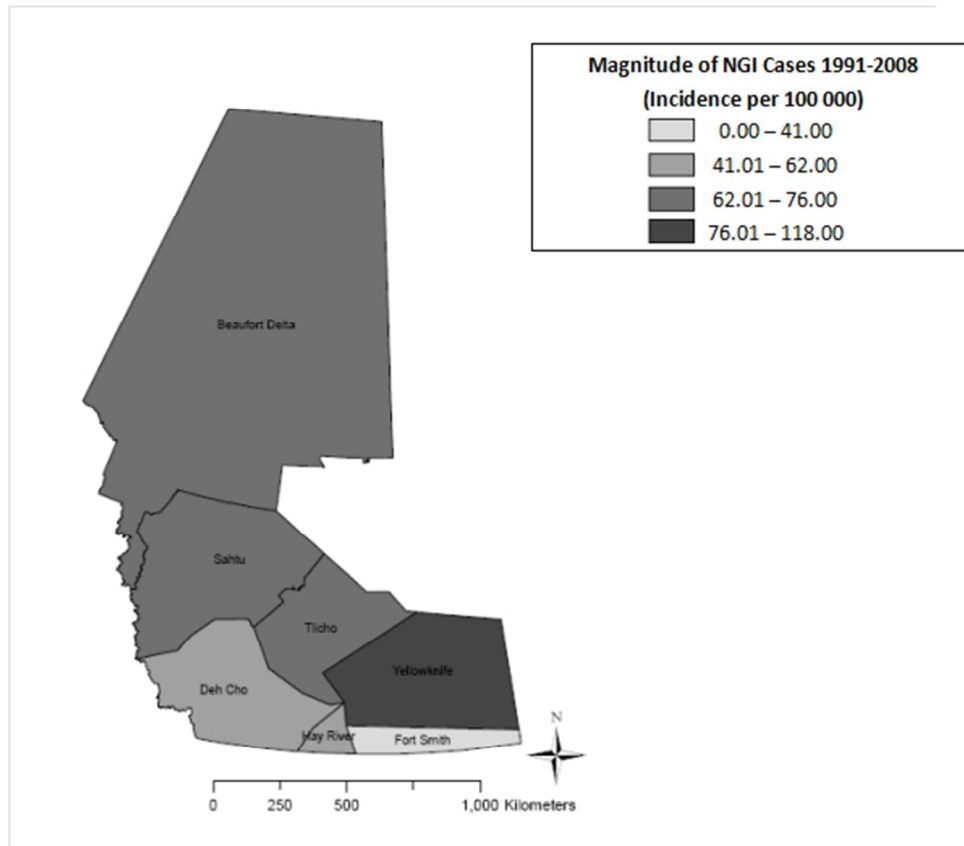


Figure 4 Map of incidence rates per 100,000 population for reported cases of notifiable gastrointestinal illness (NGI). Northwest Territories. 1991 to 2008  
163x139mm (96 x 96 DPI)

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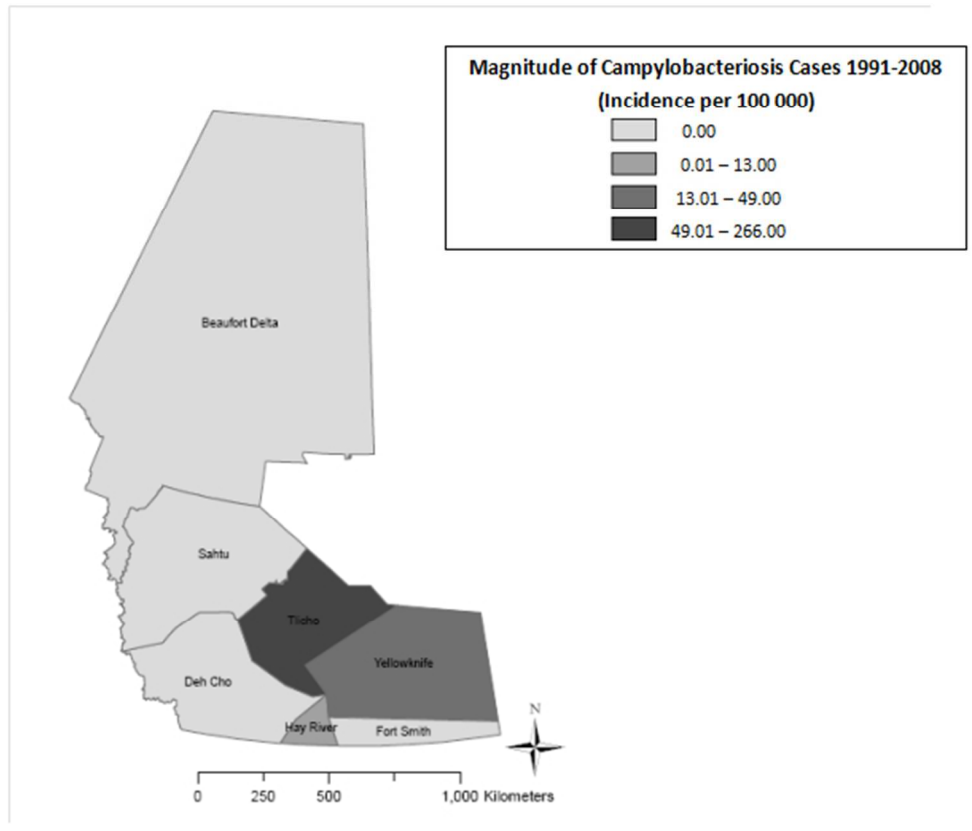


Figure 5 Map of incidence rates per 100,000 population for reported cases of campylobacteriosis. Northwest Territories. 1991 to 2008  
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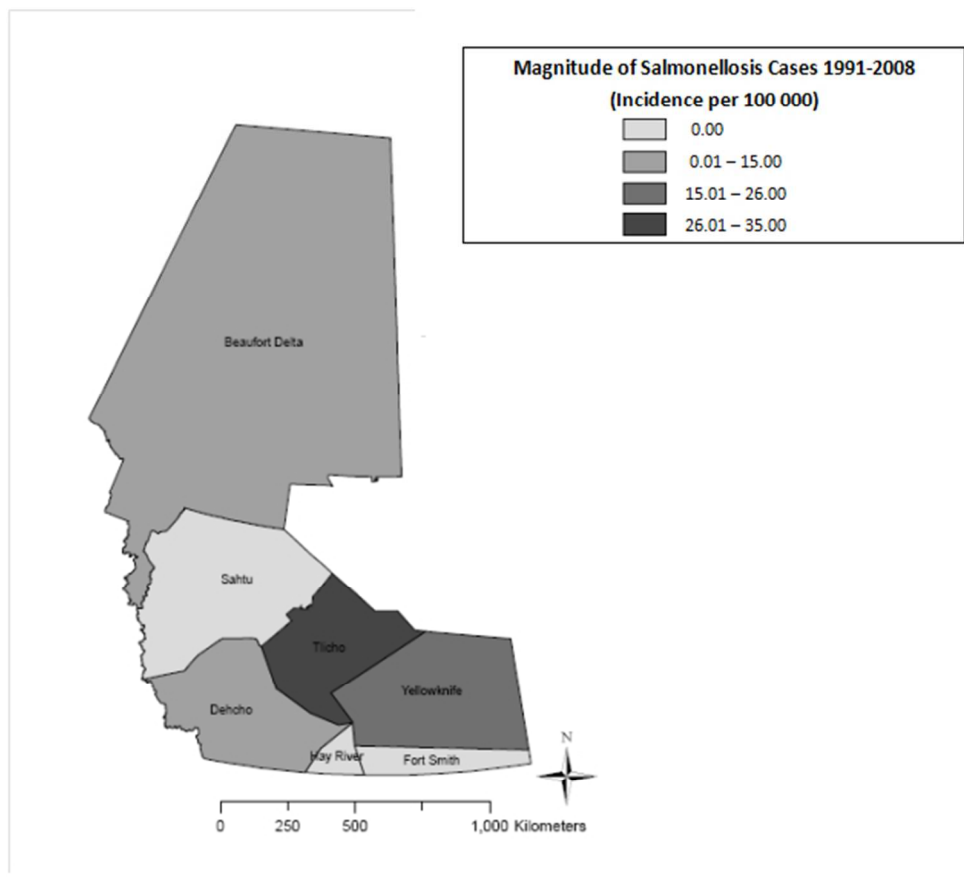


Figure 6 Map of incidence rates per 100,000 population for reported cases of salmonellosis. Northwest Territories. 1991 to 2008  
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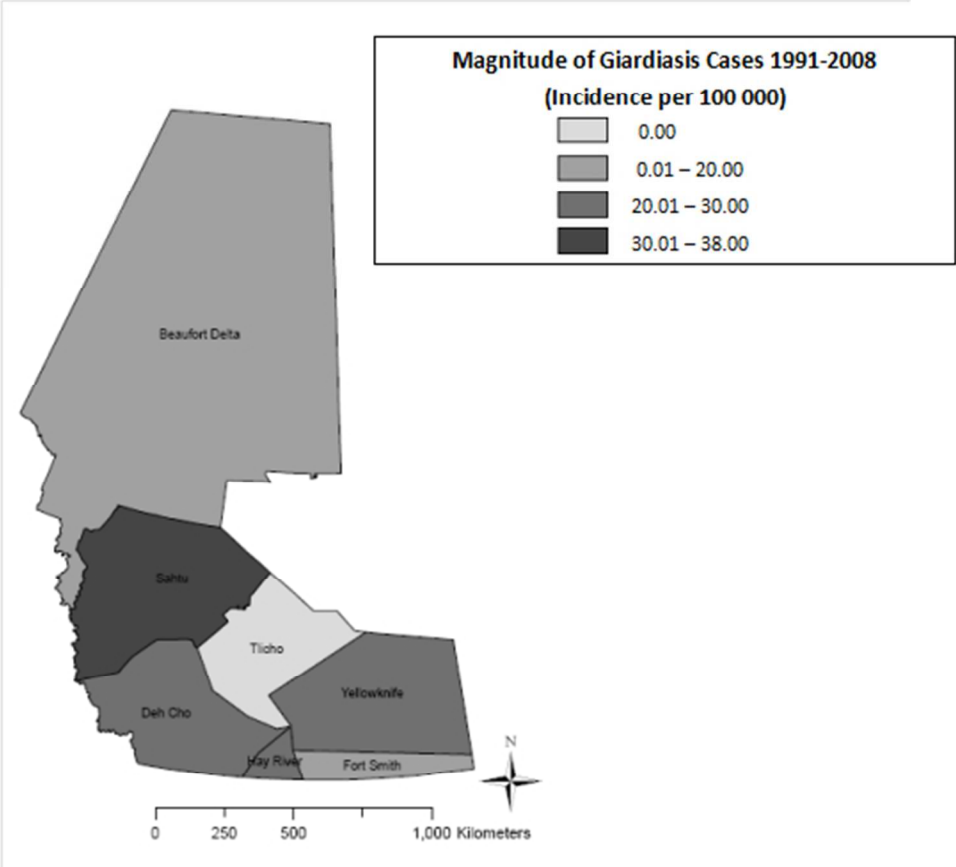


Figure 7 Map of incidence rates per 100,000 population for reported cases of giardiasis. Northwest Territories. 1991 to 2008  
149x130mm (96 x 96 DPI)

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**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\***  
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-7
Objectives	3	State specific objectives, including any pre-specified hypotheses	6
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	N/A
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	18
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8-9
		(b) Describe any methods used to examine subgroups and interactions	8-9
		(c) Explain how missing data were addressed	8-9
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	N/A

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	N/A
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9,30-31
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9,32
		(b) Indicate number of participants with missing data for each variable of interest	9,21
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	N/A
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	N/A
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	N/A
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	11-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).



