Social inequity, gender and *Helicobacter pylori* infection in Arctic Canada

by

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Abstract

Helicobacter pylori (Hp) infection has an elevated prevalence in northern Indigenous communities in Canada. This thesis investigates social inequities in the *Hp*-associated disease burden within Indigenous communities in the Northwest Territories and Yukon. I examined how deprivation indicators relate to this disease burden, with particular interest in differences in gender, and in households headed by unpartnered women relative to other households.

I used data from projects conducted by the Canadian North *Helicobacter pylori* (CAN*Help*) Working Group to address community concerns about *Hp*-associated risks. I estimated the Canadian Deprivation Index (CDI), a validated predictor of health status, from its 3 components: home ownership; education; and food security. CAN*Help* Working Group researchers ascertained most variables by interviewing participants as they enrolled in community projects during 2007-2017; I ascertained food security in a subset of participants during 2017- 2018, using the Canadian Government Household Food Security Survey, adapted for Arctic communities. As a disease burden variable, I used the prevalence of *Hp* infection based on urea breath test screening, histopathology, and/or culture. I constructed a multivariable logistic regression model to estimate odds ratios for the effect of selected variables on *Hp* prevalence while controlling for the effects of other variables, with a random

effects parameter for household to account for clustering of *Hp* infection in households.

Hp prevalence was higher among participants at higher deprivation levels, after adjustment for identified confounding variables. The estimated trend in *Hp* prevalence with increasing deprivation levels was more notable in members of households led by unpartnered women relative to members of other households, and in men relative to women, though there was insufficient statistical precision to conclude that the observed difference in the trend was beyond what would be expected from random variation. Thus, the *Hp*-associated disease burden seems related to social and gender inequities within Indigenous communities in Arctic Canada.

Preface

This thesis is my own original work. The research conducted by the CAN*Help* Working Group, which includes the research completed in this thesis, received ethics approval from the University of Alberta Health Research Ethics Board under the Project Name "Addressing Community Concerns about Risks from *H. pylori* Infection in the Circumpolar North" on October 4, 2016 and again on September 26, 2017; Study ID: No. Pro00007868. This research was approved by Northwest Territories and Yukon licensing authorities under License IDs 15785 and 16-13S&E respectively.

I estimated the prevalence of *H. pylori* infection and social deprivation from data previously collected by project staff in Aklavik, Old Crow, Fort McPherson, Inuvik, Teslin, and Ross River; I assisted with the collection of this data in Pelly Crossing and Carmacks. Food insecurity data was collected by project staff from 2016 through 2018; I designed a data collection tool for ascertaining food insecurity data in 2017, and directed and assisted with the collection of this data beginning September 2017 and ending April 2018. This research benefitted from the guidance of several collaborators: Dr. Karen Goodman (KJG), Dr. Sherilee Harper, Dr. Janis Geary, Dr. Yan Yuan, and the CAN*Help* Working Group Community Planning Committees. No part of this thesis has been previously published.

Acknowledgements

This thesis and the degree of which it is a part represents a lifelong goal. Not many can say they have had the good fortune of completing their childhood dream, and for that alone I am indebted to all who have given me the chance to achieve it.

The incredible experiences I have had throughout my graduate career would not have been possible without the support and encouragement of my supervisor, Dr. Karen Goodman. Karen, thank you so much for everything. I am eternally grateful for the opportunities you have given me, such as the opportunity to have been a graduate student at the University of Alberta SPH, to have been a part of the CAN*Help* Working Group – and, most importantly, to have been your student. My sincerest wish is to some day be a mentor of your calibre. It is a considerably lofty goal, but I will keep your example ever-present in my mind.

I would also like to thank the current and former members of my supervisory committee: Dr. Yan Yuan, Dr. Janis Geary, and Dr. Sherilee Harper. Thank you for your time and your expertise. I would also like to thank Doug Dover, whose work on the CDI inspired my thesis project.

I would also like to take the opportunity to thank everyone who has been a part of the CAN*Help* Working Group. In no particular order, I would especially like to thank Emily Walker, Laura McAlpine, Hsiu-Ju Chang, Katharine Fagan-Garcia, and Ali Assi. As well, I am very grateful for the hard work of interns Bushra Alam, Michael Hindelang, and Rabail Shahid for their help with data collection, data entry, and article screening respectively. I extend a particularly deep thanks to all of the community planning committee members for their direction and warm hospitality while I was in the communities.

I would also like to thank UAlberta North and Polar Knowledge Canada (POLAR) for awarding me a UAlberta North Research Award and Northern Scientific Training Program (NSTP) support, respectively, to conduct field research to ascertain food insecurity for CAN*Help* project participants. I would like to thank UAlberta North for subsequently awarding me a Community Reporting Award so I could return the results of my thesis research to the communities in person.

Thank you to my family and friends, who never stopped encouraging me. In particular, I extend my thanks to my grandparents, Jill and Ron, who fostered my interest in epidemiology. I would also like to thank my partner of twelve years, Erin. Thank you for your unconditional support.

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List of Abbreviations

CDI	Canadian Deprivation Index
C13	Carbon 13
CHFSSM	Canadian Household Food Security Survey Module
CI	Confidence Interval
FS	Food Security
HFSSM	Household Food Security Survey Module
LR	Likelihood ratio
OR	Odds ratio
RUT	Rapid Urease Test
SES	Socioeconomic Status
UBT	Urea Breath Test
Hp	*Helicobacter pylori*

Chapter 1: Introduction

Background

Helicobacter pylori (Hp) are spiral-shaped, gram-negative bacteria that colonize the protective lining of the stomach, nearly always causing gastritis (inflammation of the stomach lining)[1]. *Hp*-induced gastritis increases the risk of peptic ulcers, gastric atrophy, and stomach cancer[2,3] . Abundant evidence suggests that most *Hp* infection occurs from contact with the digestive fluids of an infected person, most often during childhood[4]. Much evidence shows that *H. pylori* prevalence is inversely associated with socioeconomic status (SES), though not consistently across all indicators within geographically defined communities[5]. Broadly, geographic variation in prevalence is associated with disparities in wealth; reported prevalence estimates range from 24% in Australia-New Zealand to 70% in Africa, with prevalence in Canada and the United States estimated at approximately 37%[6]. It should, however, be noted that many available country-level estimates are limited by poor representativeness of screened population samples[7]. While recent evidence suggests prevalence is decreasing in affluent countries, prevalence remains high among disadvantaged groups[8]. Within geographically defined populations with smaller income differentials, education is the SES indicator most consistently associated with *Hp* prevalence; groups with higher levels of education experience substantially lower prevalence of infection[5].

Hp has a disproportionately high prevalence in northern Canada: prevalence >50% has been reported for Arctic communities, while prevalence estimated in southern Canada is closer to 30%[9,10]. The Canadian North *Helicobacter pylori* (CAN*Help*) Working Group is a collaboration of academic scientists, with northern community leaders and health care providers who investigate *H. pylori* infection to address community concerns. Community-driven projects conducted by this group have shown that Arctic Canadians with *H. pylori* infection have an elevated prevalence of severe chronic stomach inflammation, consistent with an increased risk of stomach cancer[11]. Residents of participating CAN*Help* communities are predominantly Indigenous, with 90% of community project participants identifying as First Nations, Inuit, or Métis.

Studies from around the world do not show large differences between men and women in *H. pylori* prevalence[12]. The literature includes scant information, however, on the joint impact of social inequity and gender on the disease burden from *H. pylori* infection. In Canada, women tend to have lower socioeconomic status than men. According to the most recent census data analysis, using data collected in 2011, women's average annual personal income was approximately $16,100 lower than men's[13]. While Canadian women are more likely to have a university or college degree than Canadian men, they are less likely to enjoy the benefits of those degrees: women

are less likely to be employed than men with the same qualifications, and are paid less on average for equivalent work[13].

Indigenous women in Canada experience substantial socioeconomic disadvantages compared to non-Indigenous women. In 2011, 12% of Indigenous women had a university degree compared to 28% of non-indigenous women[13]. Indigenous women and girls are more likely to live in poor quality homes: 21% live in homes requiring major repairs, compared to 7% of their non-Indigenous counterparts[13] and a higher proportion of Indigenous women and girls live in crowded homes, which is associated with increased incidence of infectious disease and has deleterious effects on academic achievement[13]. Indigenous women in Canada are also more likely to be lone parents than non-Indigenous women. In 2011, 17% of women classified as Aboriginal and 8% of non-Aboriginal women led lone-parent households[13]. In Canadian surveys of self-reported health, a statistically validated measure of overall health status, less than half of women classified as Aboriginal report their health as "excellent" or "very good", a notably lower proportion relative to Aboriginal men and non-Aboriginal women[14]. In fact, Aboriginal women are more likely than non-Aboriginal women to be diagnosed with a chronic health condition[14].

As a general health indicator, low socioeconomic status, measured in diverse ways, is linked to poor chronic disease outcomes[15]. Though often used in research, household

income is not an optimal indicator of population inequity for several reasons. Ascertainment of income using questionnaires and interviews typically results in low response rates and frequent reporting error[16]. A research participant may feel uncomfortable revealing their income to an investigator; they may report a higher level of income to avoid judgment or decline to respond. A participant may also incorrectly assess their household's income if they are not the primary income earner or if the income fluctuates from sporadic employment. This is particularly so where unemployment and underemployment are high, such as in Arctic communities. There may also be substantial differences between income and wealth across settings with respect to what a participant's income allows them to purchase and what resources are available to them. Further, as an average, static measure, income does not capture events that may influence socioeconomic status, such as instability due to the loss of a household income earner, or the loss of property[17].

The Canadian Deprivation Index is a statistically validated measure of material deprivation that does not use income data. Of several SES indices used in research in Canada (Table 1), the CDI is the easiest to capture accurately and the most useful for health research in its description of inequality: it has the best agreement with self-reported health, uses indicators highly relevant to health research, and allows comparison at both individual and community levels[16]. Increased deprivation as measured by the CDI has been shown to have a dose-response relationship with the

frequency of health outcomes including chronic disease, self-reported pain, injury, and oral health[16]. All three of the CDI's component measures (food security, education, and home ownership) have high response rates across census and health research surveys[16]. Of these component measures, only food security data had not been collected in CAN*Help* community projects before this research project.

Table 1.1: Indicators of socioeconomic status (SES) used in Canadian health research[16]

Deprivation Index	**Indicators used**
Pampalon[18]	High school completion Employment Average personal income Marital status Living alone (Y/N) Lone-parent (Y/N)
SEFI-2 (Socioeconomic Factor Index 2)[19]	Average household income Lone-parent (Y/N) Employment High school completion
VANDIX (Vancouver Area Neighbourhood Deprivation Index)[20]	High school completion University completion Employment Lone-parent (Y/N) Income Home ownership
OnDep (Ontario Deprivation Index)[21]	Income Level of education completed Employment Citizenship Family structure Home ownership
CDI (Canadian Deprivation Index)[16]	Home ownership Level of education completed Severity of food insecurity

The government of Canada defines food security as a household's financial ability to access an adequate amount of high-quality, healthy food[22, 23]. Food insecurity has been disproportionately high among Indigenous Peoples of Canada for as long as food security has been monitored in Canada: one of the earliest estimates, collected in 1998 and reported in 2001, demonstrated that Indigenous Canadians had 1.5 [95% CI: 1.1, 2.1] times the odds of being food insecure compared to other Canadian-born ethnicities [17]. Canadian census reports show that the prevalence of food insecurity has increased steadily across Canada since 2001, particularly in northern communities[23]. According to the 2012 census (the most recent census to collect food security data from all provinces and territories), 28% of households classified as [*]"Aboriginal" reported some level of food insecurity, more than double the national average of 13%[23]. These values are likely to underestimate the food insecurity gap between Indigenous and non-Indigenous Canadians, given that food security data is not collected from on-reserve households - approximately half of Indigenous people in Canada - and on-reserve households have been shown to have a higher overall prevalence of household deprivation compared to off-reserve households[24]. In a 2011 survey conducted across 16 Northwest Territory Indigenous communities, more than

[*]Canadian Census data classifies First Nations, Metis and Inuit peoples as "Aboriginal." In recent consultation, CAN*Help* community project planning committees preferred "Indigenous" to "Aboriginal"; thus, this thesis uses "Indigenous" to refer to First Nations, Metis, or Inuit people except when quoting other sources (in which "Aboriginal" will appear in quotation marks).

90% of respondents reported reducing portion size, skipping meals, or remaining hungry after a meal because they could not afford enough food[25].

Other evidence has shown that households with children are more likely to be food insecure (16% of Canadian households with children in 2012); in 2012, 20% of children in Yukon and 32% of children in NWT lived in food insecure households[23]. Food insecurity affects unpartnered women with children disproportionately: in 2012, 34% of unpartnered women living with children or teenagers experience food insecurity, as well as 15% of unpartnered women living with their adult children[23]; in contrast, food insecurity prevalence among partnered adults not living with children was 6%[23]. Food insecurity is also associated with other, non-income indicators of socioeconomic status: in the 2012 census, 22% of renters in Canada reported food insecurity, compared to 6% of homeowners[26]. The Government of Canada defines severe food insecurity as frequently missing meals, reducing food intake, and/or going days without food, as reported by the head of household; as well, severe household food insecurity is the level at which children experience chronic hunger[26]. Nationwide, 2.6% of Canadians were severely food insecure in 2012[23]; in contrast, severe food insecurity affected 18.5% of Nunavut households, 4.4% of NWT households, and 3.7% YT households[23]. According to 2016 Canadian Census data, 86% of the population of Nunavut, 51% of the population of NWT, and 23% of Yukon are classified as Aboriginal[27].

Food insecurity is a complex public health concern. According to a 2001 report of national Canadian data, those living in food insecure households were over twice as likely to describe their health as "poor" or "fair" than those living in food secure households[17]. The severity of food insecurity has been reported to have a gradient effect on several mental health outcomes, including, but not limited to, depression, anxiety, and suicidal behavior[28]. Food insecurity also appears to be associated with development of chronic diseases such as diabetes and heart disease, as well as other adverse health outcomes: compared to Canadians living in food secure households, those living in food insecure households were more likely to report having at least three chronic health conditions after adjusting for age, sex, and household income[17].