**A Descriptive Analysis of Notifiable Gastrointestinal Illness  
in the Northwest Territories, Canada, 1991-2008**

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2011-000732.R2
Article Type:	Research
Date Submitted by the Author:	25-May-2012
Complete List of Authors:	Pardhan-Ali, Aliya; University of Guelph, Department Population Medicine, Ontario Veterinary College Wilson, Jeff; Novometrix Research Inc., Edge, Victoria; University of Guelph, Department of Population Medicine, Ontario Veterinary College Furgal, Chris; Trent University, Department of Indigenous Environmental Studies Reid-Smith, Richard; University of Guelph, Department of Population Medicine, Ontario Veterinary College Santos, Maria; Government of the Northwest Territories, Department of Health and Social Services McEwen, Scott; University of Guelph, Department of Population Medicine, Ontario Veterinary College
<b>Primary Subject Heading</b>:	Epidemiology
Secondary Subject Heading:	Infectious diseases, Gastroenterology and hepatology
Keywords:	Gastrointestinal infections < GASTROENTEROLOGY, Epidemiology < INFECTIOUS DISEASES, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Public health < INFECTIOUS DISEASES

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13 3 Canada, 1991-2008

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16 4 **Authors:**

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46 18 **Medical Subject Headings-Key Words:**

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49 19 Gastrointestinal illness, Foodborne Diseases, Minority Health, Population Surveillance

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51 20 **Word count:** 4566

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9 21 **ABSTRACT**

10 22 **Objectives:** To describe the major characteristics of reported Notifiable Gastrointestinal Illness  
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12 23 (NGI) data in the Northwest Territories (NWT) from January 1991 through December 2008.

14 24 **Design:** Descriptive analysis of 708 reported cases of NGI extracted from the Northwest  
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16 25 Territories Communicable Disease Registry (NWT CDR).

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19 26 **Setting:** Primary, secondary and tertiary health care centers across all 33 communities of the  
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22 27 NWT.

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24 28 **Population:** NWT residents of all ages with confirmed NGI reported to the NWT CDR from  
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26 29 January 1991 through December 2008.

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29 30 **Main Outcome Measure:** Laboratory-confirmed NGI, with a particular emphasis on  
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31 31 campylobacteriosis, giardiasis, and salmonellosis.

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33 32 **Results:** Campylobacteriosis, giardiasis and salmonellosis were the most commonly identified  
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35 33 types of NGI in the territory. Seasonal peaks for all three diseases were observed in late summer  
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37 34 to autumn ( $p<0.01$ ). Higher rates of NGI (all 15 diseases/infections) were found in the 0 to 9  
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39 35 years age group and in males ( $p<0.01$ ). Similarly, rates of giardiasis were higher in the 0 to 9  
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41 36 years age group and in males ( $p<0.02$ ). A disproportionate burden of salmonellosis was found in  
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43 37 people 60 years and older and in females ( $p<0.02$ ). Although not significant, the incidence of  
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45 38 campylobacteriosis was greater in the 20 to 29 years age group and in males ( $p<0.07$ ). The  
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47 39 health authority with the highest incidence of NGI was Yellowknife ( $p<0.01$ ) while for  
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49 40 salmonellosis and campylobacteriosis it was Tlicho ( $p<0.01$ ) and for giardiasis, the Sahtu region  
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51 41 ( $p<0.01$ ). Overall, disease rates were higher in urban areas ( $p<0.01$ ).

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9 42 Contaminated eggs, poultry and untreated water were believed by health practitioners to be  
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11 43 important sources of infection in cases of salmonellosis, campylobacteriosis and giardiasis,  
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13 44 respectively.

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15 45 **Conclusion:** The general patterns of these findings suggest that environmental and behavioral  
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17 46 risk factors played key roles in infection. Further research into potential individual and  
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19 47 community-level risk factors is warranted.

## 20 21 22 48 **ARTICLE SUMMARY**

### 23 24 49 **Article Focus**

- 25 50
- 26 51 • To date, there is very little baseline data on notifiable gastrointestinal illness (NGI)  
27 52 diseases in the Northwest Territories (NWT), where Aboriginal people constitute a  
28 53 majority of the population. The demographic, socio-cultural, and health conditions of  
29 54 northern Aboriginal people are markedly different from those of other Canadian  
30 55 populations.  
31 56
  - 32 57 • There is a clear need to identify the major characteristics of reported NGI in order to  
33 58 generate hypotheses, guide future studies, and help public health officials target  
34 59 resources, interventions or increased surveillance to areas of greatest need in the NWT.  
35 60

### 36 37 38 39 40 41 58 **Key Messages**

- 42 59
- 43 60 • The annual average rate of NGI over the study period was 95.5 cases per 100,000 with  
44 61 increased risk in the 0 to 9 years age group and males.  
45 62
  - 46 61 • Reported rates of NGI declined from 1991 to 2008 however, seasonal peaks were  
47 62 observed in late summer and autumn.

**Comment [TA1]:** Reviewer 1: My earlier comment about seasonal peaks has not been fully addressed in lines 33-34 and 206-209 the authors indicate late summer and autumn peaks but in lines 61-62 they note spring and fall peaks. I believe lines 61 and 62 should be edited for consistency and accuracy.

APA: I apologize - I have corrected lines 61-62.

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9 63 • There was variability in the rates of NGI with higher notifications in the southern, urban  
10 64 areas compared to the northern, rural/remote areas of the territory suggesting the possible  
11 65 involvement of geographical risk factors and/or bias in the surveillance data.  
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#### 15 66 **Strengths and Limitations**

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17 67 • The study provides a historical portrait of NGI as the Northwest Territories  
18 68 Communicable Disease Registry (NWT CDR) broadly covered the entire territory over  
19 69 18 years, therefore allowing comparisons across communities and time periods.  
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23 70 • Due to under-reporting, the rates of infections reported in this study are likely  
24 71 underestimates of the true incidence of diseases and therefore, should be interpreted as  
25 72 reporting rates rather than as incidence rates.  
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30 73 • Suspected sources of infection are infrequently confirmed by microbiological testing  
31 74 therefore, the results regarding 'suspected exposure' must be viewed with caution and be  
32 75 thought of as hypotheses.  
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9 76 **BACKGROUND**

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11 77 Notifiable gastrointestinal illness (NGI) is an important global public health issue and a  
12 78 growing concern in the Northwest Territories (NWT), where Aboriginal people constitute a  
13 79 majority of the population.[1]. The Aboriginal population of the NWT maintains strong ties to  
14 80 the environment, continually adapting and learning to use available resources to provide food  
15 81 and other necessities, sustain livelihoods, and reinforce social relations.[2] Foods obtained by  
16 82 harvesting, hunting, fishing and trapping are referred to as traditional or country foods. About 40  
17 83 to 60% of NWT residents living in remote and/or isolated communities rely on country food for  
18 84 75% or more of their meat and fish consumption.[3]

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28 85 Country foods in the NWT vary by geographic area, season, climate and availability and  
29 86 include items such as caribou, moose, ducks, geese, seals, hare, grouse, ptarmigan, lake trout,  
30 87 char, inconnu, white fish, pike, and burbot.[4, 5] Due to the harsh climate, animal products are  
31 88 the staple, and fresh vegetables and fruits provide additional nutrients when available. During the  
32 89 short summers, items such as blueberries, cranberries, blackberries and cloudberries are  
33 90 gathered, both for eating fresh and for drying or freezing to eat during the winter.[4] The  
34 91 consumption of untreated water from lakes, creeks, and rivers in the summer or from melted ice  
35 92 or snow in winter and spring is also common practice during subsistence activities.[6]

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44 93 A well-balanced diet is primarily achieved by consuming muscle meat and other parts of  
45 94 the animals (raw or with minimal processing) such as the stomach, liver and fat which contain  
46 95 iron, calcium and a range of vitamins.[7] Common traditional meats are also an excellent source  
47 96 of protein and are lower in fat compared to meats eaten in Southern Canada. Seal and whale are a  
48 97 good source of omega-3 fatty acids which help reduce the risk of chronic conditions such as



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9 98 cardiovascular disease.[7] Although the traditional diet is nutritious, it is also very high in  
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11 99 calories. High caloric intake is an adaptation feature that enables residents of the North to keep  
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13 100 warm through the long, frigid winters.[5]

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15 101 Sharing food is a key element of the Aboriginal culture in the NWT. Traditionally, when  
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17 102 hunters return to communities with fresh game or fish, it is distributed according to social rules  
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19 103 or convention.[2] Meals are communal and fresh, uncooked animal-derived foods are first given  
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21 104 out to people who are cold or hungry, then to the rest of the community, and finally, the  
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23 105 remaining portion is shared within the household. The distribution and consumption of raw  
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25 106 meats can occur several times in a week.[2]

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28 107 Activities such as hunting, fishing and trapping as well as the traditional preparation,  
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30 108 storage and consumption of wild game, seafood and untreated water can increase exposure to  
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32 109 pathogenic agents in the environment.[8] Illness can result from the ingestion of micro-  
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34 110 organisms in contaminated food or water, through contact with animals or other contaminated  
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36 111 objects, and some infections can be further spread by person-to-person transmission.[9]  
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38 112 Symptoms can include loss of appetite, abdominal cramps, diarrhea of variable severity, nausea,  
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40 113 vomiting, and fever.[10] Estimates of the overall morbidity and identification of potential risk  
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42 114 factors for NGI in the NWT have not been previously published in the literature and hence, there  
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44 115 is very little baseline data to inform policies and guide public health interventions in the territory.  
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46 116 Using data elements extracted from cases of NGI in the Northwest Territories Communicable  
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48 117 Disease Registry (NWT CDR), this study provides a descriptive analysis of reported NGI in the  
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50 118 NWT from January 1991 through December 2008.

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9 119 **METHODS**

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11 120 **Study Area**

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13 121 The NWT is located in Northern Canada with a majority Aboriginal population  
14 122 (50.3%).<sup>[11]</sup> As of the 2006 Census, the population was 41,464, an increase of 11% from  
15 123 2001.<sup>[3]</sup> There are 33 officially recognized communities across 1,140,835 km<sup>2</sup> of land; the  
16 124 smallest is Kakisa with 52 residents and the largest is Yellowknife with 18,700 residents.<sup>[12]</sup>  
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18 125 The NWT population density is 0.03 people per km<sup>2</sup>. There is a high proportion of children  
19 126 under 15 years of age (23.9%) and a low proportion of people over 65 years of age (4.7%).<sup>[12]</sup>  
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21 127 The median age for both sexes is 31 years; males comprise a majority of the population  
22 128 (51.2%).<sup>[12]</sup>

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29 129 **Data Sources**

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31 130 Data on reported cases of NGI for the period January 1991 through December 2008 were  
32 131 obtained from the NWT CDR. Reported NGI is an umbrella term for 15 enteric, food- and  
33 132 waterborne conditions that were reportable under the NWT Public Health Act during the study  
34 133 period: amoebiasis, botulism, brucellosis, campylobacteriosis, cryptosporidiosis, infection with  
35 134 *Escherichia coli*, food poisoning, giardiasis, hepatitis A, listeriosis, salmonellosis, shigellosis,  
36 135 tapeworm, tularemia, and yersiniosis. Ethics approval was obtained from the University of  
37 136 Guelph Research Ethics Board, the Government of the Northwest Territories, and the Aurora  
38 137 Research Institute.

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47 138 The NWT Communicable Disease Manual provides guidelines to assist public health  
48 139 practitioners with decision making about specific situations, and to support consistency of  
49 140 territorial public health practice;<sup>[13]</sup> therefore the general procedures for notification remained

**Comment [TA2]:** Reviewer 1: Line 142-is there a referene (even online) for the NWT CD Manual?

APA: Please see reference 13

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9 141 consistent over the study period. Upon symptomatic presentation of NGI as described in the  
10 142 Manual, health practitioners send the patient's clinical specimen to the laboratory for  
11 143 confirmation and sero-typing. The patient's demographic information, food and water histories  
12 144 are collected by the health practitioner and manually-entered into the food and waterborne illness  
13 145 investigation form. The paper form is submitted to the Population Health Division of the  
14 146 Government of the Northwest Territories Department of Health and Social Services. Health  
15 147 practitioners and laboratories are required to report patients with confirmed NGI to the  
16 148 Population Health Division within 24 hours. Once the paper form is received, disease registry  
17 149 officers at the territorial level collate, verify, enter, and disseminate illness investigation data  
18 150 electronically through the Integrated Public Health Information System (i-PHIS) for inclusion  
19 151 into the NWT CDR and the National Notifiable Disease database at the Public Health Agency of  
20 152 Canada.[13]

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32 153 Case notification data, stripped of personal identifiers, were received for 15  
33 154 diseases/infections and associated fields listed in Table 1; none of these fields was considered  
34 155 mandatory at the time of notification. A geographical conversion database was used to assign  
35 156 case-patients to their respective census subdivision (community), Health and Social Services  
36 157 Authority (HSSA) as well as assign them a status of rural or urban location; cases were classified  
37 158 as urban if reported at a health center located in a community of at least 1,000 persons and 400  
38 159 persons / sq km, others were classified as rural.[3, 12]

#### 39 160 **Data Quality Evaluation and Descriptive Analyses**

40 161 Data quality evaluation involved manually checking data associated with each case for  
41 162 completeness and internal consistency. Missing values were replaced with the term

**Comment [TA3]:** Reviewer 1: Line 155 and throughout-I could not find a definition of NWT CDR. Please indicate what the acronym is and my apologies if it is noted earlier and I missed it.

APA: Please see line 24 in abstract, line 67 in key messages and line 117 in background.

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9 163 “unspecified”. The numbers and percentages related to “unspecified” values were calculated for  
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13 165 Population denominators for each year were obtained from the NWT Bureau of Statistics  
14 166 and the mean annual age-specific rates of disease were calculated for the territory. The average  
15 167 annual number of cases was calculated using the total number of notifications divided by 18  
16 168 years. Data manipulation and statistical analyses were conducted in SPSS version 17 (SPSS Inc.,  
17 169 Chicago, Illinois) and choropleth maps of disease rates by health authority were created in  
18 170 ArcView GIS version 3.1 (ESRI, Redlands, California). Means and medians were used to  
19 171 describe the data; medians were used when dealing with highly skewed distributions. A least  
20 172 squares regression analysis was used to determine the rate of change over time. Fischer’s Exact  
21 173 tests were used to determine statistical significance [ $p < 0.05$  (two-tailed)] for categorical  
22 174 variables. Community level risk factors for NGI are reported elsewhere.[14]  
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## 34 175 **RESULTS**

35 176 The percentages of missing or unspecified values for the nine fields considered in the  
36 177 analysis are also shown in Table 1.

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40 178 From the 708 case-patients with NGI from all years, 458 (64.7%) had bacterial infections,  
41 179 240 (33.9%) had parasitic infections and 10 (1.4%) had viral (hepatitis A) infections. The three  
42 180 largest contributors to the total number of notifications were giardiasis with 205 cases (29.0%),  
43 181 salmonellosis with 202 cases (28.5%) and campylobacteriosis with 175 cases (24.7%). Too few  
44 182 cases were attributed to other agents (<6% each) to draw inferences, therefore, the focus of the  
45 183 rest of this paper was on the three most commonly notified diseases.  
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9 184 The annual reported incidence rates of NGI (total and cause-specific for giardiasis,  
10 185 salmonellosis and campylobacteriosis) are shown in Figure 1. A least squares regression analysis  
11 186 indicated that the incidence of NGI decreased by 3.7 ( $p<0.01$ ) cases per 100,000 per year over  
12 187 the study period. Giardiasis and salmonellosis decreased by 1.7 ( $p<0.01$ ) and 1.2 ( $p<0.01$ ) cases  
13 188 per 100,000 per year, respectively, but there was no significant ( $p<0.13$ ) linear change in  
14 189 incidence of campylobacteriosis. A majority of campylobacteriosis (85.7%), giardiasis (62%),  
15 190 and salmonellosis (58.4%) cases were reported from health facilities in urban areas ( $p<0.01$ ).  
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23 191 The average annual incidence of NGI (total and cause-specific for giardiasis,  
24 192 salmonellosis and campylobacteriosis) by age-group are shown in Figure 2. The highest rates of  
25 193 NGI (128.5 cases per 100,000) were observed in the 0 to 9 years age group with 56% of cases  
26 194 occurring in males ( $p<0.01$ ). The highest rates of giardiasis (50.4 cases per 100,000) were also  
27 195 found in the 0 to 9 years age group with 57% of cases occurring in males ( $p<0.02$ ). The highest  
28 196 rates of salmonellosis (46.1 cases per 100,000) were found in the 60+ years age group with 51%  
29 197 occurring in females ( $p<0.02$ ). Although not significant ( $p<0.07$ ), the highest rates of  
30 198 campylobacteriosis were observed in the 20 to 29 years age group for campylobacteriosis (28.2  
31 199 cases per 100,000) with 53% of cases occurring in males.  
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40 200 Table 2 shows that the most frequently suspected vehicle for NGI was contaminated food  
41 201 ( $p<0.01$ ). The probable source of giardiasis was most often attributed to untreated water whereas  
42 202 for campylobacteriosis and salmonellosis it was poultry and eggs, respectively ( $p<0.01$ ).  
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47 203 Figure 3 show that cases of NGI ( $p<0.01$ ) and more specifically campylobacteriosis  
48 204 ( $p<0.01$ ) and salmonellosis ( $p<0.04$ ), occurred more frequently in the late summer and early fall.  
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9 205 Although not significant ( $p<0.07$ ), giardiasis showed a similar trend on visual inspection of the  
10 206 data.

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13 207 As shown in Figure 4, the highest median annual incidence of NGI (118.0 cases per  
14 208 100,000) was observed in Yellowknife HSSA ( $p<0.01$ ) whereas the lowest median annual  
15 209 incidence (41.0 cases per 100,000) was found in Fort Smith HSSA ( $p<0.01$ ). Figure 5 shows  
16 210 that the highest median annual incidence of campylobacteriosis (265.5 cases per 100,000) was  
17 211 found in Tlicho ( $p<0.01$ ) whereas the lowest median annual incidence (0.0 cases per 100,000)  
18 212 was found in Beaufort Delta, Dehcho, Fort Smith, and Sahtu HSSAs ( $p<0.01$ ). Figure 6 shows  
19 213 the highest median annual incidence of salmonellosis (35.0 cases per 100,000) was also found in  
20 214 Tlicho HSSA ( $p<0.01$ ) however the lowest median annual incidence (0.0 cases per 100,000) was  
21 215 found in Fort Smith, Hay River, and Sahtu HSSAs ( $p<0.01$ ). Figure 7 shows highest median  
22 216 annual incidence of giardiasis (38.0 cases per 100,000) was found in the Sahtu HSSA ( $p<0.01$ )  
23 217 whereas the lowest median annual incidence (0.0 cases per 100,000) was found in Tlicho HSSA  
24 218 ( $p<0.01$ ).