Food insecurity is also emerging as a cause of chronic infectious diseases. Food insecurity is highly correlated with poor nutrition, and deficiencies in essential nutrients such as vitamins A, C and D, or zinc, copper, and selenium are known to compromise immunity and increase susceptibility to infectious diseases[17]. Compatible evidence suggests that food insecure households are burdened with greater exposure to infectious disease[29] and that food insecurity is associated with both reduced immune suppression and poor treatment adherence, especially for patients who must take medications with food[30]. Recent evidence revealed elevated levels of biomarkers for chronic inflammation among food insecure patients[29]. Thus, food security may

influence the onset, severity, and persistence of *H. pylori* infection. However, few reports in the literature present information on the relation of food security to *Hp* prevalence.

Objectives

My thesis research aims to address concerns voiced in participating CAN*Help* communities about the effect of socioeconomic deprivation on the prevalence and severity of *H. pylori* infection. Because previous analyses of CAN*Help* data have not investigated gender-based inequities, and because of the vulnerability to poverty of unpartnered women with children, my research will examine the frequency of *H. pylori* infection in women relative to men and in members of households led by unpartnered women relative to members of other households.

Specific Aims

These objectives have the following specific aims:

1) Conduct a systematic literature review to describe the relation of socioeconomic deprivation indicators to *H. pylori* infection

2) Conduct a literature review to describe methods used to quantify food security in the Arctic in prior research

   a. Describe methods used to quantify food security in the Arctic

3) Describe the food security status of community *H. pylori* project participants using collected data

a. Build a questionnaire that accurately classifies food security status in Arctic Canada

b. Compare the proportion of participant nonresponse between pilot questionnaire and full questionnaire to assess the potential for selection bias

4) Assess the validity of the CDI as a deprivation indicator for Arctic communities

5) Estimate the effect of socioeconomic deprivation indicators (food security, education, home ownership, household income, CDI) and relevant demographic variables (gender, gender stratified by partnership status, ethnicity, age, household includes children) on the prevalence of *H. pylori* infection

6) Assess whether gender or gender stratified by partnership status modifies the effect of socioeconomic deprivation indicators on the prevalence of *H. pylori* infection

a. Estimate stratum-specific effects of deprivation (measured by the CDI and other indicators) on the prevalence of *H. pylori* in: women and children; households led by unpartnered women

Thesis structure

The remainder of this thesis contains three papers and a final concluding chapter. Chapter 2, which contains a paper titled "A systematic review of the literature on the association between *Hp* infection and socioeconomic status, measured by various indices", summarizes the evidence of the effect of socioeconomic status on the disease burden of *Hp,* and comprehensively catalogues the indicators used to estimate this effect. Chapter 3, which contains a paper titled "Adapting the Canadian Household Food Security Survey Module for Arctic Canadian contexts", is a descriptive analysis of the development and results of a tablet-based questionnaire used to asses food security in eight community-driven projects in Arctic Canada. Chapter 4, which contains a paper titled "Social inequity, gender, and *H. pylori* infection in Arctic Canada", is a descriptive analysis of the effect of socioeconomic status on the disease burden from *Hp* infection in Arctic Canada.

Finally, the conclusion summarizes the results reported in all papers included in this thesis research.

Chapter 2: A systematic review of the literature on the association between *Helicobacter pylori* infection and socioeconomic status, measured by various indices.

Introduction

Helicobacter pylori (Hp) are spiral-shaped, gram-negative bacteria that colonize the protective lining of the stomach, nearly always causing gastritis (inflammation of the stomach)[1]. *Hp*-induced gastritis increases the risk of peptic ulcers, gastric atrophy, and stomach cancer.[2,3] Much evidence shows that *Hp* prevalence is inversely associated with socioeconomic status (SES), though not consistently across all indicators within geographically defined communities[5]. Broadly, geographic variation in *Hp* prevalence is associated with disparities in wealth; reported prevalence estimates range from 24% in Australia-New Zealand to 70% in Africa, with prevalence in Canada and the United States estimated at approximately 37%[6], though it should be noted that many available country-level estimates are limited by poor representativeness of screened population samples[7]. While recent evidence suggests prevalence is decreasing in affluent countries, prevalence remains high among disadvantaged groups[8].

Socioeconomic status, which can be viewed from the opposing perspectives of either affluence or deprivation, is a complex, multifactorial construct of social standing that is difficult to capture accurately. Various indicators and indices attempt to measure SES in health research. Of indicators used in *Hp* research, education is most

consistently associated with *Hp* prevalence; though it should be noted that the benefits of socioeconomic status offered by higher education may vary substantially by location and are constrained by job opportunities in an individual's field of study. Despite often being used in research, household income is not an optimal indicator of population inequity for several reasons. Ascertainment of income using questionnaires and interviews typically results in low response rates and frequent reporting error[16]. A research participant may feel uncomfortable revealing their income to an investigator; they may report a higher level of income to avoid judgment or decline to respond. A participant may also incorrectly assess their household's income if they are not the primary income earner or if the income fluctuates from sporadic employment. This is particularly so where unemployment and underemployment are high. There may also be substantial differences between income and wealth across settings with respect to what a participant's income allows them to purchase and what resources are available to them. Further, as an average, static measure, income does not capture events that may influence socioeconomic status, such as instability due to the loss of a household income earner, or the loss of property[17]. Rather than using a single indicator to define social deprivation, then, many health researchers opt to use a composite index of several demographic or household characteristics. Ideal indices are easily interpreted, provide good comparability over time, and are easy to collect with limited participant non-response[16]. However, there is no universally applicable deprivation index, nor are there consistent approaches to measuring SES in health research, and *Hp* research in

particular; this makes comparisons of results across studies challenging. This review aims to summarize indicators and indices used to quantify deprivation in *Hp* research, and to critically examine the relationship between these varying measures of social deprivation.

The specific aims of this literature review are:

1) To summarize measures used to quantify deprivation (SES, social class) in *Hp* research, and
2) To review the association between *Hp* infection and the reported social deprivation indices.

Methods

I conducted a systematic literature review guided by a comprehensive search strategy. I selected the primary health sciences database available through the University of Alberta online library, Medline, was selected to find articles indexed through 2019. I used Ovid's search form to conduct the review. The search terms I used for the literature review on Medline were:

1. exp *Helicobacter pylori*/

Which explodes into *Helicobacter pylori* and *Campylobacter pylori.*

2. exp Social Class/

Which explodes into *caste; castes; class population, middle; class populations, middle; class, social; classes, social; middle class population; middle class populations; population, middle class; populations, middle class; social class; social classes; socioeconomic status; status, socioeconomic.*

3. SES.mp

4. exp poverty/

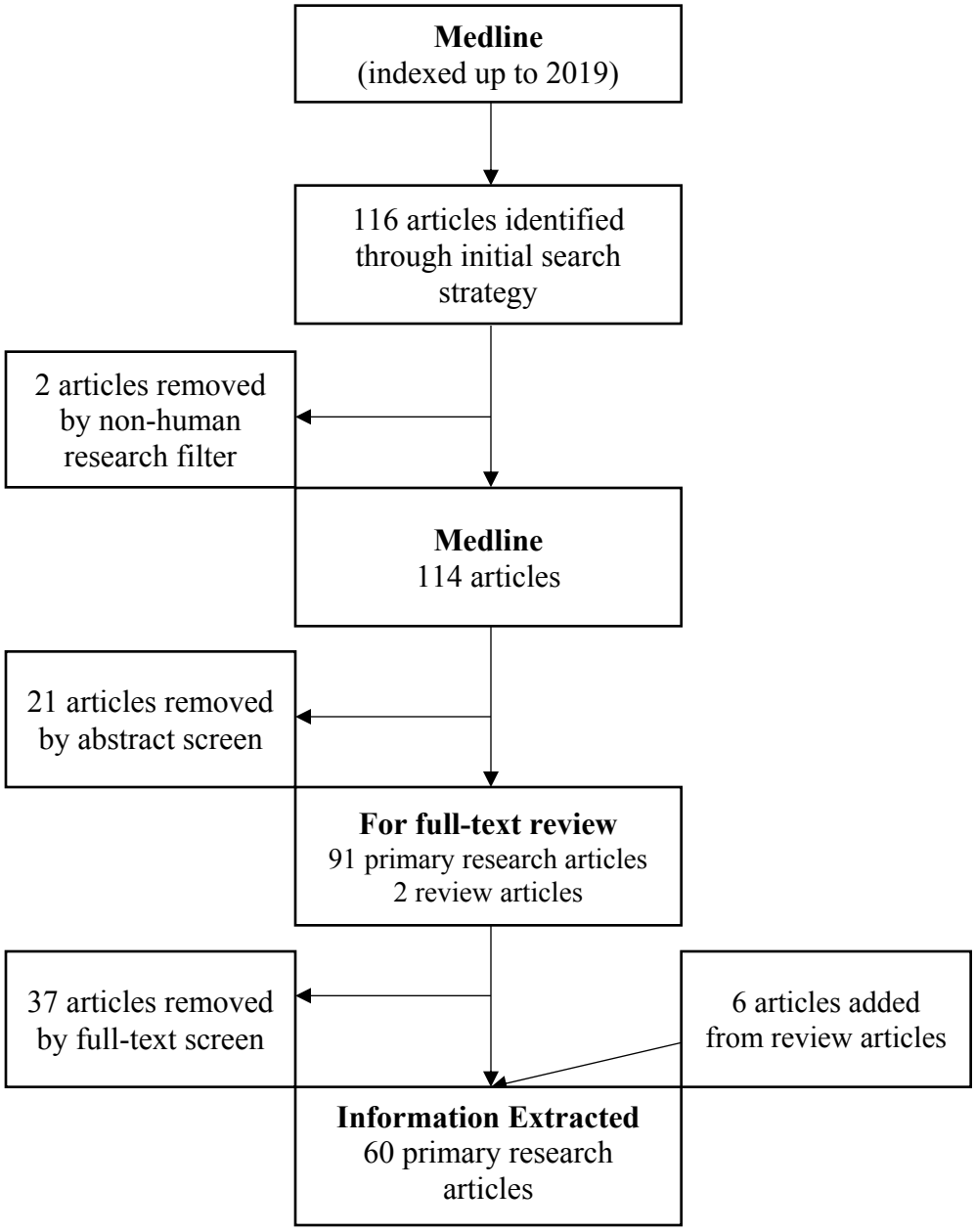
5. 2 OR 3 OR 4

6. 1 AND 5

I restricted my review to articles and review articles that were available in English online, and to studies conducted on humans using a validated search filter developed by a University of Alberta health sciences librarian. Search results were not restricted by year of publication. With the help of a CAN*Help* Working Group research assistant, I reviewed the title and abstract of all search results and selected articles that estimated the measure of association between *Hp* infection and social deprivation or, when measures of associations were not reported, provided sufficient data on the measure of occurrence of *Hp* infection stratified by social class so measures of association could be calculated. I added relevant articles identified by review articles in the search results. I then used full-text review to scrutinize articles; at this stage, I either extracted information, or excluded the article for one of the following reasons:

combining *Hp* infection with another outcome inextricably, not stratifying *Hp* infection by social class or SES indicators, insufficient data reported (i.e. no data), or irrelevance (in vivo laboratory studies, reporting on another outcome, et cetera). Information extracted from each article included: year of publication, location of study, study population and methods, *Hp* diagnostic test, SES Indicator(s), occurrence or effect measures reported, estimated measures of associations (if applicable) with 95% CIs, and adjustments for confounding. I did not include articles that were not accessible via the University of Alberta library, or otherwise available in open access journals. I compared the results of the search to published systematic reviews to ensure completeness, subsequently adding literature not captured in my review but identified in review articles. A research assistant duplicated data extraction to minimize errors; I corrected any discrepant data by a third review of the article. I organized extracted data in tables. In tables and text, I rounded proportions and ratios if needed to avoid exaggerating precision of estimates. I followed the Meta-analysis of Observational studies in Epidemiology (MOOSE) guidelines for the presentation of results and the discussion to the extent that they applied to my review[31].

Figure 2.1: Articles included and excluded for review



Results

Table 2.1: Location of studies included in literature review

Geographic Region	Location	Number of Studies
Africa	Egypt	1
	Ethiopia	1
	Libya	1
	Nigeria	1
	Tanzania	1
	Zambia	1
	Total	**6**
East Asia	Korea	1
	Taiwan	1
	Total	**2**
South Asia	India	3
	Israel	3
	Pakistan	1
	Saudia Arabia	2
	Total	**9**
West Asia	Lebanon	1
	Turkey	1
	Total	**2**
North America	United States	5
	Mexico	1
	Total	**6**
South America	Brazil	1
	Chile	2
	Peru	2
	Total	**5**
Eastern Europe	Poland	1
	Republic of Georgia	1
	Russia	1
	Total	**3**
Western and Central Europe	Great Britain (England, Scotland, Wales)	9 3

	Italy San Marino Northern Ireland Ireland Denmark Spain Czech Republic Netherlands **Total**	1 3 1 2 1 1 1 **22**
Oceania	Australia New Zealand **Total**	1 4 **5**

Geographic profile of the literature

Table 2.1 illustrates the geographic distribution of all 60 papers in the selected body of literature. Overall, the geographic regions of Western and Central Europe were greatly overrepresented in the body of literature, representing 37% of all selected primary research articles. Great Britain (England, Scotland and Wales) and the United States were the specific locations that were the most overrepresented; studies from Great Britain and the United States alone represented almost one quarter of all studies reviewed (23%). Africa, South America, West Asia and East Asia were largely underrepresented, and studies from China and Japan were entirely absent from the review.

Table 2.2: Population-based studies of *Hp* infection and deprivation.

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Klein et al (1991)[32]	Lima, Peru	407 children from four communities	C13 UBT	Place of residence divided into "low" and "high" income groups	Prevalence only	Calculated OR: 2.8	1.8, 4.2	No
Sitas et al (1991)[33]	Caerphilly, South Wales	749 male participants from two separate population-based heart disease studies	IgG Serology	Registrar-General's Classification (UK)	Prevalence only	Calculated ORs: I and II: Referent III Manual and Non: 1.5 IV and V: 1.9	 1.0, 2.2 1.2, 3.0	No
Palli et al (1993)[34]	Italy	930 adults randomly sampled from the general population	IgG Serology	Not Reported	Odds Ratio	Social Class OR Low: Referent Medium: 0.9 High: 0.8	 0.6-1.2 0.5-1.2	Yes; gender, age, migration from south, residence, gastric cancer risk by area, gastric cancer family history
Hopkins et al (1993)[35]	Santiago and Punta Arenas, Chile	1815 participants younger than 36 years, randomly recruited from three areas of varying SES	IgG Serology	Place of residence divided into "low" and "high" SES groups	Adjusted OR	Adjusted OR: 1.7 Calculated Crude OR: 1.3	1.3-2.1 1.1-1.6	For all variables collected (Age, vegetable consumption, region, sex, shellfish consumption, swimming near contaminated beaches, and bathing in local rivers, lakes and irrigation ditches)

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Webb et al (1994)[36]	Stoke on Trent, England	471 male workers from three factories	IgG Serology	Registrar-General's Classification (UK), dichotomized into "manual" or "non-manual"	Adjusted OR	Calculated Crude ORs (Nonmanual referent) Occpuation: 2.4 Father's occupation: 2.6 AOR: Occupation: 2.5 Father's occupation: 2.7	 1.3, 4.5 1.2, 5.6 1.3, 4.7 1.2, 5.7	Yes; age
Malaty & Graham (1994)[37]	Houston metropolitan area, Texas, United States	150 Black and Hispanic volunteers between the ages of 19 and 49	IgG Serology	Modified Hollingshead Index	Odds Ratio; incorrect as reported?	Childhood social class (Higher the number, higher the class): IV and V : Referent II and III: 8.9 I: 55 Present social class: OR IV and V Referent II and III: 2.2 Example recalculation: Class I, recalculated: 59	 7.3-10.5 53-56 1.5-2.9 11-318	No
Gasbarrini et al (1995)[38]	San Marino	2237 adults randomly sampled from nine districts	IgG Serology	Occupation	Prevalence only	Calculated ORs: Nonmanual: Referent Manual: 2.4	 1.9, 3.0	No

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Murray et al (1995)[39]	Northern Ireland	1182 men and 1192 women randomly selected from general practitioner's lists	IgG Serology	Registrar-General's Classification (UK), dichotomized into "manual" or "non-manual"	Prevalence only, excluded in logistic regression analysis	Not enough data to calculate.	N/A	N/A
Rosenstock (1996)[40]	Copenhagen, Denmark	3589 adults sampled from the National Danish Civil Registration System	IgG, IgM Serology Only reported IgG	Highest educational and occupational attainment in household	Odds Ratio	High SES: Referent Moderate-High: 1.1 Low-Moderate: 1.3 Low: 2.2	0.9, 1.3 1.1, 1.6 1.7, 2.9	Yes; age, social status, marital status, geographical residency, educational level, vocational training/education, occupation, work-related energy expenditure
Fawcett et al (1996)[41]	Dunedin, New Zealand	785 21-year-old participants from the Dunedin Multidisciplinary Health and Development Study Cohort	IgG Serology	Elley-Irving Scale	Reported statistically significant differences in exposures between Hp+ and Hp- participants, reported differences in SES distribution at age 5.	Not enough data to calculate.	N/A	No
Fraser et al (1996)[42]	New Zealand	5677 participants aged 40-64 years sampled from "worksites" in New Zeland	IgG Serology	Elley-Irving Scale based on occupation	Reported as Relative Risk	SES RR unadjusted ; RR Adjusted (95% CI) **1&2 (high)** 1.0 ; 1.0 **3** 1.4 (1.0, 1.8); 1.2 (0.85, 1.6) **4** 1.80 (1.4, 2.3); 1.3 (0.99, 1.6) **5&6 (low)** 1.8 (1.4, 2.4); 1.2 (0.87, 1.6) Income **1 (low)** 1.4 (1.0, 1.8); 0.82 (0.63, 1.1)		Yes, age and ethnicity

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
						2 1.4 (1.1, 1.7); 0.99 (0.81, 1.2) **3** 1.3 (1.0, 1.6); 1.1 (0.90, 1.3) **4 (high)** 1.0 ; 1.0		
Murray, McCrum, Evans, Bamfort (1997)[43]	Northern Ireland	4742 randomly selected subjects from Northern Ireland	IgG Serology	Registrar-General's Classification (UK), Home ownership	Odds Ratio comparing lowest social class to highest	Manual compared to non-manual: 1.7 Lowest social class compared to highest: 2.8	1.5-2.0 1.8-4.4	Yes, age and sex
McDonagh et al (1997)[44]	North Glasgow, Scotland	Random sample of 1428 men and women between the ages of 25 and 74.	IgG Serology	Registrar-General's Classification (UK)	Prevalence only, stratified by sex	Calculated OR: I: Referrent II: 2.2 III nonmanual: 3.5 III manual: 7.1 IV: 6.4 V: 7.4 Unclassified: 7.6	 1.1, 4.4 1.9, 6.9 3.7, 14 3.2, 13 3.7, 15 3.7, 15	Yes, age and sex
Buckley et al (1998)[45]	Dublin, Ireland	1000 donors for a blood transfusion service	IgG Serology	Registrar-General's Classification (UK)	Prevalence only	Calculated OR: Social Class I and II: Referent Social Class III: 1.4 Social Class IV and V: 1.7	 1.0, 1.8 1.2, 2.4	No

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Strachan et al (1998)[46]	Caerphilly, South Wales	1796 men enrolled in Heart Disease study	IgG Serology	Registrar-General's Classification (UK)	Prevalence only	Calculated OR: Social Class: I and II: Referent IInM: 1.2 IIIM: 1.7 IV and V: 2.1 Father's Social Class: I and II: Referent IInm: 0.8 IIm: 1.4 IV and V: 1.5	 0.86, 1.8 1.3, 2.2 1.5, 3.0 0.4, 1.5 0.96, 2.1 0.9, 2.4	No
Lin et al (1998)[47]	Melbourne, Australia	250 randomly selected from a pool of "Anglo-Celtic names" from a telephone directory	IgG Serology	Various (Income divided into 5 categories; Education in years divided into four categories; Occupation (retired, domestic service, manual, clerical, professional))	Prevalence & "Relative Risk", Adjusted OR	Adjusted OR, reported for multivariate model: Sex 2.4 Household income 1.5 Education levels 1.2 Occupation 0.99	1.3, 4.5 1.1-2.4 0.9-1.7 0.9-1.1	Yes, mutual adjustment and adjustment for age, smoking habit, alcohol consumption, family size, and NSAID use.

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Torres et al (1998)[48]	Mexico	Seroprevalence of 11,605 sera samples from the National Serum Bank	IgG Serology	Composite index of person per room, type of floor material, availibility of municipal water and waste disposal, years of education of the head of family	Adjusted OR	Adjusted OR: SES: High: Referent Middle: 1.3 Low: 1.4	1.1-1.4 1.3-1.6	Yes, Mutually adjusted for gender, crowding, education, economic development, and region.
Souto et al (1998)[49]	Nossa Senhora de Livramento, Brazil	204 randomly selected participants	IgG Serology	Income	OR without CI	In USD: <1200: Referent 1201-2400: 0.5 2401-3600: 0.3 3601-4800: 0.2 4801-6000: 0.6 >6000 USD: 0.1	Calculated CIs: 0.09, 2.2 0.5, 1.4 0.04, 1.6 OR is undefined 0.1, 0.62	No
Stone et al (1998)[50]	Leicester, England	111 asian participants	C13 UBT	Occupation (manual, non-manual)	Prevalence of exposure to manual class in *Hp*+ and *Hp*-	Calculated OR for Hp infection: Nonmanual: Referent Manual: 4.0	1.3, 12	No
Dominici et al (1999)[51]	Campogallian o, Italy	550 children from 416 families, representing about 66% of the population	IgG Serology	Father's occupation	Adjusted OR	OR: White collar father: Referent Blue collar and farmer father: 2.0	1.2, 3.5	Yes, adjusted for children's age, sex, and family social environment

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Bakka and Salih (2002)[52]	Libya	360 asymptomatic subjects apparently randomly selected from the population (reported to be sampled from "a group of blood donors, nursery homes, housewives, nurses, labor workers, and school children").	IgG Serology	Not reported	Prevalence only	Calculated ORs: Low SES : Referent Middle: 0.11 High: 0.13	 0.6, 0.19 0.02, 0.63	No
McLaughlin, McLaughlin, Lefcort (2003)[53]	Zimba, Zambia	87 students	IgG Serology	Parent's occupation OR boarding school attendance	No data reported; only "no statistical correlation"	Not enough data to calculate.	N/A	N/A
Fawcett et al (2005)[54]	Dunedin, New Zealand	882 participants in a birth cohort; testing seroprevalence at age 26	IgG Serology	Elley-Irving Scale at age 5	Prevalence only	High and Low SES had the same prevalence. (6.3 or 6.4%)	N/A	N/A

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Tsai, Perry, Sanchez, Parsonnet (2005)[55]	San Francisco, USA	Prevalence study nested in a cohort study; 1537 participants from the Stanford Infection and Familial Transmission (SIFT) study	Serology (antibody not specified) for adults, stool assay for children under 2	Various (people in household, highest education of household, combined household income)	Age-adjusted OR, Mutually adjusted OR	People in household More than six 1.4 (0.99, 2.1) Six or less: Referent Highest education in household No HS graduate 1.8 (1.3, 2.7) At least one HS graduate: Referent Combined household income <30,000 1.5 (0.86, 2.7) >=30,000: Referent Mutually adjusted OR, 95% CI: People in household More than six 1.2 (0.84, 1.8) Six or less: Referent Highest education in household No HS graduate 1.8 (1.2, 2.6) At least one HS graduate Referent		Yes, adjusted for age; then adjusted for ethnicity, immigration status, immigration generation, age, Hp positive parent, and sex
Pearce, Thomas, Campbell, and Parker (2005)[56]	Newcastle upon Tyne, England	Seroprevalence of 407 50-year-old adults recruited from a birth cohort in 1947	IgG Serology	Father's occupation	Odds ratios (mistakenly reversed with CIs in paper)	Social class a birth OR* 95% CI I, II 0.4 III 1.0 Referent IV, V 1.8	 0.2-0.9 1.1-2.9	No

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Bures et al (2006)[57]	Czech Republic	2509 people randomly selected from the general population	C13 UBT	Self-reported group	OR adjusted for age and sex, ORs adjusted age, sex, antibiotic treatment; ORs adjusted for all variables collected	ORs Adjusted for Age and Sex: Social Class Lower 1.7 Middle 1.5 Higher Referent Unknown 1.3	 1.0, 2.7 0.99, 2.3 0.7, 2.4	*See notes
Garcia, Diz, Benavides and Seara (2006)[58]	Ourense, Spain	383 participants randomly selected from the general population	Not reported	Profession; subject's, head of family's in childhood, and current head of family's.	Odds Ratios	Subject's Profession Univariate OR (95% CI) White Collar Referent Blue Collar 1.4 (0.93-2.5) Head of Family in Childhood's Profession Univariate OR White Collar Referent Blue Collar 1.41 (0.91-2.1) Current Head Of Family's Profession Univariate OR White Collar Referent Blue Collar 2.1 (1.2-3.9)		No

* The ORs adjusted for age, sex and antibiotic (abx) treatment are not meaningfully different from the ORs adjusted for age and sex and are not reported here. The ORs adjusted for all variables collected (age, sex, abx tx, residence, education, marital status, smoking in one category of adjustment; and then adjust for age, sex, abx tx, residence, education, marital status, smoking, place of residence in childhood, mother's education, father's education, running warm water, crowding, and number of siblings) are very likely to be overadjusted and are also not reported here.

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Naous et al (2007)[59]	Lebanon	414 children from "several schools"	Stool antigen test	"SES standard" of school enrolled in	Prevalence only	Calculated OR: Middle to High SES: Referent Poor SES: 9.8	5.1, 19	No
Mohammad et al (2008)[60]	Cairo, Giza and Sohag; Egypt	Cross-sectional study of 286 schoolchildren	C13 UBT	Composite index of education and occupational levels of both parents	"Relative Risk" (Prevalence ratio); prevalence in unlabelled histogram	low SES relative to High: 2.6, Moderate SES relative to High: 2.0	Not reported, not enough data to calculate	No
Dowd, Zajacova, Aiello (2009)[61]	United States	4342 participants in the NHANES III cross-sectional study, with a higher proportion of black and Hispanic participants relative to the general population; 1962 of which had *Hp* data	IgG Serology	Years of education of the "household reference person" and annual family income.	Logistic regression coefficients	Calculated ORs: 1 unit increase in the log transformation of income in USD: 0.86 1 year increase in education: 0.92	0.78, 0.95 0.87, 0.97	Yes; age, sex (male as referent), race (non-Hispanic white is referent), household size.