## 25 26 27 28 29 30 31 32 33 34 35 36 37 219 **DISCUSSION**

38 220 The results of this study suggest that NGI is an important health problem in the NWT and  
39 221 that giardiasis, salmonellosis and campylobacteriosis account for the great majority (82.2%) of  
40 222 reported NGI in the territory. The mean annual reported rate of these three enteric diseases in the  
41 223 NWT was 78.0 cases per 100,000, which is less than reported for Ontario (87.0 cases per  
42 224 100,000) and British Columbia (145.8 cases per 100,000) based on notifiable disease data from  
43 225 1991 through 2008.[9] This may suggest that compared to some southern areas as of Canada,  
44 226 NWT residents may be at decreased risk of infection or alternatively, there may be a higher

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9 227 degree of under-reporting in the territory;[15, 16] further investigation is required. Previous  
10 228 studies have shown that about one out of 313 (Ontario) to 350 (British Columbia) cases of acute  
11 229 gastrointestinal illness are captured by surveillance systems.[17, 18] Using these adjustment  
12 230 factors from Ontario and British Columbia, we estimate that between 182,748 and 204,282 cases  
13 231 of campylobacteriosis, giardiasis and salmonellosis, collectively, may have occurred in the NWT  
14 232 over the 18 years.[10, 11, 19] Several explanations for under-reporting have been proposed, such  
15 233 as cases not presenting to medical facilities, health workers not submitting clinical samples to  
16 234 laboratories, laboratory test sensitivity issues, absence or delay of reporting from local to  
17 235 territorial health authorities. Patients may not seek medical attention because symptoms are mild  
18 236 and self-limiting, they may be too ill to travel, or they may prefer to seek treatment from local  
19 237 healers.[19] These tendencies are exacerbated in rural/remote communities of the NWT due to  
20 238 the relative paucity of available health services, facilities, and health professionals. Increased  
21 239 distances to health facilities and transportation problems further aggravate other barriers to  
22 240 accessing the health systems in rural/remote settings in northern communities.[15, 16] There are  
23 241 no data addressing possible geographical reporting biases in the NWT; therefore, research to  
24 242 characterize and quantify reporting bias in the NWT CDR is needed. Reduction of under-  
25 243 reporting and differential reporting (if it does exist) would require increased awareness of  
26 244 community health practitioners about the potential usefulness of surveillance data and therefore,  
27 245 the need to improve their quality.

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45 246 In the NWT, seasonal peaks over the study period may have been attributed to social  
46 247 environmental factors such as higher ambient temperatures, frequent travel for subsistence  
47 248 activities, centralized outdoor meal preparation as well as the consumption of country foods and  
48 249 surface water.[4, 6, 20-23] Therefore, control strategies, such as regular, coordinated public  
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9 250 education and communication about known risk factors of the disease (e.g., drinking  
10 251 contaminated water, safe food preparation) would therefore need to be targeted during these  
11 252 seasons. Such public health programs need to take into account the wide geographic distribution  
12 253 of these communities, their cultural diversity and the number of languages used.[24]  
13 254 Community-oriented media such as local television and radio, have proven to be successful  
14 255 methods of reaching rural/remote populations by providing a forum for which health issues can  
15 256 be identified and discussed thus, increasing general awareness.[25-27]

16 257 Fluctuations in rates of NGI over the 18 years are likely to be explained, at least in part,  
17 258 by random variation due to small number of cases. The peaks in 1995 and 2001 also coincide  
18 259 with known outbreaks of salmonellosis and cryptosporidiosis, respectively.[28] The incidence of  
19 260 NGI however, declined over the last few years of the study period (since 2002), which is  
20 261 consistent with observed trends in Southern Canada and the USA. The decline may attributed to  
21 262 effective, ongoing efforts to improve food and water quality or an artifact of diagnostic  
22 263 procedures, reporting practices or changes in population demographics.[29, 30] The extent to  
23 264 which these factors may have contributed to a decrease in incidence is unknown but it is an  
24 265 important topic for future research. The statistically significant decreasing trend of NGI  
25 266 incidence however, is inconsistent with predicted temperature-driven increase of enteric disease  
26 267 in the North.[31] Since the 1940's (when record collection began), the average annual  
27 268 temperature in NWT has been increasing about 2°C and scientists predict that temperatures will  
28 269 continue to warm due to climate change.[32] The potential impact of warmer temperature on the  
29 270 incidence of NGI in the NWT should be further explored.

30 271 Spatial analysis revealed that the incidence of campylobacteriosis, giardiasis and  
31 272 salmonellosis varied substantially between health authorities. Higher or lower-than-expected

**Comment [U4]:** Reviewer 1: Lines 267-271. I think the note about pursuing further study around temperature change and GI illness is interesting but these sentences are unclear. Do you have a reference that indicates that temperature has increased in NWT over this time period? Would it be more appropriate to reword that these factors should be explored?  
APA: I have rephrased for clarity in lines 265-270.



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9 273 rates in health authorities could be a result of disparities in the geographical distribution of risk  
10 274 factors and behaviors,[33] suggesting that further studies on population-level risk factors are  
11 275 warranted. Overall, NGI was reported more frequently in urban than rural areas, but the  
12 276 underlying reasons could not be evaluated with the available data. In theory, higher reporting  
13 277 rates in urban areas could reflect greater propensity for person-to-person transmission; however,  
14 278 this is more commonly seen with organisms with human reservoirs.[34] Other possibilities  
15 279 include greater accessibility, affordability and/or reliance on store-purchased foods, restaurant  
16 280 meals, and foreign travel as well as other population-level risk factors such as community water  
17 281 systems.[35] It is also possible that some infections were acquired in rural/remote areas of the  
18 282 NWT but were reported at health facilities in urban areas.[36] We expected exposure to these  
19 283 environmental or zoonotic pathogens to be more common in rural/remote areas, through contact  
20 284 with animals, their feces, as well as contaminated surface water and raw foods compared to  
21 285 urbanized areas.[37] Furthermore, higher disease rates could also be an artifact of differential  
22 286 reporting of cases or methods of data collection that vary by area or practitioners. Several studies  
23 287 have demonstrated that higher reporting rates in urban areas are often a function of the amount  
24 288 and type of available health services, rather than the occurrence of illness itself.[38-40]

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40 290       Giardiasis was the most commonly reported infection in this study, reflecting its  
41 291 importance as an enteric pathogen in the territory. Giardiasis commonly occurs through the  
42 292 ingestion of infective cysts found in contaminated water, food, or infected persons by the fecal-  
43 293 oral route. The cysts can be present in contaminated wells and water systems, particularly those  
44 294 sourced from surface water such as fresh water lakes and streams. Person-to-person transmission  
45 295 also accounts for many *Giardia* infections and is usually associated with poor hygiene and

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9 296 sanitation. In the Arctic, cysts of *Giardia* spp. have been found in water, sewage and fecal  
10 297 samples of marine mammals harvested for food.[23] Our findings of higher rates in infants and  
11 298 children in NWT could be related to reporting bias, poor hygiene, more frequent exposure to  
12 299 communal facilities or recreational water, lack of protective immunity, or a combination of  
13 300 factors.[41, 42] High rates in patients 30 to 39 year of age may also be at least partially attributed  
14 301 to contact with infected children as parents or as caregivers, and these persons are possibly more  
15 302 likely to seek medical care and therefore more likely to be captured by the surveillance  
16 303 system.[43] The higher rate of giardiasis in males is unexplained, but has also been noted in  
17 304 other studies.[44] In the NWT, gender may act as a surrogate for true causal variables related to  
18 305 exposure, such as the consumption of untreated surface water or contaminated traditional foods,  
19 306 particularly while carrying out subsistence activities in northern areas of the NWT. Consistent  
20 307 with previous research, the incidence of giardiasis in this study was higher in the late summer  
21 308 and autumn months, which may be related to greater environmental exposure during leisure and  
22 309 subsistence activities, potentially greater likelihood of infectious levels of cysts in water at this  
23 310 time of year, or exposure to contaminated recreational water that favors indirect person-to-person  
24 311 transmission.[45]

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40 312 Salmonellosis, the second most frequently reported enteric infection, is commonly  
41 313 acquired through consumption of contaminated food of animal origin, mainly meat, poultry, eggs  
42 314 and milk, but also contaminated fruit and vegetables.[36] In the NWT, poultry/eggs were  
43 315 identified by those reporting illness as the most probable sources of this infection. Other  
44 316 suspected food vehicles included pork, caribou, beef, and fish/seafood; however, we do not know  
45 317 whether these vehicles were identified through epidemiological investigation, follow-up  
46 318 microbiological testing, or speculation by the health practitioner. Moreover, we do not know

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9 319 whether suspect foods were obtained through individual subsistence activities, community  
10 320 freezers, or retail locations making it difficult to hypothesize the source of microbial  
11 321 contamination; however, outbreaks of verotoxin-producing *Escherichia coli* O157:H7 (fourth  
12 322 highest notification) in the NWT have been attributed to frozen minced beef and caribou  
13 323 obtained from grocery stores and homes.[46, 47] Higher observed rates of salmonellosis in  
14 324 infants and children (0 to 9 years age group) and the elderly (60+ years age group) in this study  
15 325 have been noted in a previous study and may be related to lack of protective immunity or other  
16 326 factors mentioned for giardiasis.[41, 48, 49] Higher rates of disease in females are so far  
17 327 unexplained, but further research considering differences in food handling practices and hygiene  
18 328 as well as the types of foods consumed, may indicate their role in apparent gender  
19 329 differences.[50] Higher rates of infection in the late summer and autumn months may be  
20 330 attributable to environmental and social factors. These may include higher ambient temperatures,  
21 331 frequent travel as well as higher prevalence in food animal populations, centralized outdoor meal  
22 332 preparation and consumption related to large social gatherings.[20, 51]

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36 333 *Campylobacteriosis*, the third most frequently reported infection, commonly occurs  
37 334 through the poor handling of raw poultry, and consumption of undercooked poultry,  
38 335 unpasteurized milk and contaminated drinking water. *Campylobacter* is also common in  
39 336 migratory birds and the consumption of fresh water from surface contaminated with bird feces  
40 337 could be a seasonal driver of this disease in the North.[52] In the NWT, the predominant mode of  
41 338 transmission was believed to be foodborne; poultry, eggs, pork, caribou, beef, and fish/seafood  
42 339 from unspecified sources, were once again identified as probable exposures for infection.  
43 340 Incidence rates were highest in adults 20 to 49 years of age. The relatively higher rates in young  
44 341 males noted in other studies have been thought to reflect poor hygiene and food handling

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9 342 practices.[53] As with other studies on campylobacteriosis, disease occurred more frequently in  
10 343 the late summer and autumn months.[54] Traditionally, in northern communities, hunting  
11 344 activities and the collection of plants, berries, and bird's eggs as well as the consumption of  
12 345 surface water occur more frequently during this time period.[4]. *Campylobacter* however, are  
13 346 more susceptible to freezing than other bacteria, therefore it is tempting to speculate that the  
14 347 colder northern climate may play a role in reducing exposure in food and water.