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Jafri et al (2010)[62]	Karachi, Pakistan	1976 children cluster sampled in Karachi	IgG Serology	Hollingshead Index	Crude & Adjusted Odds Ratio	Crude: Upper SES: Referent Middle SES: 1.7 Low SES: 1.5 Adjusted: Upper SES: Referent Middle 1.5 Lower 1.6	 1.2,1.9 1.6, 2.5 1.1, 2.1 1.2, 2.1	Yes, adjusted for age, father's education and mother's education
Faleh et al (2010)[63]	Aseer, Madinah, and Al-Qaseem; Saudi Arabia	1200 students between the ages of 16 to 18	IgG Serology	Composite index on a point scale from 1 to 21, with housing on a scale of 3 points, the education of the parents on a scale of 6 points, the occupation of parents on a scale of 6 points, the number of family members on a scale of 3 points, the number of rooms in the house on a scale of 3 points	Odds Ratios only	Aseer: Lower class: Referent Lower Middle: 1.4 Upper middle: 1.1 Upper: 2.0 Madinah: Lower class: Referent Lower Middle: 0.80 Upper middle: 1.43 Upper: 0.8 Al-Quaseem: Lower class: Referent Lower Middle: 2.3 Upper middle: 1.5 Upper: 1.1	 0.7-2.7 0.48, 2.6 0.83, 4.8 0.46, 1.4 0.68, 3.0 0.32, 1.8 0.57, 9.6 0.31, 7.7 0.19, 6.5	No. As well, did not combine the three regions; not enough data provided to calculate combined ORs and CIs

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
den Hollander et al (2013)[64]	Rotterdam, The Netherlands	Prevalence of 6837 pregnant women participating in a population-based prospective cohort study	IgG Serology and Cag-A antibodies	Income	Odds Ratio	<1200 Euro: 5.2 1200-2000 Euro: 2.5 >2000 Euro: Referent	4.5-6.0 2.2–2.9	No
Laszewicz et al (2014)[65]	Poland	7127 children and adults sampled from the general population	IgG Serology	Family income, welfare status	OR	Children Income: 1st (lowest) tax level: 1.5 Other tax levels: Referent Welfare status of family: On welfare: 1.7 Not: Referent Adults: 1st (lowest) tax level: 1.5 Other tax levels: Referent Welfare status of family: On welfare: 0.79 Not: Referent	1.0-2.3 1.4-2.1 1.1-2.2 0.5-1.2	No
Nguyen et al (2015)[66]	United States	1200 black and Hispanic American Veterans selected from a Veteran Affairs Centre, either scheduled for elective endoscopy or screened from a primary care clinic.	Culture or histopathology	Household income	Prevalence only	Calculated ORs: <25,000: 1.6 25000-50000: 1.3 >50,000: Referent	1.2, 2.3 0.89, 1.9	No

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Al-Hussaini et al (2019)[67]	Riyadh city, Saudi Arabia	3551 children randomly sampled from 104 schools	IgG and IgA Serology combined	Composite index of parents' educational level, family income, habitation, and parents' jobs	OR of SES category against all other participants; recalculated to have reference categories	Low SES: 2.0 Lower middle SES: 1.5 Higher middle SES: Referent Higher SES: 0.81	1.6, 2.6 1.3, 1.8 0.62, 1.0	No
Suki et al (2018)[68]	Israel	235,107 adult patients in a Health Services Network	C13 UBT	Pre-determined, undisclosed SES index extracted from Health Services database	Prevalence only	Calculated ORs: Low SES: 2.2 Medium SES: 1.6 High SES: Referent	2.2, 2.3 1.6, 1.6	No

Table 2.3: Hospital-based prevalence studies of *Hp* and deprivation.

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Mendall et al (1992)[69]	London, England	215 patients over the age of 8 recruited out of a general practice health-screening clinic	IgG Serology	Registrar-General's Classification (UK)	Odds Ratio	Higher the number, lower the social class: I and II: Referent III nonmanual: 0.74 III manual: 2.2 IV and V: 0.61	 0.25-2.1 0.85-5.5 0.22-1.7	Yes; age, sex, children in household, hot water in childhood, crowding.
Malaty, Kim, Kim and Graham (1996)[70]	Korea	413 healthy, asymptomatic volunteers who visited Guro Hospital	IgG Serology	Hollingshead Index	Odds Ratios; incorrect as reported.	**Reported:** Adults: High social class: Referent Middle: 1.0 Low: 1.7 Children: High: Referent Middle: 2.5 Low: 5.2 **Recalculated ORs** Adults High: Referent Middle: 0.96 Low: 1.7 Children High: Referent Middle: 2.5 Low: 5.2 Total: High Class: Referent Middle Class: 1.1 Low Class: 1.8	 1.0-2.2 1.8-18 1.1-5.5 1.5-17 0.44, 2.0 0.51, 5.9 1.1, 5.6 1.5, 17 0.63, 2.0 0.76, 4.3	No

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Malaty et al (1996)[71]	St. Petersburg, Russia	520 Asymptomatic participants recruited from two hospitals	IgG Serology	Various (Mother's education, father's education, income, type of dwelling, rooms in home, crowding)	Odds Ratio; some reported CIs are incorrect.	OR (95% CI) Education University Graduate Referent Technical School 0.9 (0.6-1.1) 8-10 years 0.8 (0.5-1.4) Income Above poverty level Below poverty level 0.3 (0.2-0.8) Dwelling Private Apartment Referent Dormitory 1.1 (0.1-1.4) Orphanage 0.8 (0.3-1.8) Rooms in Home >2 rooms Referent 1 or 2 0.9 (0.2-1.8) Crowing Index Low Referent Moderate 0.7 (0.6-2.2) High 1.4 (1.1-4.5) Mother's education University Referent Technical school 1.4 (1.3-2.5) 8-10 classes 1.8 (1.0-3.2) Father's education University Referent Technical school 1.0 (0.7-1.9) 8-10 classes 1.2 (1.3-4.4) Income Above poverty level Referent Below poverty level 1.4 (1.2-2.5) Dwelling Private Apartment Referent		Yes, age

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
						Dormitory 1.3 (0.7-1.9) Orphanage 2.1 (1.3-4.4) communal apartment Rooms in Home >2 rooms Referent 1 or 2 1.2 (1.0-1.9) Crowing Index Low Referent Moderate 1.0 (0.8-1.5) High 2.1 (1.2-2.5) From Table 3: Age-adjusted ORs for Hp infection among Adults: Education University Graduate Referent Technical School 0.9 (0.6-1.1) 8-10 years 0.8 (0.5-1.4) Income Above poverty level Referent Below poverty level 0.3 (0.2-0.8) Missing Dwelling Private Apartment Referent Dormitory 1.1 (0.1-1.4) Orphanage 0.8 (0.3-1.8) Rooms in Home >2 rooms Referent 1 or 2 0.9 (0.2-1.8) Missing Crowing Index Low Referent Moderate 0.7 (0.6-2.2) High 1.4 (1.1-4.5)		

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
McCallion et al (1996)[72]	Not reported; apparently Northern Ireland	485 children attending the Royal Belfast Hospital for Sick Children	IgG Serology	Registrar-General's Classification (UK), dichotomized into "manual" or "non-manual"	Odds Ratio	Crude OR: 2.0 Adjusted OR: 1.6	1.3, 3.3 0.97, 2.6	Yes; age, bedsharing, and household density.
Cilla et al (1997)[73]	Gipuzkoa, Spain	1147 patients chosen from admissions for traumatology or elective surgery	Serology (antibody not specified)	Highest educational attainment; small sub-analysis of place of residence of children	Prevalence only	Calculated OR: Advanced studies: Referent HS or Professional training: 2.1 Less than HS: 3.6 Slum-dwelling children: Referent Middle class children: 5.1	 1.4, 3.2 2.5, 5.2 3.0, 8.4	No
Guiraldes et al (2001)[74]	Chile	79 children referred for upper endoscopy	Histopathology	Graffar Index	Prevalence only	Calculated ORs: 1 and 2 (Highest): Referent 3: 1.9 4 and 5: 7.5	 0.45, 7.7 1.7, 33	No
Moayyedi et al (2002)[75]	Leeds and Brafford, England	8429 invited from general practitioner's lists	C13 UBT	Registrar-General's Classification (UK)	Crude ORs and Adjusted ORs	<u>Crude OR (95% CI)</u> Social class aged 8 years I or II 1.0 - III 1.74 (1.5-2.0) IV or V 2.5 (2.0-3.0) Present social class I or II 1.0 - III 1.46 (1.3-1.6) IV or V 2.17 (1.8-2.6)		Yes, mutually adjusted for all variables

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
						Adjusted OR (95% CI) Social class aged 8 years I or II 1.0 - III 1.18 (1.0-1.4) IV or V 1.31 (1.1-1.6) Present social class I or II 1.0 - III 0.96 (0.84-1.1) IV or V 1.1 (0.94-1.4)		in *analysis
Chong et al (2003)[76]	United States	992 Children referred from 12 children's hospitals	IgG Serology	Various (Income, father's education, mother's education, father's occupation, mother's occupation)	"Rate" (Prevalence ratio, referred to as Relative Risk in body of paper)	SES Indicator Prevalence Ratio (CI) Income <36000 2.9 (1.7-4.7) >=36000: Referent Father's education <=12 years 1.9 (1.2-3.1) >12 years: Referent Mother's Education <=12 years 2.1 (1.3-3.2) >12 years: Referent Father's occupation Unemployed or manual 2.3 (1.5-3.5) Other: Referent Mother's occupation Unemployed or manual 2. 7 (1.7-4.2) Other: Referent No GI Referral SES Indicator Prevalence Ratio (CI) Income <36000 1.8 (1.0-3.1) >=36000 Referent Father's education		No

* (country of birth, ethnic origin, age, housing, crowding at age 8, bathroom access at age 8, shared bedroom as child, shared bed as child, shared bed with parent, no siblings, education, present housing, present crowding, central heating, telephone ownership, car ownership, partner's SES, smoking, alcohol consumption, coffee consumption)

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
						<=12 years 1.5 (0.92-2.5) >12 years Referent Mother's Education <=12 years 1.6 (1.1-2.5) >12 years Referent Father's occupation Unemployed or manual 1.4 (0.91 -2.2) Other Mother's occupation Unemployed or manual 1.4 (0.89-2.1) Other		
Ahmed et al (2007)[77]	Hyderabad, India	500 adults who visited hospital with GI symptoms	PCR Amplification	Modified Hollingshead Index	Odds Ratios	Socioeconomic Status OR Upper Referent Lower 2.9	1.7-5.0	No
Farag, Stoltzfus, Khalfan, Tielsch (2007)[78]	Zanzibar, Tanzania	857 pregnant women attending antenatal care clinics	C13 UBT	Various (household latrine, household books other than the Koran, household motorcycle, household bicycle, Husband prestigious job, Costly Household Lighting, Roofing); chose Household Lighting as indicator of interest	Odds ratio, adjusted OR	Crude OR of 2.4 location-adjusted OR 1.6	1.5-3.3 1.1-2.4	First adjusted all proposed SES indicators for Costly Household Lighting and found effect on Hp infection was nullified; then adjusted the effect of Costly Household Lighting for location.
Suoglu et al (2007)[79]	Istanbul, Turkey	70 patients presenting for upper GI endoscopy	Histo-pathology	Hollingshead Index	Odds Ratios	High SES: Referent Low SES: 6.1	1.9, 20	No

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Muhsen et al (2011)[80]	Israel	1623 children who presented for medical attention where their blood was drawn at Israel hospitals between 1997 and 2007	IgG Serology	Israel Central Bureau of Statistics Composite Index	Adjusted OR	High SES: Referent Intermediate SES: 1.8 Low SES: 2.5	 1.2, 2.7 1.7, 3.6	Yes, adjusted for age, ethnicity and sex
Tarkhashvili et al (2012)[81]	Republic of Georgia	217 participants presenting for upper endoscopy	Histo-pathology, Rapid Urease Test, IgG Serology	Income, Crowding	Odds Ratios	Income <=600 GEL: 1.1 >600 GEL Referent Crowding (>1.5 people/room) Yes 0.9 No - Referent	 0.7-1.8 0.6-1.5	No
Chen et al (2014)[82]	Lanyu Island, Taiwan	796 participants sampled from outpatient clinics	C13 UBT	Income	Prevalence only	Calculated OR: 1.7	1.1, 2.7	No
Sebanjo, Oshikoya, Njokanma (2014)[83]	Ikeja, Nigeria	118 children recruited from an outpatient clinic	IgG Serology	Composite index of education, occupation and income of children's parents	OR	3.2	1.2, 8.7	No
Dutta et al (2017)[84]	Vellore, India	1000 patients with dyspepsia	RUT	Kuppuswamy Index	Prevalence only	Calculated ORs: Low SES: 0.95 Middle or High SES: Referent	 0.74, 1.2	No

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted
Sherifaw & Abera (2019)[85]	Addis Ababa, Ethiopia	487 patients recruited from a private clinic	Stool antigen test	Income	Crude & Adjusted Odds Ratio	Crude: 1000-1500: 7.2 2000-2500: 9.4 3000-3500: 2.3 >4000: Referent Adjusted: 1000-1500: 4.3 2000-2500: 6.0 3000-3500: 2.2 >4000: Referent	 1.9, 26 2.6, 34 0.87-6.3 1.1, 17 1.6, 23 0.82, 6.0	Yes; adjustments not disclosed

Table 2.4: Cohort studies of *Hp* and deprivation

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted?
Fawcet et al 1998[86]	Dunedin, New Zealand	1000 participants in a birth cohort	IgG Serology	Elley-Irving Scale	Seropositivity at age 11 and 21	**Calculated Risk Ratio:** Seroprevalence at age 11 High SES: Referent Low SES: 1.3 Seroprevalence at age 21 (all) High SES: Referent Low SES: 2.5 Seroprevalence at age 21 given being seronegative at age 11 High SES: Referent Low SES: 4.0 **Calculated Incidence Rate Difference** between High SES and Low SES: 0.00157/py or 1.5 cases per 1000 person years **Calculated Incidence Rate Ratio** from cases seronegative at age 11: High SES: Referent Low SES: 4.0	 0.63, 2.5 0.91, 6.9 0.4, 197 -0.001, 0.003 -1, 3 0.39, 195	No

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted?
Muhsen, Jurban, Goren and Cohen (2012)[87]	Israel	231 infants identified in a birth cohort	Stool antigen test	*Various	Incidence proportion, Crude & Adjusted Odds Ratio	IP: 33% Adjusted OR: Father's education: >=10 years: Referent 0-9 years: 3.4 High SES Village: Referent Low SES Village: 9.6	 1.2, 9.3 2.9, 32	Yes, adjusted for father's education, mother's education, village of residence, household crowding index, attending day care center and antibiotic use
Jaganath et al 2014[88]	Lima, Peru	183 Hp+ children from a birth cohort of 187; as only 4 children were Hp-, they were removed from analysis	C13 UBT	† Principle component analysis of multiple household variables.	HR	1.6	1.2, 2.2	Yes; Adjusting for sex, breast-feeding, height-for-age Z score, days of diarrhea, and days on antibiotics

* Income, father's education, mother's education, income, place of residence divided into "low" and "high" SES groups. Place of residence and Father's education were selected as SES indicators of interest.

† Number of rooms in the home, number of rooms used as bedrooms, number of persons that sleep in the same bedroom, source of water, location of latrine, ownership of a refrigerator, radio, black/white tv, color tv, dvd/chs player, stereo, telephone, and animals for breeding or pets; modified using guidelines from the DHS wealth index.

Table 2.5: Case-control studies of *Hp* and deprivation

Authors & Publication year	Location	Population	Diagnostic test	SES Indicator(s)	Measures Reported	Estimated Associations	95% CI	MoA Adjusted?
Whincup et al (1996)[89]	24 towns from Great Britain, UK	Case-control study of 135 cases of myocardial infarction, 137 cases of stroke, and 136 controls	IgG Serology	Registrar-General's Classification (UK), dichotomized into "manual" or "non-manual"	Prevalence only	2.4	1.2, 4.8	No
Mhaskar et al. (2013)[90]	Maharashtra State, India	Case-control of 190 peptic ulcer patients, 35 stomach cancer patients, and 125 controls selected from a hospital in Maharashtra State	Stool antigen test	Car ownership	OR	Does not own a car: 1.10 Owns car: Referent	1.0–1.4	Yes; consumption of filtered water, smoking, chili pepper consumption, meat consumption, outdoor food consumption, parasite infestation.
Dore et all (2000)[91]	Sassari, Italy	891 Type 1 & Type 2 diabetics and controls selected from an outpatient clinic	IgG Serology	Occupation and education, apparently Hollingshead Index	Prevalence only	Calculated ORs: Social Group IV (Lowest): Referent III: 0.75 II: 0.61 I (Highest, not many in category): 0.38	 0.51, 1.1 0.41,0.90 0.13, 1.1	No

Methodology

Population-based cross-sectional (prevalence) or cohort-nested prevalence studies made up most of the selected articles with 37 of the 60 papers (62%). Clinic-based studies accounted for 33% of the 60 articles: 17 (28%) used cross-sectional designs and 3 (5%) used case-control designs. There were 3 (5%) true cohort studies.

Ascertainment of Hp infection

Ascertainment methods of *Hp* infection in the selected body of literature

The majority of studies (40/60, 66%) ascertained *Hp* infection using IgG Serology (rarely, IgA, IgM, or Cag-A antibodies were ascertained concurrently) or did not specify the type of antibodies used for serological analysis; in these cases, it is likely that IgG was used, as it is the standard in *Hp* serology research. Evidence indicates that only the *Hp* IgG antibody isotype, and no other immunoglobulin class, validly classifies antibody status for chronic *Hp* infection[3]. Less common *Hp* ascertainment methods in the body of literature included: Urea Breath test (UBT) (nine studies); Stool Antigen Test (SAT) (five studies); Rapid Urease Test (RUT) (Dutta et al 2017)[84]; and PCR Amplification (Ahmed at al 2007)[77]. Almost all studies used just one ascertainment method (Tsai et al 2005[55] used SAT for children under two; Tarkhashvili et al 2012[81] used histopathology, rapid urease test and IgG serology; Nguyen et al 2015[66] used a positive result from either culture or histopathology). One study (Garcia et al 2006)[58] did not report the ascertainment method.

Ascertainment of SES

Validated Indices

Of the validated indices used in the body of literature, two of them- the Registrar General's Classification of Social Class[92] and the Elley-Irving Index[93]- are exclusively occupation-based measures of social status. The Hollingshead index[94] is a composite and continuous index that measures deprivation according to occupation and highest educational attainment. The Israel Central Bureau of Statistics Composite Index selects appropriate indicators according to population and year of measurement[95]. The Kuppuswamy Socioeconomic Scale[96] measures socioeconomic status using education, occupation, income.

Registrar-General's Classification of Social Class (1911)

The majority of the studies- generally those from Europe, which represented a large portion of the included articles- used the Registrar General's Classification of Social Class (12/60, 20%), or some variation thereof, an index that measures SES by occupation. The Registrar-General's Classification of Social Class was first used in 1911 for use in fertility and mortality research[92]; it ranks occupation by social prestige as follows:

I - Professional, etc occupations
II - Managerial and technical occupations
III - Skilled occupations
    N Non manual
    M Manual
IV - Party Skilled occupations
V - Unskilled occupations

Graffar Index (1957)

One English-language paper (Guiraldes et al 2001)[74] used the Graffar Index, an ordinal composite index in which the original publication is unavailable in English. The authors of this paper separated participants into five social classes of increasing levels of deprivation. Unfortunately, the translation of this paper is vague and does not allow for meaningful interpretation of the stratifications of social class; separating participants into "lower middle class," "working class", "middle-high class," "marginal class," and "high class" without listing the Graffar score criteria or making the order of deprivation clear. Alternate primary research articles sourcing the index are either not available in English or offer conflicting or non-primary information regarding how the Index is ascertained. It is therefore difficult to further investigate the strengths and limitations of the Graffar Index.

The Elley-Irving Index (1972)

Four of the included articles used the Elley-Irving Index. The Elley-Irving Index is a measure of socioeconomic status developed for use in New Zealand; it classifies male

workers into six categories weighted by education and income[97]. A separate, less widely adopted female labor scale was developed in 1977[98]. These indices have since been replaced in their native country by various revisions, named the "New Zealand Socioeconomic Index" (NZSEI)[99], a simultaneously continuous (from most deprived to least deprived on a continuous scale from 10 to 90) and categorical (by occupation class) scale revised most recently as the NZSEI-13 in 2013[99]. However, use of the outdated Elley-Irving index persists in research despite this modern alternative; no papers in the body of literature reported use of the NZSEI, but instead adapted the Elley-Irving Index in various ways.

The Elley-Irving Index classifies socioeconomic status as follows[93]:

EI Level I – Professional Occupations
EI Level II – Managerial Occupations
EI Level III – Clerical or technical occupations
EI Level IV – Skilled trade occupations
EI Level V – Semi-skilled occupations
EI Level VI – Unskilled occupations

The Hollingshead Index (1975)

Seven of the included articles used the Hollingshead Index. The Hollingshead Index is a composite index developed in 1975 for use in United States research, which scores the participating adult's SES based on four factors: Marital status, retirement status, highest educational attainment, and occupational prestige[94]. This index is also designed to measure deprivation for children in the household by proxy of the SES of

their caregiver. If a participant is partnered with a working adult, regardless of gender, their SES is also ascertained and the combined scores are averaged into a family unit score. Otherwise, only the working adult's SES is considered[94]. The Hollingshead Index also considers unique circumstances such as an unpartnered, widowed, divorced or separated statuses[94]. The Hollingshead Index is a continuous scale from 8 to 66 and uses weighted categories, with occupational prestige rank multiplied by a factor of 5 and education multiplied by a factor of three; lower scores represent higher levels of deprivation[94].

The various factors are ranked as follows[94]:

Educational Attainment

- 7 Graduate
- 6 College or University, "Standard"
- 5 Partial college
- 4 High School Graduate
- 3 Partial High School, 10^{th} or 11^{th} grade
- 2 Junior High School, 9^{th} or 8^{th} grade
- 1 $>7^{th}$ grade
- 0 Not Applicable/Unknown

Occupational Prestige

- 9 Higher executive, proprietor of large business, major professional
- 8 Administrators, lesser professionals, priority of medium-sized business
- 7 Smaller business owners, farm owners, managers, minor professionals
- 6 Technicians, semi-professionals, small business owners (valued at $50,000-70,000)
- 5 Clerical and sales workers, small farm and business owners (valued at $25-50,000)
- 4 Smaller business owners (<$25,000), skilled annual laborers, craftsmen, tenant farmers
- 3 Machine operators and semi-skilled workers
- 2 Unskilled workers

1 Farm laborers, menial service workers, students, housewives, dependent on welfare, no regular occupation

0 Not applicable/Unknown

Kuppuswamy Socioeconomic Scale (1976)

Dutta et al 2017[84] uses the Kuppuswamy Index in their analysis. The Kuppuswamy Index was developed in 1976 for use in India; it is a composite index of education, occupation and income[96]. It was later adapted to include head of household's educational status and occupational status, and is regularly updated to adjust income categories based on analyses of income differences between social classes[96].

Israel Central Bureau of Statistics Composite Index (2001)

Muhsen et al (2011)[80] used the Israel Central Bureau of Statistics Composite Index, which is an iterative composite index that uses various weighted variables to determine the average SES of geographical regions. Variable selection for the index differs by year, but for the year cited by the paper (2001)[95] included percent of students, percent of earners more than twice the average wage, average income per capita, new motor vehicle use, general motor vehicle use, percent of population matriculated, dependency ratio, families with more than 4 children, age, unemployment, recipients on income support, unemployed persons with more than 6 days of unemployment, and pension.

Other SES Indicators & Indices

The remaining studies included in the search did not use a validated measure of SES, or heavily modified a validated index. Klein et al (1991)[32] and a sub-analysis in Cilla et al (1997)[73] used place of residence as a surrogate for income, comparing children from highly affluent areas to children from areas of low affluence. McLaughlin, Mclaughlin and Lefcort (2003)[53] used boarding school attendance as a surrogate measure of high SES; for participants who did not attend boarding school, parental occupation was used to measure SES instead. Similarly, Naous et al (2007)[59] used the "SES standard" of the school of enrollment.

Three studies (Gasbarrini et al 1995[38], Whincup et al 1996[89], Garcia et al 2006[58]) separated participants into manual and non-manual social classes. Similarly, Webb et al (1994)[36] dichotomized the Registrar-General's Classification of Social Class into manual or non-manual occupations.

In several cases, some authors assessed various SES indicators separately to determine which measure of interest related most strongly to the outcome, and chose this indicator to measure SES (Malaty et al 1996[70]; parent's education, parent's occupation, income). Several studies used principal component analyses in which household characteristics or possessions are used to measure living standard[100] (Farag et al 2007[78], Muhsen et al 2012[87], Jaganath et al 2014[88]); examples include types of

dwellings, rooms in home, crowding, combined household income, household bathroom, non-religious books in home, vehicle ownership, bicycle ownership, expensive household lighting, roofing, rooms used as bedrooms, number of persons sleeping in same room, television ownership, and others.

Several studies chose to use pre-assigned categorical differences in income to assess deprivation (Souto et al 1998[49], Dowd et al 2009[61], Tarkhasvili et al 2012[81], den Hollander et al 2013[64], Chen et al 2014[82], Nguyen et al 2015[66], Sherifaw & Abera 2019[85]). Laszewicz et al 2014[65] selected an indicator that assessed deprivation due to reduced income without collecting income data; these authors used tax brackets and welfare status to assess deprivation.

One study chose self-reported SES, separated into lower, middle, higher, and unknown (unsure) social classes (Bures et al 2006)[57]. Other studies that used just one variable to measure of SES used crowding (Tarkhashvili et al 2012[81]), car ownership (Mhaskar et al 2013[90]), highest level of educational attainment among household members (Rosenstock 1996[40], Cilla et al 1997[73], Dowd et al 2009[61]), or head of household's occupation (Pearce et al 2005)[56].

The remaining studies opted to use alternative, uncommon composite indices. Faleh et al (2010)[63] used a composite index previously published by the authors on a

continuous scale from 1 to 21; housing was measured on a 3-point scale, parental education on a 6-point scale, parental occupation on a 6-point scale, number of family members on a 3-point scale, and the number of rooms in the home on a 3-point scale. Torres et al (1998)[48] used a composite index of crowding, floor material, municipal water, waste disposal, and years of education of the head of family. Senbanjo et al (2014)[83] used a composite index previously published in 2008 by other researchers from Nigeria, classifying children's SES into high or low SES based on their parent's educational attainment, occupation (based on local occupational prestige), and income. Al-Hussaini et al (2019)[67] constructed a composite, continuous index (maximum 20; deprivation decreasing with score) of parents' educational level (6 points, one point for each level: illiterate, primary school graduate, middle school graduate, high school graduate, university graduate, postgraduate degree), family income (6 points; one point for each level: no income, <$1500 USD, $1500-2500 USD, $2000-5000 USD, $5000-8000 USD, and >$8000 USD), dwelling (4 points; one point for each level: small traditional house, apartment, villa, palace), and parents' jobs (4 points; one point for each level: unemployed, unskilled worker, office clerk, trader/businessman/professional).

Two studies (Bakka and Salih 2002[52], Palli et al 1993[34]) did not report their SES ascertainment method. One study reported the use of a regional health services SES

index for which the indicators were not publicly disclosed (Suki et al 2018[68]). These studies were included in the results for purposes of comparison.

Measure of Association between Hp and SES

The majority (63%) of included articles supported an effect of decreasing SES on increased *Hp* infection prevalence in the study population. From the perspective of deprivation, when more than two categories of socioeconomic status were measured, *Hp* infection prevalence tended to increase with increasing levels of deprivation.

Population-based prevalence studies

The majority of population-based prevalence studies (79%) reported an increase in *Hp* infection prevalence, comparing low SES groups, as the index category, to high- or middle- SES groups, as the reference category.

13 of the 38 population-based prevalence studies did not report a measure of effect, and instead assessed differences in prevalence across social strata by statistical significance testing; in some cases, there was enough data presented to estimate a crude odds ratio – the results of these calculations are presented in Table 1.1. Overall, 12 studies that presented prevalence measures only demonstrated a compelling difference in prevalence odds or prevalence proportion comparing low SES groups to

middle- or high-SES groups, though the precision of the estimate varied considerably by study. In general, odds of *Hp* infection tended to increase with increasing levels of deprivation.