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20 348 *Cryptosporidium* infections in humans may be from either human or animal origin, and  
21 349 no attempts were made to differentiate among strains in this study. The apparent low incidence  
22 350 of pathogens such as *Cryptosporidium* (2.4 cases per 100,000) in the NWT may be due to the  
23 351 lack of exposure to agricultural animals in the North.[55] Domestic livestock, including beef and  
24 352 dairy cattle as well as sheep are often perceived to be the leading environmental source of  
25 353 waterborne pathogens,[56] although contamination from human sewage also occurs. Animals  
26 354 shed oocysts through manure contributing to the *Cryptosporidium* load of drinking water sources  
27 355 [57]. Several studies have shown that concentrations of *Cryptosporidium* are significantly higher  
28 356 in agricultural rather than non-agricultural watersheds.[58, 59] The role of wildlife as a source of  
29 357 *Cryptosporidium* is less clear in published literature. A study conducted over a 4-year period in  
30 358 Northern Alaska found that the prevalence of *Cryptosporidium* spp. in fecal samples of marine  
31 359 mammals from subsistence hunts was highest in ringed seals (22.6%) followed by right whales  
32 360 (24.5%) and bowhead whales (5.1%).[60] A study in Nunavik (Quebec, Canada) also found a  
33 361 prevalence of 9% in fecal samples of ringed seals.[61] These studies suggest that some animals  
34 362 used in traditional foods may be reservoirs for the disease in the north. In this study, caribou,  
35 363 muktuk, and seal were also suspected sources of infection for 8.4% of NGI cases; therefore,  
36 364 further evaluations of environmental risk factors in the NWT are warranted.

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9 365 This study demonstrates the usefulness of surveillance data to guide epidemiological  
10 366 research and public health practice in northern communities. Of the nine reporting fields in the  
11 367 NWT CDR, eight had less than 5% of data missing; however, the field 'suspected exposure',  
12 368 unknown (missing) for 73.5% of the records, is a source of potential bias. Exposure information  
13 369 is frequently ascertained through an interview or questionnaire, thus, it is difficult to assess the  
14 370 extent to which recall or reporting bias has occurred and there are obvious limitations on the  
15 371 quality of exposure data obtained in this fashion. In addition, suspected sources are infrequently  
16 372 confirmed by microbiological testing, therefore, the results regarding the 'suspected exposure'  
17 373 must be viewed with considerable caution and can be thought of as hypotheses. For the data to be  
18 374 useful, particularly for risk factor identification, it is essential that the completeness of fields and  
19 375 hence, quality be improved. From 1991 to 2008, there were no mandatory fields enforced by the  
20 376 GNWT. Due to the contextual challenges of conducting surveillance in northern, rural/remote  
21 377 communities, the NWT CDR is based around the minimum data set concept, where the focus is  
22 378 on collecting the most essential data fields; however, these fields must be standardized and  
23 379 sufficiently detailed to support the delivery, planning and monitoring of public health initiatives.  
24 380 Although issues related to data quality are not unique to surveillance systems serving northern,  
25 381 rural/remote areas, they may be exacerbated when the systems serve sparse populations and have  
26 382 inadequate infrastructure, human and financial resources.[62] The implementation of electronic-  
27 383 based platforms for reporting have been shown to improve data quality and completeness in low-  
28 384 resource settings.[63,64]

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47 385 Published knowledge on surveillance in rural/remote areas is sparse; as a result, very little  
48 386 has been recommended in terms of cohesive and effective approaches to enhance surveillance in  
49 387 these communities. The gap in the literature suggests that the development of a comprehensive  
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9 388 public health surveillance system for rural/remote communities, which takes into account local  
10 389 realities and needs, is a priority area for research; however, this will require a collaborative effort  
11 390 from stakeholders, partners and knowledge-users of the system. Suggestions for moving forward  
12 391 include a collaborative design of suitable data elements, data collection protocols, data quality  
13 392 assurance, research and evaluation training, and procedures for confidential data entry and  
14 393 transfer. The existing literature recommends several strategies to augment insufficient data from  
15 394 traditional health surveillance. Andresen et al. (2004) suggest methodological approaches such as  
16 395 aggregation, spatial smoothing, small area estimation and exact statistics.[65] Sentinel  
17 396 surveillance, population-based sample surveys, community-based observations, and syndromic  
18 397 surveillance can also be used as surrogates for more widespread surveillance.[65,66] The  
19 398 capacity to generate high quality surveillance data in northern, rural/remote populations, such as  
20 399 those in the NWT, may exist if innovative, informal and population-specific approaches are  
21 400 considered and applied to public health surveillance.  
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34 401 In 2011, the Department of Health and Social Services (DHSS), GNWT, introduced a  
35 402 new electronic tool to improve surveillance for NGI. The application, called DHSS Tools, is a  
36 403 restricted-access site which includes a case reporting module (environmental health - food and  
37 404 waterborne illness investigation) that can be used by community public health officers, disease  
38 405 consultants, epidemiologists and environmental health officers to ensure better communication,  
39 406 follow-up, decision-making, and completeness of information.  
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45 407 In summary, the results of the study indicate that giardiasis, salmonellosis and  
46 408 campylobacteriosis were the most important enteric diseases in the NWT from 1991 through  
47 409 2008, and the incidence declined in later years of the study period. There was increased risk of  
48 410 NGI in the late summer and early fall, in infants and children, males and urban residents. The  
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9 411 geographical distribution of case-patients varied by disease suggesting that environmental and  
10 412 behavioral risk factors played key roles in infection and may provide opportunities for  
11 413 prevention. For future study, multivariable regression and spatial analyses at the community  
12 414 level are necessary for valid risk factor identification as well as for implementing specific and  
13 415 geographically-appropriate risk reduction and control strategies. It is anticipated that this  
14 416 information will guide future research as well as the allocation of resources for prevention,  
15 417 promotion and control initiatives.

#### 22 418 **COMPETING INTERESTS**

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25 419 None

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#### 38 425 **CONTRIBUTORSHIP**

39  
40 426 APA contributed to the manuscript through study design and planning, data collection,  
41 427 analysis and interpretation of results, drafting of manuscript and response to editorial comments  
42 428 and preparation of final manuscript for submission. JW, VLE, CF, RRS and SAM contributed to  
43 429 the manuscript through study design and planning, consultation on study progress,  
44 430 troubleshooting, data analysis and interpretation of results, reviewing and commenting on  
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431 manuscript drafts. MS contributed to the manuscript through data collection, interpretation of  
432 results and reviewing and commenting on manuscript drafts.

433 **DATA SHARING**

434 The dataset may be requested from Population Health, Department of Health and Social  
435 Services, Government of the Northwest Territories ([www.hltss.gov.nt.ca](http://www.hltss.gov.nt.ca)).

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Table 1. Notifiable gastrointestinal illnesses (NGI) and associated percent missing or unspecified values, by field and disease, Northwest Territories, Canada, 1991-2008.

Notifiable Disease Report Form Fields - Percent Missing Values								
Disease / Agent (number of reported cases 1991-2008)	Age	Gender	Community	Health Unit	Report Date	Etiologic Agent	Subtype	Suspected exposure
Amoebiasis (n=10)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0
Botulism (n=8)	0.0	0.0	0.0	0.0	0.0	0.0	12.5	25.0
Brucellosis (n=3)	0.0	0.0	0.0	33.3	0.0	0.0	66.7	66.7
Campylobacteriosis (n=175)	0.0	0.0	2.3	0.6	0.0	0.0	0.0	79.4
Cryptosporidiosis (n=18)	0.0	0.0	11.1	0.0	0.0	0.0	0.0	100.0
E. coli (VTEC) (n=40)	0.0	0.0	12.5	0.0	0.0	0.0	0.0	62.5

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<b>Food Poisoning*</b> (n=10)	0.0	0.0	0.0	0.0	0.0	0.0	100.0	10.0
<b>Giardiasis</b> (n=205)	0.0	0.0	3.9	0.0	0.0	0.0	0.0	73.7
<b>Hepatitis A</b> (n=10)	0.0	0.0	10.0	0.0	0.0	0.0	0.0	90.0
<b>Listeriosis</b> (n=1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
<b>Salmonellosis</b> (n=202)	0.0	0.0	0.0	4.5	0.0	0.0	0.0	70.8
<b>Shigellosis</b> (n=12)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3
<b>Tapeworm</b> (n=7)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.1
<b>Tularemia</b> (n=1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
<b>Yersiniosis</b> (n=6)	0.0	0.0	16.7	0.0	0.0	0.0	0.0	100.0
<b>Total NGI Cases</b> (n=708)	<b>0.0</b>	<b>0.0</b>	<b>2.6</b>	<b>0.1</b>	<b>0.0</b>	<b>0.0</b>	<b>1.8</b>	<b>73.2</b>

\* Includes 5 cases due to clostridium and 5 cases due to bacillus. Infections from these agents are not notifiable unless they are from food poisoning.