Murray et al (1995)[39] did not report enough data to estimate the precision of observed associations and reported that they excluded social class from logistic regression analysis after finding no statistically significant difference in *Hp* prevalence by SES as measured by the UK Registrar-General's Classification; however, there was a notable trend of increasing prevalence with decreasing status of occupation class (with I being highest and V being lowest), though the prevalence dipped down slightly in the lowest class:

Social Class	Hp Prevalence:
I	38.0
II	45.3
IIINM	52.4
IIIM	66.5
IV	70.4
V	66.0

Fawcett et al (2005) dichotomized the Elley-Irving Scale into high and low SES groups, and found no meaningful difference in prevalence between the two groups (6.3% vs 6.4%). McLaughlin et al (2003)[53] did not report any data whatsoever; dismissing the results of their study as having "no statistical correlation" without presenting substantiating details.

Most (16/21, 76%) population-based prevalence studies included in the search that estimated a measure of association for the relationship of social deprivation with *Hp* infection revealed a positive association between the social deprivation variable and *Hp* infection, though the precision of these estimates varied by study. Three of the 21 studies (14%) revealed a null association between the SES variable and *Hp* prevalence. Two of the 21 studies (10%) offered insufficient evidence to support the outcome reported; they will be discussed later in this section.

Fifteen of 21 analyses adjusted the measure of association for confounders or stratified by other variables. Some associations were reduced after adjustment or were modified by other variables. Hopkins et al (1993)[35] reported that the unadjusted odds ratio (OR) of 1.7 [1.3-2.1] reduced to 1.3 [1.1-1.6] after adjustment for all variables ascertained; however, they did not report conducting iterative model checking for their logistic regression model, thus, their resulting odds ratio may be over-adjusted. Fraser et al (1996) reported that the association between SES and *Hp* infection disappeared after adjustment for other variables. The authors initially reported an association between SES (as measured by occupation) and *Hp* infection based on unadjusted estimates (ORs, reported as "relative risk") from a study population of 5677 middle-aged participants from various worksites; these effects disappeared after adjusting for the effect of age and ethnicity. After adjustment for age, smoking,

alcohol consumption, crowding, and NSAID use, Lin et al (1998)[47] reported increased odds for lower SES as defined by income (1.5 [1.1-2.4]) and education (1.2 [0.9-1.7]) for *Hp* infection, but not occupation (0.99 [0.9-1.1]), though the referent groups and contrasts are not defined; they appear to have used categorizations of income, education and occupation as continuous variables in the model. Tsai et al (2005)[55] adjusted SES indicators for ethnicity, immigration status, immigration generation, having an *Hp* positive parent, and sex; they reported that the unadjusted OR for low SES measured by highest educational attainment of household of 1.84 [1.26, 2.68] reduced slightly to 1.76 (1.20, 2.58) after adjustment, and the unadjusted OR for low SES class measured by crowding of 1.43 (0.99, 2.06) reduced to 1.23 (0.84, 2.58). Jafri et al (2010)[62] reported a reduced association between *Hp* infection and low SES after adjusting their results for education; however, because education was one of the components of the composite index used, adjustments for education would remove its effect, so the authors should not have adjusted for this variable. Laszewicz et al (2014)[65] reported that both income and welfare status of family was associated with *Hp* infection in children, but only income was associated with *Hp* infection in adults, suggesting potential effect modification on the effect of deprivation on *Hp* infection by age.

A few papers in the body of literature require a closer examination beyond what is presented in Table 1.1. Malaty & Graham's 1994 study[37] reported an effect estimate of

55 (11-319) for the lowest social class relative to the highest social class; however, calculating the OR based on the data presented gave an effect estimate of 59 (11-319); it is possible that their estimate was adjusted for unreported factors. Though their estimated ORs have very wide CIs, they show an increasing trend in the association of deprivation with *Hp* prevalence (compared to high social class, the reported ORs were 8.9 for middle social class and 55 for low social class).

There were notable methodological problems with several papers in the body of literature. Souto et al (1998)[49] reported a protective effect of income in the way of a statistically significant decreasing trend of infection odds for every $1200 USD increase in annual income (ORs of 0.5, 0.3, 0.2, 0.6, and 0.1 referent to <$1200 USD); however, they did not report the CIs for their odds ratios. When calculated, the CIs are very wide (0.5[0.09, 2.2], 0.3 [0.5, 1.4], 0.2 [0.04, 1.6], etc); thus, these effect estimates are not precise. Similarly, Mohammad et al (2008)[60] reported ORs of 2.6 and 2.0 for the comparisons of participants of low SES and "moderate" SES, respectively, to those of high SES;; however, they did not report their CIs or data for calculating them. Dowd et al (2009)[61] reported logit coefficients in place of ORs. When calculated, the OR for 1 unit increase in the log transformation of income in USD was 0.80, and the OR for 1 year increase in education was 0.93; calculating the CIs using the reported standard errors revealed CIs of (0.78, 0.95) and (0.87, 0.97) respectively. Their data as presented in the article cannot be meaningfully interpreted, and their

conclusion that income and education are associated with *Hp* infection are based on statistical significance testing alone and not on a measure of association. Faleh et al (2010)[63] reported no association between *Hp* infection and social class, with varying effect estimates by region and very wide CIs around the null; however, their analysis was stratified into three regions with four social classes each and were not combined. It is very likely that they had insufficient statistical power to detect effects on *Hp* prevalence with 1157 participants divided into twelve categories. Fawcett et al (1996)[41] reported that the seropositive group contained proportionately more participants from families of low SES at age 5, but reported no other data that could be used to calculate a crude measure of association.

Hospital-based studies

The results from hospital-based prevalence studies were mixed and characterized by small study sizes, excessive SES categories, and resultant poor precision. Most (11/18) reported a positive association between deprivation and *Hp* infection; however, the statistical analyses for most hospital-based articles included were generally of poor quality relative to population-based articles.

Mendall et all (1992)[69] reported a null association between SES as defined by occupation and *Hp* prevalence; however, given that the 95% CIs are very wide, with only 70 positive patients of 215 and four categories of deprivation, the study lacks

sufficient statistical power to infer a null association with certainty. The precision of their estimate may have been improved by dichotomizing their SES categories into low and middle-high.

Malaty et al's 1996[70] report of a study of 413 asymptomatic Korean volunteers presented impossible results, with 95% CIs in which the lower bound either was the reported OR (1.0 [1.0, 2.2]) or did not include the reported OR (1.7 [1.8-18]; recalculating the crude OR revealed very wide CIs around the null. As the precision around the effect estimates cannot be trusted to be accurate, this study should not be considered evidence in favor of an association between *Hp* infection and social class. Similarly, recalculating the confidence intervals from Malaty et al (1996)'s[71] study of 520 asymptomatic patients recruited from two Russian hospitals revealed much wider CIs around the effect estimates than they reported, though there remained a protective effect of low income on *Hp* infection. The authors propose that one of the reasons for this observation is that income has a very weak association with social status in Russia, particularly because the standard deviation of income around the mean is very small; the authors suggest that the female head of household's educational attainment may have a greater influence than income on the household's overall standard of living.

Results Moayyedi et al's 2002[75] study of 8429 invited participants from general practitioner's lists had excellent precision, and showed generally increasing odds of *Hp* infection with decreasing social class; however, this trend disappeared after adjustment for all variables in the analysis, though an elevated prevalence relative to higher social classes remained. As discussed in the previous section, iterative model building in logistic regression is preferable to adjusting for all variables collected to avoid over-adjustment of the measure of association.

McCallion et al (1996)[72] estimated an OR for the effect of SES as measured by the Registrar-General's Classification of parent's occupation for 485 children of 2.0 (1.3, 3.3); the OR reduced after adjusting for age, bedsharing and household density (1.6 [0.97, 2.6]). However, as bedsharing and household density are effects of low SES. and thus intermediate pathways between exposure (low SES) and outcome (infection), the effect of SES should not have been adjusted for these variables.

Guiraldes et al (2001)[74] reported that the odds of infection were much higher in the lowest SES category relative to the highest [OR 7.5 (1.7, 33)], and less so for the middle SES category relative to the highest [1.9 (0.45, 7.7)]. It should be noted that these confidence intervals are very wide (there are only 79 patients, 29 *Hp*- and 50 *Hp*+, split between three SES categories), and do not provide adequate precision for

concluding that there is a dose-response. They do, however, show that the lowest SES category had the highest prevalence odds.

Chong et al (2003)[76] separated patients into those with GI referrals and those without GI referrals; income was associated with *Hp* prevalence in both groups, though more so in the GI referral group. No other SES variable was associated with *Hp* infection in both groups.

Sherifaw & Abera (2019)[85] reported estimated ORs with extremely wide confidence intervals ; the ORs reduced substantially when adjusted, but they did not disclose which variables the ORs were adjusted for, making it impossible to assess the validity of their multivariable model.

Cohort studies

Of the three cohort studies in the body of literature, two of the three reported increased frequency of *Hp* infection with decreasing social class; one reported no association between the exposure and outcome.

Muhsen et al (2012)[87] reported very imprecise estimates of their measure of association (OR: 9.6 (2.9, 32), low SES village relative to high SES village). Jaganath et al (2014)[88] did not have enough *Hp* negative participants in their cohort to estimate

relative risks of *Hp* infection; instead, they removed the 4 *Hp*- participants from their cohort of 187, and performed proportional hazards regression. They reported that children from lower SES classes were infected with *Hp* earlier in life than children from other social classes. Fawcet et al (1998)[86] reported *Hp* seropositivity of participants in a birth cohort at age 11 and 21; while a slightly increased risk of *Hp* infection was noted in lower SES categories, the estimated risk ratios do not offer compelling evidence of an increased risk of *Hp* infection with decreasing SES, because the confidence interval around the effect estimates were very wide and thus the effect estimate is imprecise.

Case-Control studies

Of the three case-control studies in the body of literature, two studies provided some evidence of odds of *Hp* infection increasing with deprivation. Whincup et al (1996)[89] estimated increased odds of *Hp* infection in manual workers compared to non-manual workers (2.4 [1.2, 3.8]). Dore et al (2000)[91] estimated the association of social group (as measured by a modified Hollingshead index) with *Hp* infection and reported decreasing prevalence with higher SES. However, this was a sub-analysis of a study of diabetics from an outpatient clinic; because diabetes and social deprivation are associated in their population of interest[101], there is an increased likelihood of selection bias in their study population. The remaining case-control study did not offer compelling evidence of a relation between exposure and outcome: Mhaskar et al

(2013)[90] reported a negligibly increased odds of *Hp* infection in adults who did not own a car relative to adults who owned at least one car (1.1 [1.0, 1.4]).

Discussion

Geographic profile of the body of literature

Though *Hp* infection is ubiquitous, the body of literature on the relation of *Hp* infection and SES indexed in Medline is primarily Amero- and Eurocentric; likely attributable to the underrepresentation of scholars from non-European & North American countries in medical research published in Medline-indexed journals. Thus, conclusions regarding the relation of *Hp* infection and social deprivation arising from this literature are broadly biased towards Western social hierarchies and their measurements.

Limitations of Ascertainment Methods

IgG Serology

Though serology is the most common ascertainment method for *Hp* infection in the body of literature, sensitivity and specificity are extremely variable by brand and have the lowest average accuracy in comparison to the other non-invasive ascertainment methods[3]. One advantage of serology is that it does not respond to transient changes in the stomach that may temporarily create inaccurate results in other non-invasive tests, such as Carbon-13 (C13) UBT[3]. However, serology may not reflect the current

Hp bacterial load; antibodies may remain elevated for years after *Hp* elimination[3], resulting in the misclassification of current *Hp* infection status. In an attempt to address this flaw, one study in the body of literature adjusted their results for previous *Hp* treatment[57]; however, because the aim of the study was to estimate the social determinants of *Hp* infection, it is not clear that current *Hp* infection status is the outcome of greatest relevance; if lifetime *Hp* status better corresponded to the underlying research question, participants previously treated for *Hp* should have been classified as 'positive' rather than adjusting for previous treatment during logistic regression. For these reasons, the limitations of serology should be taken into account when interpreting results of studies using serology to ascertain *Hp* status.

Carbon-13 Urea Breath Test & Stool Antigen Test

C13 UBT is a non-invasive and highly accepted method of *Hp* ascertainment. Sensitivity and sensitivity are high and vary only slightly by brand, with sensitivity ranges from 88-95% and specificity ranges from 95-100% [3]. C13 UBT uptake in *Hp* research is primarily limited by cost; on average, C13 UBT costs at least three times as much as the ELISA IgG Serology test and takes at least twenty minutes per participant to complete[102]. Though less acceptable among participants in comparison to C13 UBT, SAT demonstrates a similar, if less specific, validity on average to C13 UBT (estimated sensitivity of 94% and estimated specificity of 92%)[3]. The results of C13 UBTs and SATs are influenced by proton pump inhibitors (PPI), which

suppresses gastric acid secretion, resulting in lower urease production by *Hp*, which C13 UBT and SATs detect[103]. Several studies suggest up to a 40% increase in false negatives for C13 UBT[3].

Rapid Urease Test & Histopathology

Invasive *Hp* ascertainment methods- specifically, Rapid Urease Testing and Histopathology- were uncommon in the body of literature. Sensitivity for RUT ranges from 80 to 100% by brand, and specificity between 97% and 99%[104]. There are limitations to both of these methods; though *Hp* does not grow uniformly throughout the stomach, to detect the infection, histopathology samples must come from a site where *Hp* is present. Advanced *Hp*-associated gastric pathologies, such as atrophic gastritis and intestinal metaplasia, may lead to low bacterial load in the stomach and trigger false negatives[104]. RUT and histology results are also affected by PPI use[3]. When PPIs are not discontinued, several studies report a substantial increase in false negatives for RUT[3].

Limitation of measures of SES

The body of literature was characterized by SES measures of questionable relevance to their respective study populations. Occupation was the most common measure of SES in the body of literature; however, indices that measure social status at least in part by occupation have several notable limitations. Primarily, they are highly specific

to the culture, time and place of their inception; particularly those that consider the socioeconomic ranks of gender, such as the now outdated Elley-Irving Index. Of the studies which used validated measures of SES, the Hollingshead Index was most commonly used outside of its geographic location of origin; only 2 of the 7 studies using the Hollingshead Index were located in the United States. The ranking of prestige of occupation used in the indices that appear in the body of literature are based on western assumptions of status, which are often patriarchal in nature. They are not intended for use outside of their location of origin, despite their geographically widespread use in the modern body of literature. Further, it is impossible to classify every occupation into an ordered ranking that perfectly captures relative wealth and status, and such classifications are likely prone to error. Such classifications also become outdated quickly and must be regularly revised; however, even when this is done in a timely manner, use of the outdated versions may continue. The Registrar-General's Classification, for example, was intended for use in a societal structure that predated World War II, and does not consider modern occupational structures such as the increase in service jobs and the shrinking of the manual trade sector due to automation[92]. It has since been succeeded by several other validated SES indices, but its use persists. Finally, SES as measured by occupation masks retirement and inherited privileges that may render the social status of their occupation meaningless.

Several studies in the body of literature selected multiple deprivation indicators for analysis, and reported the variable that had the strongest association with *Hp* infection as their measure of SES. While such an exploratory approach may be useful to identify potential risk factors for *Hp* infection, using it to select a surrogate for SES is problematic. Primarily, it relies on the statistical significance of the association with the outcome to select an exposure definition rather than *a priori* consideration of meaningful differences between social strata in the target population. It is best to conduct analyses to validate SES indicators for the population of interest before estimating their association with an outcome.

Occasionally, authors chose to compare populations from geographic locations of varying average SES, pooling individuals into geographic SES categories. Place of residence is useful for assessing differences due to wealth between populations of sharply contrasting levels of deprivation, but is less useful for capturing meaningful differences between populations with more subtle SES distinctions. It should also be kept in mind that such aggregate ecologic exposures do not consider individual differences in SES within regions.

As discussed previously, income is a problematic measure of deprivation in scientific research. In addition to frequent reporting error and participant non-response, income distribution is wholly contextual and cannot be compared outside of the

specific study population. In several publications in the body of literature, the categorization of income into many groups led to insufficient precision to assess meaningful differences across strata. Further, categorical income cut-points are subjective and arbitrary, and may lead to misclassification of SES due to small and functionally meaningless differences in income (eg >$1200 vs $1201< in Souto et al 1998[49]). Additionally, income categories are meaningless outside of specific cultural contexts; it is impossible to meaningfully assess the differences in SES based on income without knowledge of the sociocultural context, making it difficult for outsiders to interpret the results if the reasoning for the categories is not carefully reported. To address these limitations, some authors attempted to assess SES without collecting income data, such as collecting self-reported social status. Similar to income, this may result in reporting error or non-response. A research participant may feel uncomfortable revealing their socioeconomic status to an investigator; they may report a higher social status to avoid judgment or decline to respond. Moreover, the construct validity of self-reported social status as a variable of interest is unclear.

The best measures of SES in the body of literature were deprivation indicators that were highly relevant to the study population. Torres et al (1998)[48] selected an index highly specific to the population of interest; their composite index is intuitive, captured meaningful contextual differences in SES across households, and was statistically validated in previous publications by other research teams. As well,

Senbanjo et al (2014)[83] used a composite index that specifically addressed the same time period and population that the previously published index was created to address. Al-Hussaini et al (2019)[67] attempted to construct a composite index specific to their study population, given that relevant, previously published indices were not available; however, they heavily weighted income relative to all other indicators in the index. Similarly, some composite indices, such as the Hollingshead Index or the index used in Faleh et al (2010)[63], included apparently arbitrary weightings that may not realistically reflect the complex interactions of education and occupation as indicators of social class.

Conclusion

There selected body of literature contained few high-quality studies. The western-centric publication bias in the body of literature complicates the interpretation of these results; further, many investigators chose measures of SES that lacked relevance to the population, place or time of their study.

Most population-based studies reported prevalence data for *Hp* infection across groups without estimating a measure of association, relying solely on statistical significance testing to detect differences between social strata. In some reports, over-reliance on statistical significance testing masked meaningful differences between

groups and led to erroneous conclusions about the relation of SES with *Hp* infection. Most studies that did report estimated measures of association did not adjust for confounding factors. Investigators who adjusted for confounding factors often did not make clear that they performed adequate model building to avoid over-adjustment or residual confounding. In particular, adjusting a measure of SES for variables that capture effects of SES, such as household crowding, will bias estimated effects of SES toward the null.

Overall, however, studies that resulted in evidence of no association between SES and *Hp* infection prevalence, or even an inverse association implying a protective effect of deprivation, are of poorer quality relative to studies that revealed a positive association between low SES and the odds of *Hp*. The overall weight of the evidence suggests that deprivation is associated with increased *Hp* prevalence, though the strength of this association varies by population, place, time, and the indicator or index used to measure SES.

Chapter 3: Adapting the Canadian Household Food Security Survey Module for Arctic Canadian contexts

Introduction

Food insecurity has been disproportionately high in the Indigenous population of Canada for as long as food security has been monitored in Canada. One of the earliest estimates, collected in 1998 and reported in 2001, demonstrated that Indigenous Canadians had 1.5 [95% CI: 1.1, 2.1] times the odds of being food insecure compared to other Canadian-born ethnicities [17]. Canadian census reports show that the prevalence of food insecurity has increased steadily across Canada since 2001, particularly in northern communities[23]. According to the 2012 census (the most recent census to collect food security data from all provinces and territories), 28% of households classified as Aboriginal reported some level of food insecurity, more than double the national average of 13%[23]. These values are likely to underestimate the food insecurity gap between Indigenous and non-Indigenous Canadians, given that food security data is not collected from on-reserve households - approximately half of the Indigenous population of Canada - and on-reserve households have been shown to have a higher overall prevalence of household deprivation compared to off-reserve households[24]. In a 2011 survey conducted across 16 Northwest Territory Indigenous communities, more than 90% of respondents reported reducing portion size, skipping meals, or remaining hungry after a meal because they could not afford enough food[25].

The government of Canada defines food security as a household's financial ability to access an adequate amount of high-quality, healthy food[22, 23] The Government of Canada developed the Household Food Security Survey Module (CHFSSM) to measure food insecurity by this definition[22]. The CHFSSM assesses food security based on how often the following occurs due to insufficient income: food shortages, unbalanced meals, low-quality foods, meals skipped, days spent without food, inadequate portion sizes, and weight loss. While the CHFSSM is a useful tool to measure food security in southern urban centers, it does not reflect the Arctic Canadian context, including subsistence food sources. Participants in pilot food security surveys conducted in Arctic Canadian community-driven research projects, including those with results reported in the literature[105] as well as CAN*Help* projects, have suggested adapting the CHFSSM to include locally harvested and traditional foods. Further recommendations in the literature resulted from a 2012 series of workshop discussions that included representatives from 7 Arctic countries who proposed six indicators of food security for use in developing a universal tool to measure food security in Arctic populations[106]. These indicators were: healthy weight (as measured by body mass index (BMI)), traditional food proportion in diet, monetary food costs, non-monetary food accessibility, prevalence of food-borne disease, and prevalence of food-related contaminants. Other proposed measures included accessibility of hunting, fishing, collecting, or herding equipment,

accessibility of sufficient land area, environmental conditions suitable for obtaining traditional food, and the gifting or exchange of traditional food for other goods or services.

The Canadian North *Helicobacter pylori* (CAN*Help*) Working Group is a collaboration of academic scientists, with northern community leaders and health care providers who investigate *H. pylori (Hp)* infection to address community concerns. Community-driven projects conducted by this group have shown that Arctic Canadians with *H. pylori* infection have an elevated prevalence of severe chronic stomach inflammation, consistent with an increased risk of stomach cancer[11]. Residents of participating CAN*Help* communities are predominantly Indigenous, with 90% of community project participants identifying as First Nations, Inuit, or Métis. An objective of my research within this group was to describe the food security status of community *Hp* project participants in relation to *Hp* infection. Because food security was not assessed in CAN*Help* community projects before 2017, a specific aim of my work was to build a questionnaire that accurately classifies food security status in Arctic Canada. This paper describes methods I used to quantify food security in the circumpolar North and evaluates the acceptability of these methods among Indigenous CAN*Help* community project participants to assess the potential for selection bias in analyses that rely on food security data.

Methods

I began to develop the food security questionnaire by conducting a pilot project in conjunction with ongoing data collection in project communities. Pilot project participants responded to a 4-item food security questionnaire (Appendix E and F), with 4 questions selected from the CHFSSM for rapid assessment of food security, designed to assess the suitability of such questions in project communities.[22] After piloting this questionnaire in Teslin and Ross River, I replaced the questions with 4 new questions (Appendix F) at the recommendation of participants and researchers.

To collect more nuanced information on food security in Arctic communities for my research, I developed a more comprehensive questionnaire, following a comprehensive literature review.

I reviewed literature published by the government of Canada to review their methodology for building the Canadian Household Food Security Survey Module, and reviewed validation studies that assessed the CHFSSM. I then searched the International Journal of Circumpolar Health (IJCH), a peer-reviewed journal which publishes articles related to Indigenous health in the circumpolar Arctic regions, for food security surveys conducted in Indigenous communities in Canada and the United States. I also consulted key articles such as the Expert Panel on the State of Knowledge of Food Security "Assessment on the State of Knowledge"[107], and a 2013

expert panel report on proposed food and water security indicators in Arctic communities[106]. I selected questions based on articles that examined community members' assessments of how well food security questions reflect realities in Arctic communities, as well as suggestions from community project participants and interviewers. In total, I added 30 items to the 4 questions in Appendix F modified for suitability based on pilot feedback; of these added questions, 14 were modified from the CHFSSM, and 16 were added based on the results of the literature review. I used the resulting 34-item (42 including sub-items) CAN*Help* Food Security questionnaire (CAN*Help* FSQ) (Appendix B) for my thesis project. Questions added to the CHFSSM are described in Table 3.1.

Once I had completed adapting the CAN*Help* FSQ, I asked the community planning committees that guided each project to review it for relevance to Arctic Canadian contexts; no further changes were made based on this review. After collecting data using my questionnaire, I compared the frequency of participant willingness to answer (declined to respond) and missing data of pilot questionnaire items, CANHelp FSQ items, and SES indicators previously ascertained in CAN*Help* projects to assess the potential for selection bias in analyses that use these variables.

As part of my questionnaire evaluation, I compared missing data frequencies for food security questions to missing data frequencies for other socioeconomic deprivation

indicators as a measure of how feasible this information is to ascertain in participating Arctic Canadian communities. For each question included in the pilot questionnaire and CAN*Help* FSQ, I tabulated the proportion of respondents who declined to answer as a measure of the acceptability of each question; I also tabulated the proportions that declined to respond for other commonly used SES indicators (education, home ownership, annual personal income, annual household income and employment status).

Because of several logistical challenges in the field - such as the lack of a permanent office space, baggage weight limits, shipping costs, and the confidentiality of sensitive health data recorded on paper questionnaires - I developed a tablet-based questionnaire to optimize portability. I assessed the acceptability of a tablet-based questionnaire in place of a paper-based questionnaire in 4 communities where I interviewed participants and allowed them to choose one of the two (Carmacks, Ross River, Teslin, Old Crow).

Results

Terminology & Definitions

I consulted community planning committees to confirm which terminology for local food sources was most meaningful to community members. Though "country food" and "subsistence food sources" have been used elsewhere, including in previous

CAN*Help* questionnaires, planning committees expressed a preference for "traditional foods" during in-person community consultations. Questions included in the final CANHelp Food Security Questionnaire (CAN*Help* FSQ) assessed the household's ability to obtain locally harvested foods when desired; "locally harvested foods" include traditional foods, but may also include other food sources, such as non-traditional crops grown locally.

How the Reviewed Literature Informed Questionnaire Development

Scoring accuracy

The government of Canada's Household Food Security Survey Module (CHFSSM) was adapted from the United States Department of Agriculture Food Security Survey Module (USDA HFSSM), and uses the same set of questions to assess food insecurity[22]. The key difference between these two survey modules is that the threshold for classifying households as "food insecure" is 2 affirmative responses for the Canadian survey and 3 for the US survey. Statistical analyses have shown that using the USDA HFSSM 3-affirmative response threshold results in a marginal increase to sensitivity, but a considerable reduction in specificity; for example, in analyses assessing the overall accuracy of each question in the HFSSM to detect food insecurity based on the results of the entire questionnaire, using the 3-affirmative-response cut-off increased the sensitivity of the question "Did you ever worry whether the food for you and your family would run out before you have enough

money to buy more?" by 2.5%, but decreased the specificity by 16.9%, with similar results for other questions[108]. Based on this evidence, I decided to use the CHFSSM scoring guidelines (Appendix C), and not the USDA HFSSM scoring guidelines, in my analysis in order to improve overall accuracy.

Rapid assessment vs. detailed assessment

Rapid assessment of food insecurity (1-6 questions instead of 18) is a statistically validated strategy for assessing food insecurity while reducing respondent burden[108]. However, in the publication introducing the HFSSM, the USDA cautioned against using rapid assessment in populations where assessing the severity of food insecurity is important, especially where child food security is a measure of interest[109]. Rapid-assessment questionnaires can measure moderate food insecurity, but not severe food insecurity, because not enough items are included to screen for it. This is especially problematic when it comes to assessing child food insecurity, which is found almost exclusively in the most severe overall household food insecurity categories[109]. Because children are a population of interest in my analysis, I decided to adapt every question in the HFSSM to ensure that I could reliably capture child food insecurity in households. Further, documentation for the CHFSSM gives two additional arguments as to why the 18-item questionnaire is advantageous over rapid assessment when it is feasible to use. The first of these reasons is that it provides a more reliable measurement when respondents are likely to misunderstand the questions being

asked; "inconsistent understanding of questions may be offset or moderated by responses to other questions.[22]" The second, and most notable, is that using the 18-item version allows for the administrant to assess how well each question predicts food insecurity using the results of the entire questionnaire; particularly so where it is valuable to assess whether the questionnaire is suitable for a certain sub-population or linguistic group in Canada[22]. This is particularly useful to accomplish one of the specific aims (build a questionnaire that accurately classifies food security status in Arctic Canada) of my analysis.