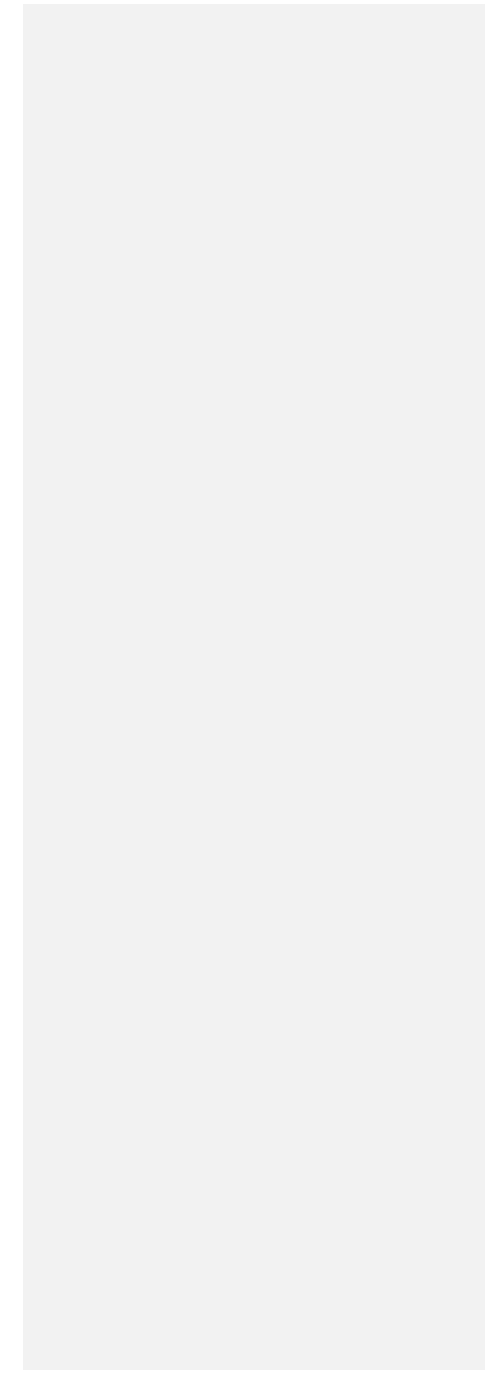
Table 2. Percentage distribution of reported suspected sources of infection for notifiable gastrointestinal illness, campylobacteriosis, giardiasis and salmonellosis, Northwest Territories, Canada, 1991-2008.

<b>Percent of cases attributed to suspected exposure</b>				
<b>Suspected Exposure (%)</b>	<b>NGI</b>	<b>Campylobacteriosis</b>	<b>Giardiasis</b>	<b>Salmonellosis</b>
<b>Beef</b>	6.8	2.8	3.7	3.4
<b>Caribou</b>	6.3	2.8	5.6	5.1
<b>Fish/Seafood</b>	3.2	11.1	0.0	1.7
<b>Muktuk (Whale)</b>	1.6	0.0	0.0	0.0
<b>Pork</b>	4.7	2.8	0.0	13.6
<b>Poultry/eggs</b>	18.9	38.9	1.9	33.9
<b>Seal</b>	0.5	0.0	0.0	0.0

<b>Foodborne unknown</b>	28.4	41.7	5.6	37.3
<b>Untreated water</b>	27.9	0.0	81.5	0.0
<b>Waterborne unknown</b>	0.5	0.0	1.9	5.1
<b>Perinatal transmission</b>	0.5	0.0	0.0	0.0
<b>Person-to-person</b>	0.5	0.0	0.0	0.0

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## FIGURES

**Figure 1:** Annual incidence rates of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis). Northwest Territories, Canada, 1991 to 2008.

**Figure 2:** Incidence of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis) by age-group, Northwest Territories, Canada, 1991 to 2008.

**Figure 3:** Incidence of notifiable gastrointestinal illness (total and cause-specific for giardiasis, salmonellosis and campylobacteriosis) by month, Northwest Territories, Canada, 1991 to 2008.

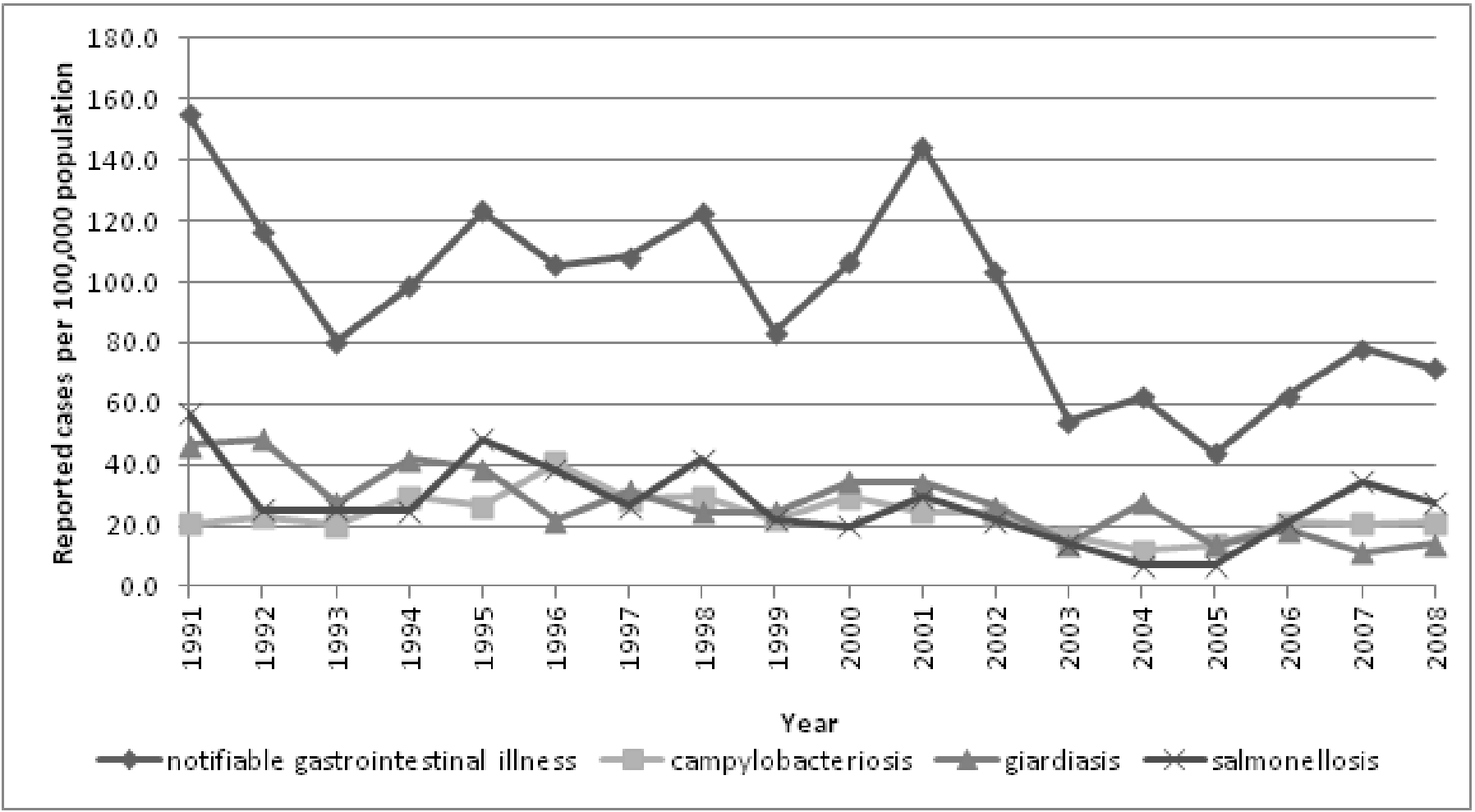
**Figure 4:** Map of incidence rates per 100,000 population for reported cases of notifiable gastrointestinal illness (NGI). Northwest Territories. 1991 to 2008.

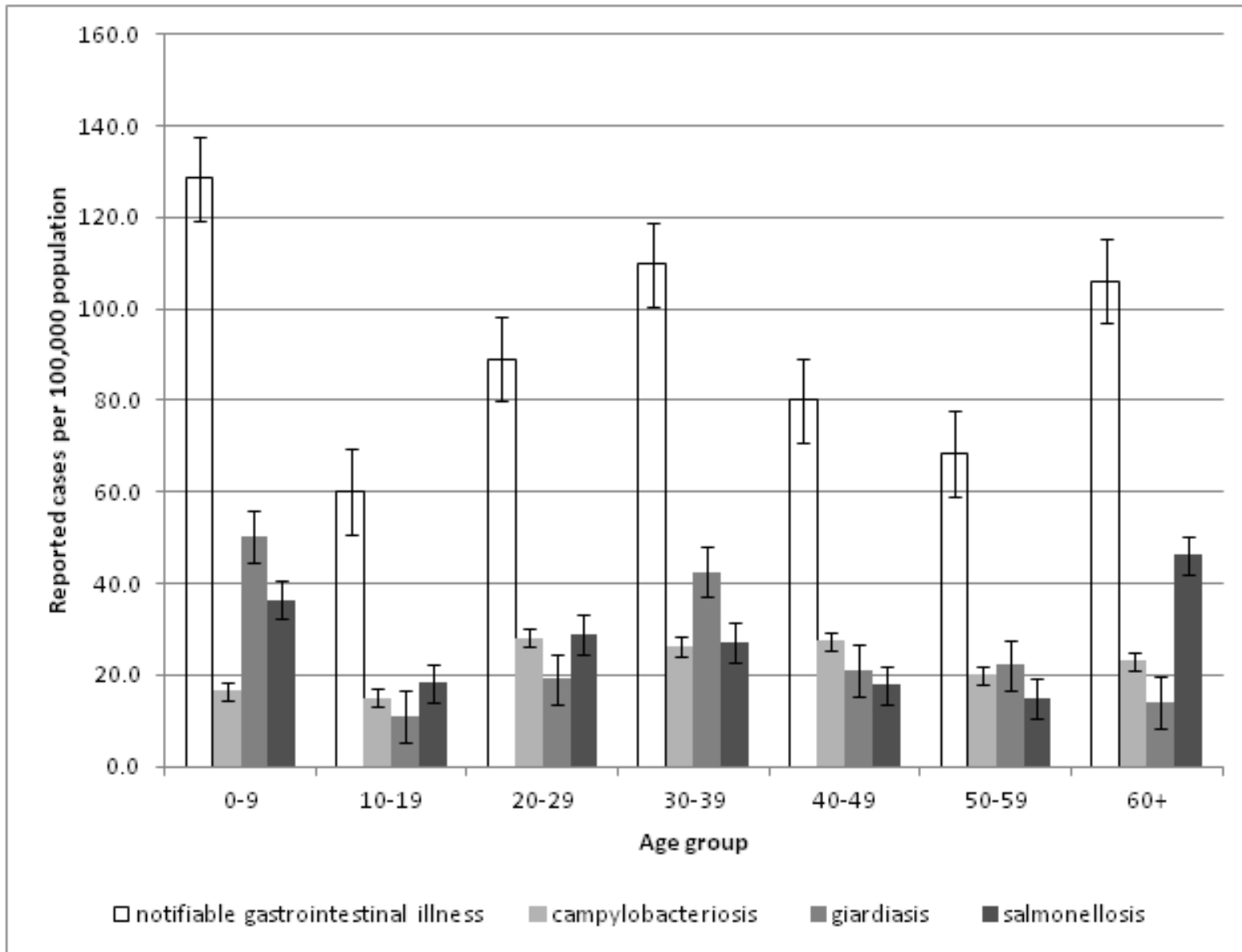
**Figure 5:** Map of incidence rates per 100,000 population for reported cases of campylobacteriosis. Northwest Territories. 1991 to 2008.

**Figure 6:** Map of incidence rates per 100,000 population for reported cases of salmonellosis. Northwest Territories. 1991 to 2008.

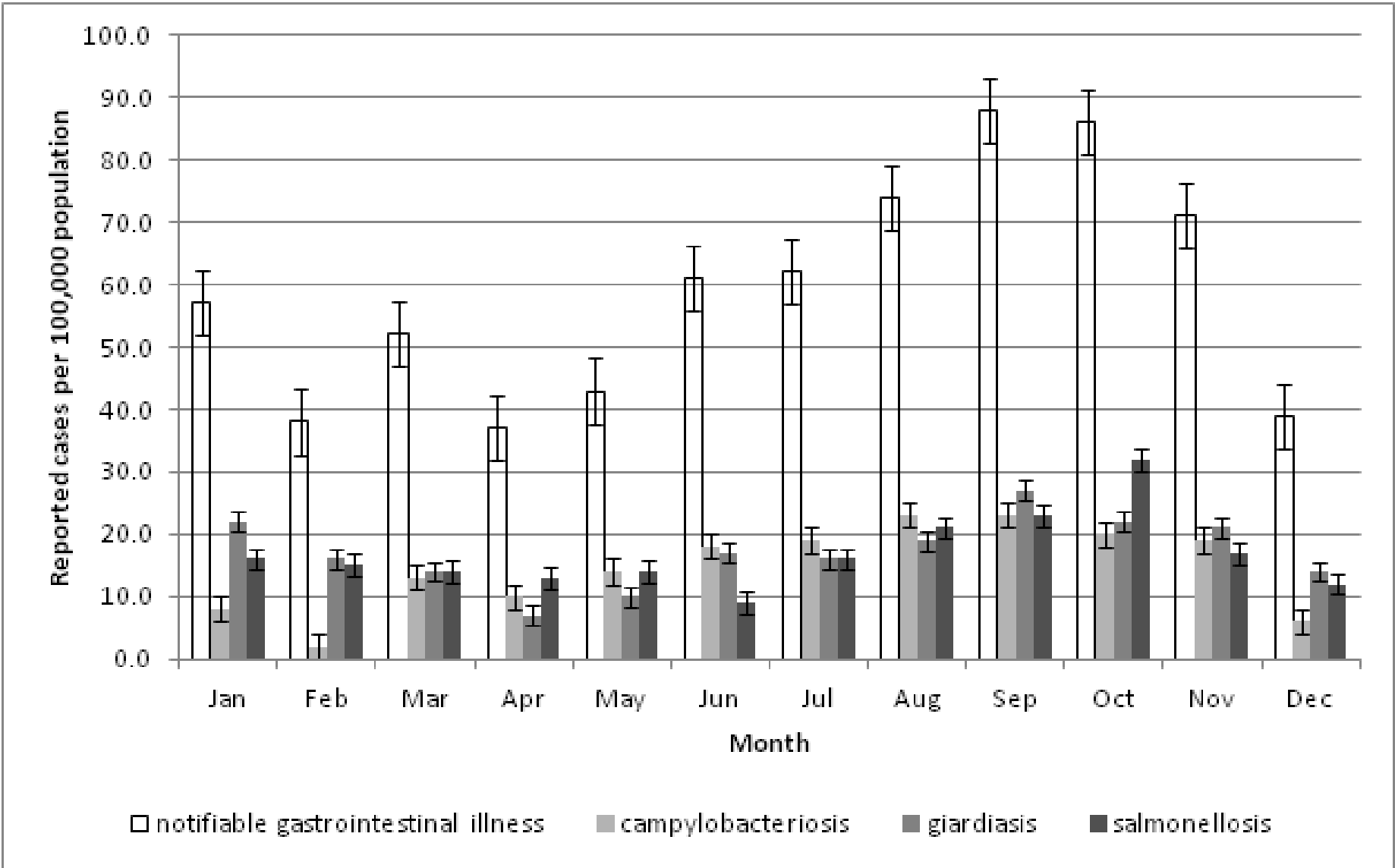
**Figure 7:** Map of incidence rates per 100,000 population for reported cases of giardiasis. Northwest Territories. 1991 to 2008.

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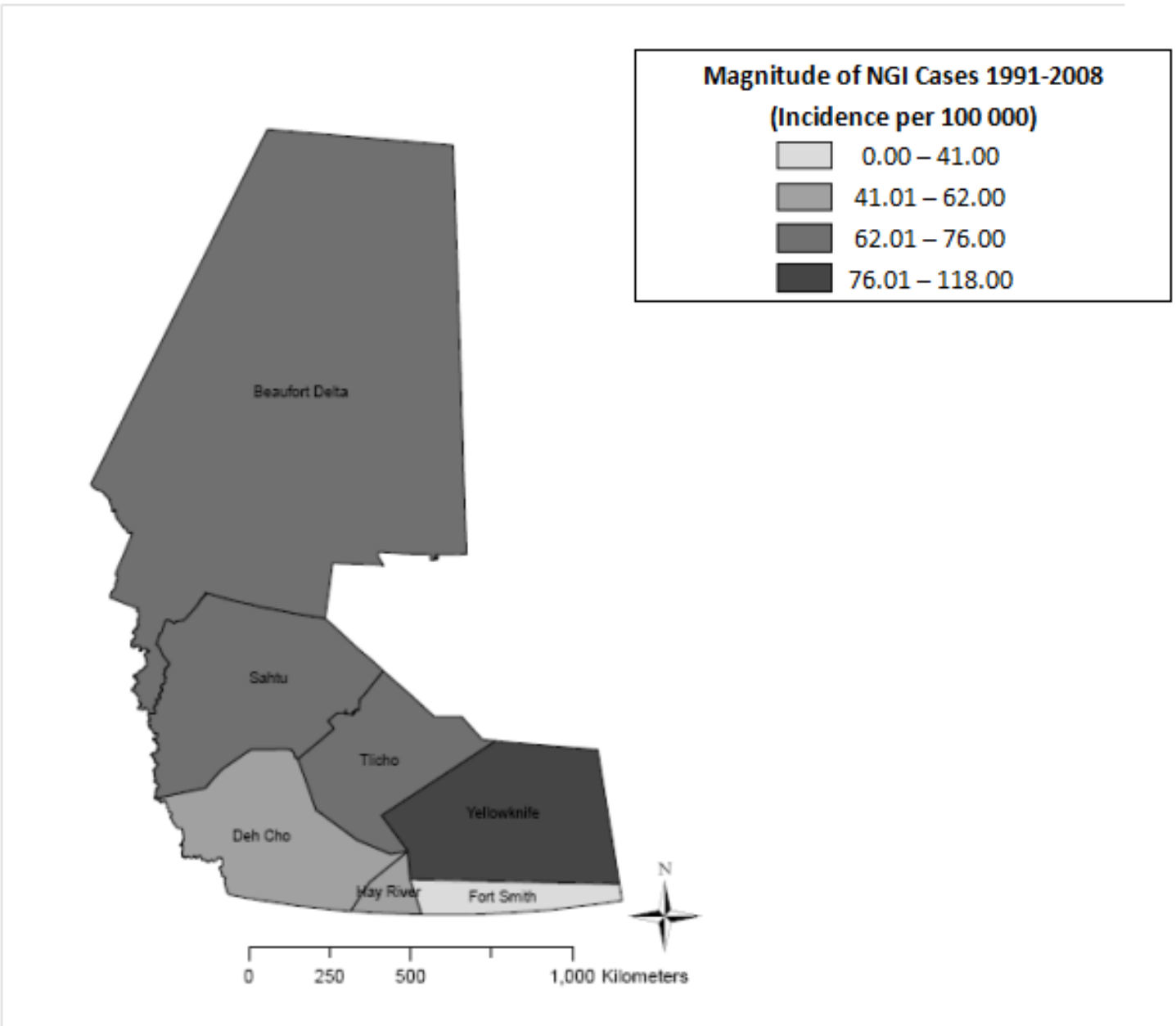


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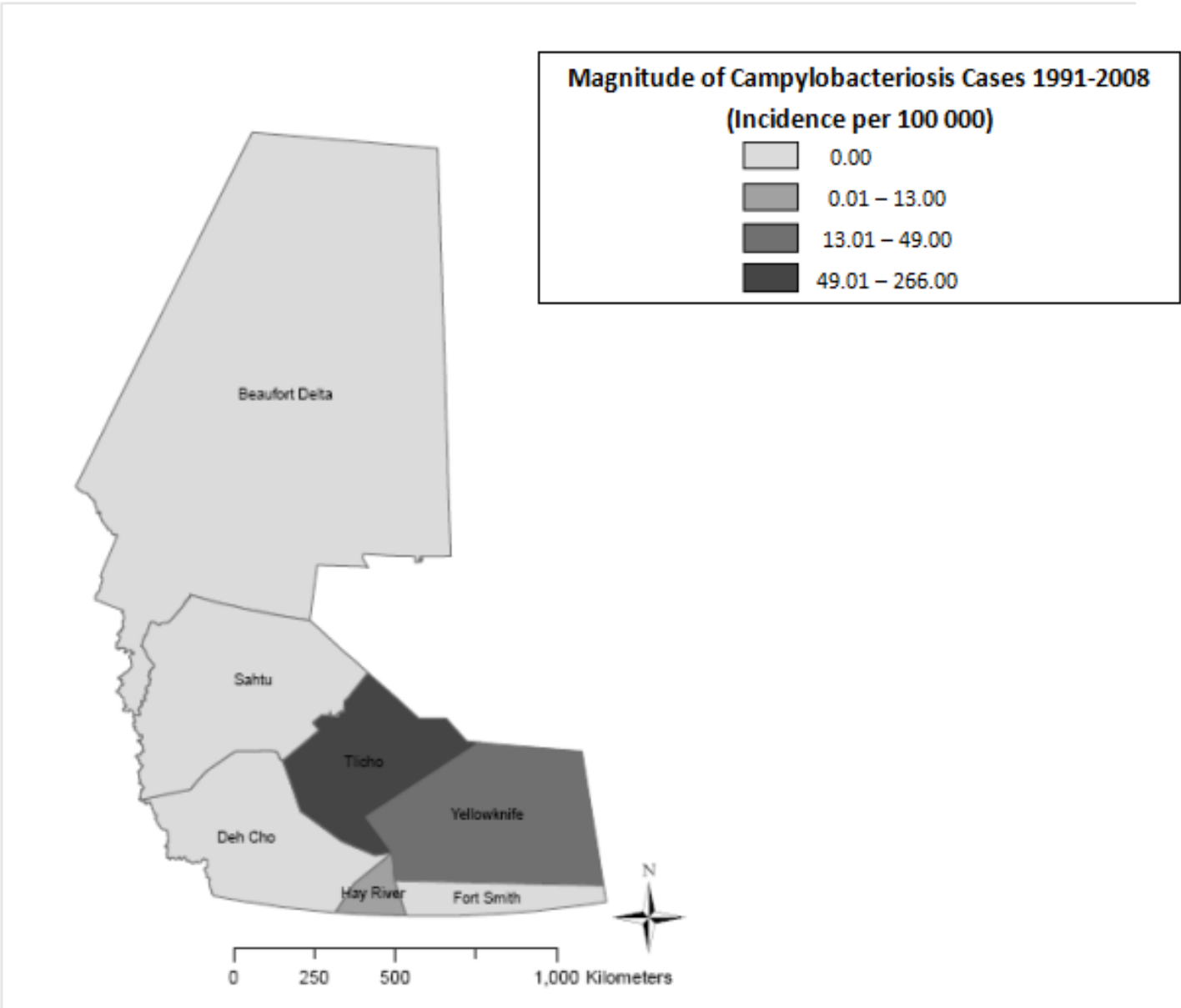




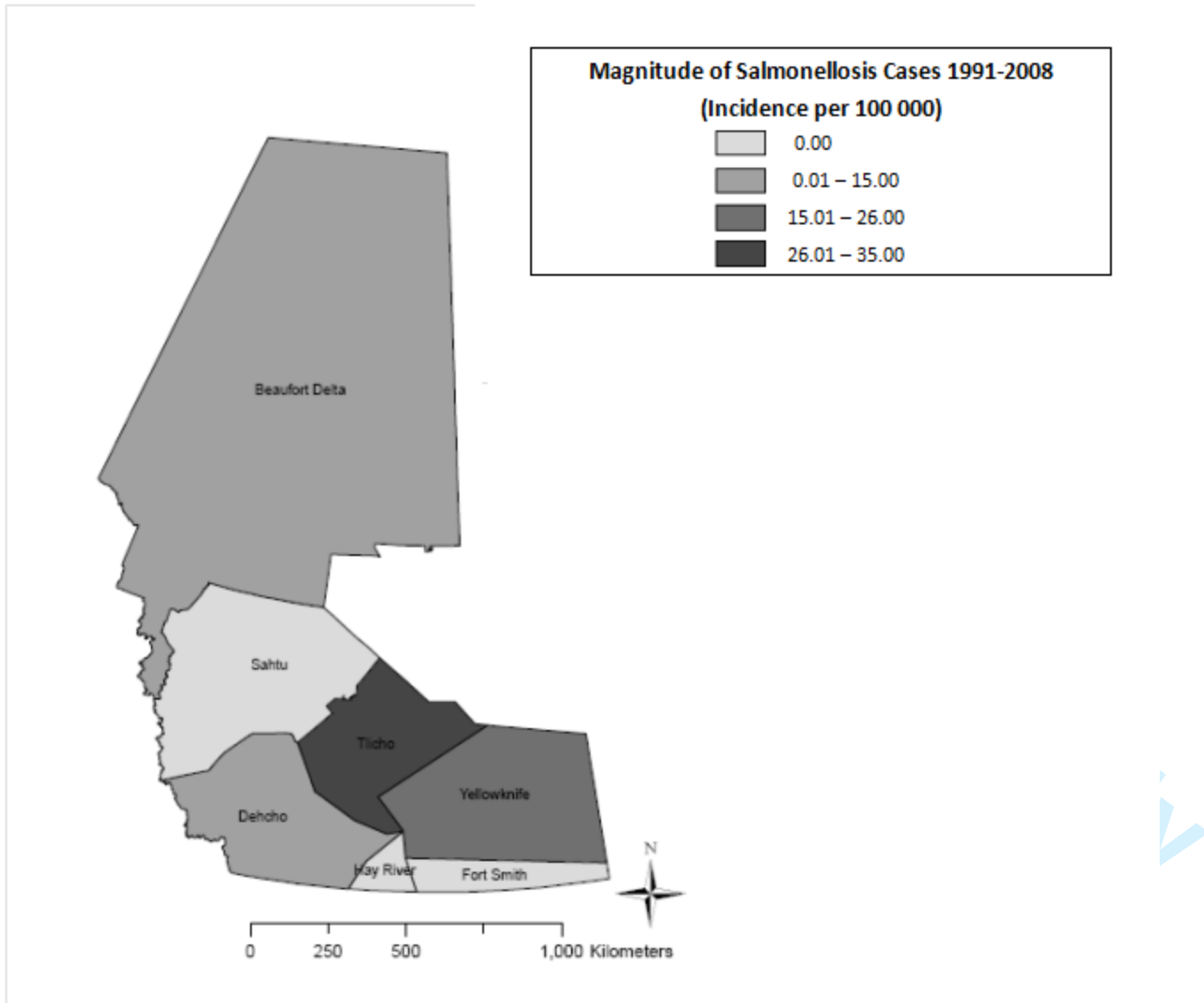
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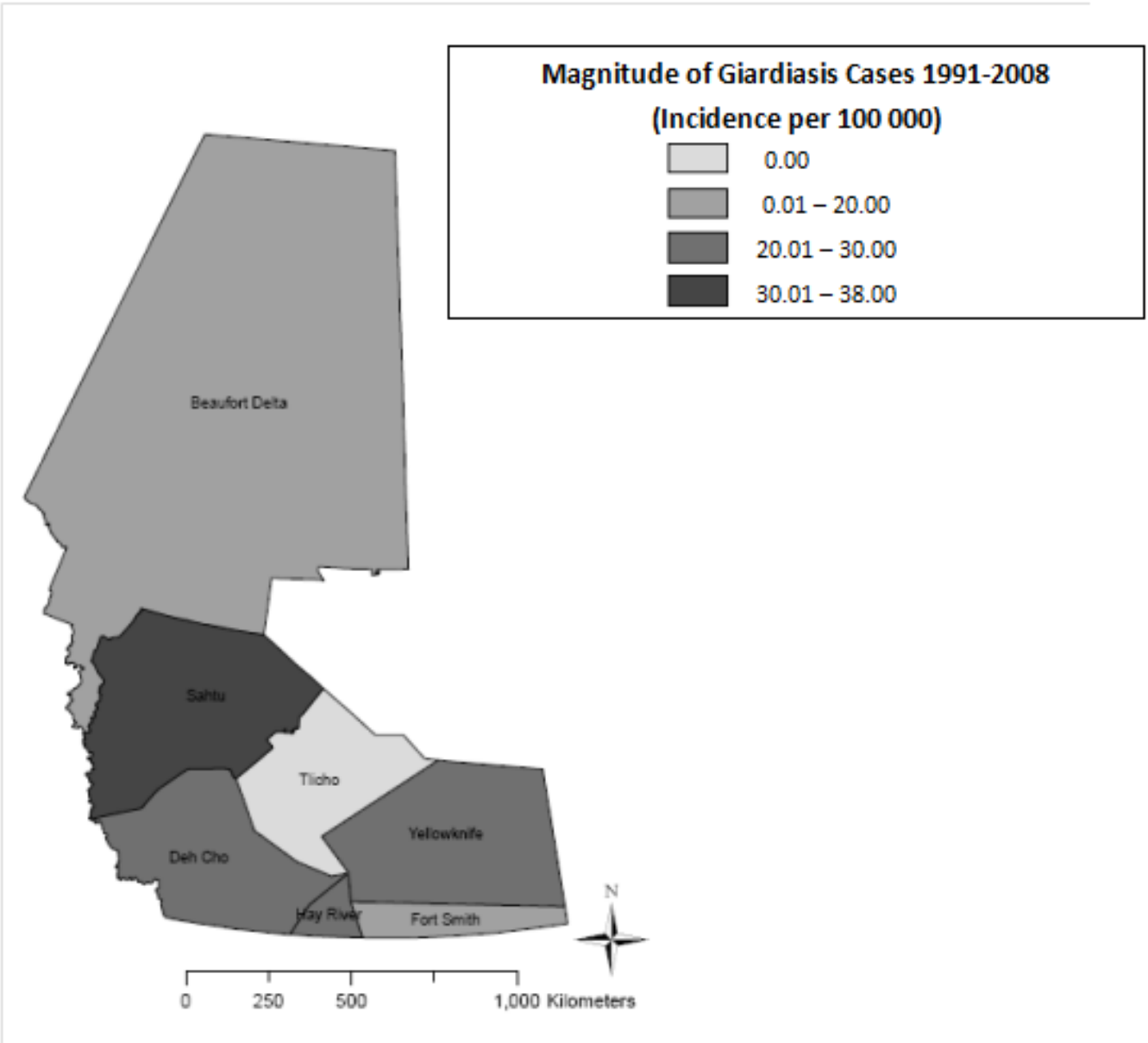
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**STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology\***  
**Checklist for cohort, case-control, and cross-sectional studies (combined)**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2, 3
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any pre-specified hypotheses	6
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	8-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	N/A
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	18
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-9
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-9
		(b) Describe any methods used to examine subgroups and interactions	7-9
		(c) Explain how missing data were addressed	7-9
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	N/A

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		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	N/A
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9,30-31
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9,32
		(b) Indicate number of participants with missing data for each variable of interest	9,21
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	N/A
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	N/A
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	N/A
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	11-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	18-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.  
**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).