Food security indicators ascertained without use of a structured questionnaire

While qualitative methods dominate traditional food security research in Indigenous communities, qualitative methods and open-ended questions were not ideal to address the specific aims of my thesis research. Suggestions for food insecurity indicators that could not be ascertained via structured questionnaire, such as seroprevalence of foodborne disease antibodies or information derived from qualitative methods[106], were not considered for inclusion.

Thus, the best option to address the specific aims of my research was to adapt the CHFSSM, adding in questions that captured food security complexities related to traditional and subsistence food sources that were not included in the original.

Internal screening & respondent burden

Skip patterns for the CANHelp FSQ remained largely consistent with internal screening for the CHFSSM. I implemented two levels of internal screening to reduce the respondent burden. I arranged questions related to low-severity food insecurity at the start of the questionnaire; if the participant did not respond affirmatively to any of the questions in a given screening level, they did not continue to answer questions related to more severe food insecurity. I then added a skip pattern in which, if the participant was screened out of a section, they skipped to last section of the questionnaire. I structured the skip pattern in this way because the last section records current height and weight; this required participants to stand for measurement, and thus it was most convenient to arrange this question at the end.

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Adapting the HFSSM

In February 2017, I created a short version of the food security questionnaire, which CAN*Help* staff piloted as participants were being recruited for new community projects in February 2017. I analyzed the pilot results and sought additional feedback on the questionnaire from community members. Participants did not feel comfortable answering the pilot food security questions; project staff recommended rephrasing the questions using less direct language, a suggestion supported by literature; many food security pilots conducted in Indigenous communities present questions as hypothetical scenarios (ie "some people might say…") or less invasive interrogations ("some people have told us that…")[110]. I chose to use hypothetical language for the first and second level screening; the questions asked once food security was confirmed were not hypothetical.

The Alaska Department of Fish and Game (ADFG) identified two additional elements that made using the HFSSM problematic in Inuit communities.[111] The first is the lack of consideration of subsistence food sources; to adjust for this, the ADFG recommended splitting each adapted HFSSM item into three items[111]. The first

question would specify that it was assessing "all kinds" of food sources; the second and third would substitute "food" with "subsistence food" and "store-bought food" respectively. This recommendation proved feasible in food security questionnaires that adapted few HFSSM items[111], but this recommendation would considerably increase the burden on respondents in questionnaires that adapted every HFSSM item. I decided to adapt the questionnaire to have each item specify that the item was assessing food from all sources. Their second recommendation was to reduce the emphasis on money by adapting every instance of "because there wasn't enough money for food" to "because the household could not get the food that was needed" or "because there wasn't enough food" in order to consider subsistence food sources[111]. For the CAN*Help* FSQ, I kept one question that mentioned money because it was required for calculating the Canadian Deprivation Index (CDI) used for my thesis research [Chapter 4], but other questions that were adapted where possible to mention both subsistence food sources and money.

Several CHFSSM questions use the term "balanced meals." Ready's 2016 publication "Challenges in the assessment of Inuit Food Security"[105] proposes that "healthy meals" is a preferred alternative because "balanced" implies the use of the Government of Canada-recommended food guide, which does not consider the nutritional value of traditional diets. The 2007 "Canadian Food Guide: Indigenous, Metis and Inuit"[112] recommendations emphasized the consumption of non-traditional

food items, while also recommending limiting the consumption of traditional food sources such as seal and whale. As of 2019, Health Canada was still making significant changes to this guide to consider traditional foods. I decided to replace each instance of "balanced" in the CHFSSM to "healthy."

Table 3.1: Questions added to the CHFSSM for use in the CAN*Help* FSQ

Food Security Indicator		Response
Total food store bought		Proportion
Total food traditionally harvested		Proportion
Members of the household or extended family bring in food by:		--
	Fishing	Yes/No
	Hunting	Yes/No
	Trapping	Yes/No
	Picking berries	Yes/No
	Gardening	Yes/No
	Trading	Yes/No
	Receiving from other household	Yes/No
Perceived changes in traditional food consumption over the past 5 years		Eating More Now/ Eating Less Now/Eating Same Amount
Perceived changes in traditional food consumption over the past 15 years		Eating More Now/ Eating Less Now/Eating Same Amount
Perceived changes in quality or health of traditional foods		Y/N
		Qualitative description
Concerns about environmental contaminants in traditional foods		Not at all concerned/Somewhat concerned/Very Concerned
Perception of how often people they know get sick from eating traditional food		Often/Sometimes/Never
Perception of how often people they know get sick from eating store-bought food		Often/Sometimes/Never

How often household lost access to resources needed to hunt, fish, gather, or buy food in the last 12 months	Often/Sometimes/Never
Body Mass Index (BMI); measured by: (weight in kg)/(weight in m^2)	Ordinal: under 25.0 [Not overweight], 25.0-29.9 [Overweight], 30.0+ [Obese], measured by: (weight in kg)/(weight in m^2)

Data Collection and Participant Response

Setting

Participating communities (with year of project launch in parentheses) include Aklavik (2007), Fort McPherson (2012) and Inuvik (2017) in the Northwest Territories, and Old Crow (2010), Ross River (2016), Teslin (2016), Pelly Crossing (2017) and Carmacks (2017) in Yukon.

Discontinued Questions

Pilot project participants responded to a 4-item food security questionnaire (Appendix E and F, Table 3.2), with questions selected from the CHFSSM for rapid assessment of food security; the goal of the pilot was to assess the suitability of such questions in project communities.[22]

Table 3.2: Pilot Questionnaire Version 1 Participant Responses: Teslin and Ross River

Q1. The food that you [or other household members] bought just didn't last, and there wasn't any money to get more. In the past 12 months, was that true almost every month, some months but not every month, one or two months or never?		
Response	**n**	**%**
Almost every month	7	3.3
Some months but not every month	17	8.1
One or two months	2	1.4
Never	178	85
Unsure	2	1.0
Declined to answer	1	0.5
Missing data	3	1.4
Q2. You [or other household members] couldn't afford to eat balanced meals. In the past 12 months, was that true almost every month, some months but not every month, one or two months or never?		
Response	**n**	**%**
Almost every month	3	1.4
Some months but not every month	17	8.1
One or two months	10	4.8
Never	172	82
Unsure	4	1.9
Declined to answer	1	0.5
Missing data	3	1.4
Q3. You [or other household members] cut the size of your meals or skipped meals because there wasn't enough money for food. In the past 12 months, was that true almost every month, some months but not every month, one or two months or never?		
Response	**n**	**%**
Almost every month	6	2.86
Some months but not every month	7	3.3
One or two months	4	1.9
Never	184	88
Unsure	4	1.9
Declined to answer	2	1.0
Missing data	3	1.4

Q4. You [or other household members] were hungry but didn't eat because you couldn't afford enough food? In the past 12 months, was that often true, sometimes true or never true?		
Response	**n**	**%**
Often true	2	1.0
Sometimes true	15	7.4
Never true	185	88
Unsure	3	1.4
Declined to answer	2	1.0
Missing data	3	1.4

Among the first pilot food security questions, the proportion of respondents who declined to answer ranged from 0.5%-1%, or 1 or 2 participants out of 135 interviewed, with 3 participants whose responses were not recorded (1.4%). While at least 98% of participants answered each question, suggesting very good acceptability, interviewer feedback indicated that the questions were uncomfortable both for them to ask and for the participants to answer. After data collection concluded in Teslin and Ross River, the pilot questions were replaced by 4 new questions in consultation with interviewers and community planning committees. These questions were used in the initial data collection component of the subsequent Inuvik *H. pylori* project (Table 3.3):

Table 3.3: Pilot Questionnaire Version 2 Participant Responses: Inuvik

Q1. We'd like to know to what extent your [household], that is, you and everyone living in your house, relies on store-bought food. Would you say that most weeks the amount of store-bought food is…		
Response	**n**	**%***
Half or more of the total food your household eats	79	96
Less than half of the total food your household eats	2	2
Missing data	1	1
Precisely what percent of your total food is store-bought, would you say?		
0-24%	0	0
25-50%	4	5
51-75%	13	16
75-99%	45	55
100%	11	13
Missing data	0	0
Q2. Is there someone in your household or extended family who brings in food by:		
Option	**Yes (n)**	**%**
Fishing	45	55
Hunting or trapping	51	62
Berry picking	50	61
Gardening	27	33
Q3. Thinking about the past 12 months, we'd like to know how often, if at all, you [or other household members] worried that food would run out before you got money to buy more. In the past 12 months, would you say that was often true, sometimes true, or never true?		
Response	**n**	**%**
Often	6	7
Sometimes	14	17
Never	62	76
Unsure	0	0
Declined to answer	0	0
Q4. Thinking about the past 12 months, we'd like to know how often, if at all, you [or other household members] cut the size of your meals or skipped meals because there wasn't enough food. In the past 12 months, would you say that was true almost every month, some months but not every month, one or two months or never?		

Response	n	%
Almost every month	1	1
Some months but not every month	5	6
One or two months	4	5
Never	72	88
Unsure	0	0
Declined to answer	0	0
*May not add to 100% due to rounding		

Interviewers reported that these questions were both more comfortable for them to ask and for participants to answer. Further, zero participants declined to answer any of the questions.

CANHelp FSQ Participant Responses

200 people participated in data collection for this questionnaire. Of these, 196 people answered all of the questions on behalf of their household.

Table 3.4: CANHelp FSQ Participant Responses: All participating communities

SECTION A		
Q1. We'd like to know to what extent your [household], that is, you and everyone living in your house, relies on store-bought food. Would you say that most weeks the amount of store-bought food is…		
Response	**n**	**%***
Half or more of the total food your household eats	167	85
Less than half of the total food your household eats	28	14
Unsure	1	1
Decline to answer	0	0

Precisely what percent of your total food is store-bought, would you say?		
Response	**n**	**%***
0-19%	10	5
20-39%	8	4
40-59%	49	25
60-79%	53	27
80-100%	69	35
Unsure	7	4
Q2. Is there someone in your household or extended family who brings in food by:		
Option	**Yes (n)**	**%***
Fishing	169	86
Hunting or trapping	172	88
Berry picking	158	81
Gardening (household or community)	97	49
Unsure	1	1
Trading goods or resources	50	25
Unsure	1	1
Declined to answer	1	1
Receiving it from another household	153	78
Q3. Do you think that you are eating more, less, or about the same amount of traditional food than 5 years ago?		
Response	**n**	**%***
More now	39	20
26 of these participants lived in the community 5 years ago		
Less now	91	46
84 of these participants lived in the community 5 years ago		
About the same amount	64	33
61 of these participants lived in the community 5 years ago		
Unsure	1	1
Declined to answer	1	1
Q3a. Were you living in this community 5 years ago?		
Response	**n**	**%***
Yes	171	87
No	24	12
Declined to answer	1	1
Q4. Do you think that you are eating more, less, or about the same amount of traditional food than 15 years ago?		

Response	n	%*
More now	48	25
28 of these participants lived in the community 15 years ago		
Less now	102	52
92 of these participants lived in the community 15 years ago		
About the same amount	42	21
37 of these participants lived in the community 15 years ago		
Unsure	3	2
Declined to answer	1	1

Q4a. Were you living in this community 15 years ago?

Response	n	%*
Yes	158	80
No	37	19
Declined to answer	1	1

Q5. Have you noticed any recent changes in the quality or health of traditional plants or meals of land animals, birds or fish?

Response		n	%*
Yes		158	80
	93 participants had specific concerns, which is summarized in Appendix H		
No		37	19
Unsure		1	1

Q6. How concerned are you about environmental contaminants in the game, fish or other meats that you eat?

Response	n	%*
Not at all concerned	20	10
Somewhat concerned	49	25
Very concerned	120	61
Unsure	7	4

Q7. In your experience, how often do people you know get sick from eating store-bought food?

Response	n	%*
Often	36	18
Sometimes	75	38
Never	54	28
Unsure	31	16

Q8. In your experience, how often do people you know get sick from eating traditional food?

Response	n	%*

Often	1	1
Sometimes	28	14
Never	153	78
Unsure	14	7

Q9. At times, some families might say something like, ***"****We worried whether our food would run out before we got money to buy more."* In the last 12 months, did that happen often, sometimes, or never for your household?

Response	**n**	**%***
Often	18	9
Sometimes	42	21
Never	135	69
Unsure	1	1

Q10. At times, some families might say something like, "*We could not get the food we wanted to eat because of a lack of resources*." (By lack of resources, we mean your household did not have what you needed to hunt, fish, gather, or buy food.) In the last 12 months, did that happen often, sometimes, or never for your household?

Response	**n**	**%***
Often	21	11
Sometimes	56	29
Never	117	60
Unsure	1	1
Declined to answer	1	1

Q11. At times, some families might say something like, *"The food that we bought or harvested just didn't last, and we were not able to get more****."*** In the last 12 months did that happen often, sometimes, or never for your household?

Response	**n**	**%***
Often	29	15
Sometimes	62	31
Never	103	53
Unsure	2	1

Q12. At times, some families might say something like, ***"****We couldn't afford to eat healthy meals," or "Healthy meals just weren't available."* In the last 12 months did this happen often, sometimes, or never for your household?

Response	**n**	**%***
Often	31	16

Sometimes	50	26
Never	113	58
Unsure	2	1

Q13. Are there children under 18 in your household?

Response	**n**	**%***
Yes	73	37
No	116	59
Missing data	7	4

Q13a. At times, some families might say something like, *"We could only feed our children less expensive foods because we were running out of money to buy food."* In the last 12 months did this happen <u>often</u>, <u>sometimes</u>, or <u>never</u> for your household?

Response	**n**	**%***
Often	9	12
Sometimes	14	19
Never	50	68

Q13b. At times, some families might say something like, "We couldn't feed our children a healthy meal, because healthy food wasn't available" or "because we couldn't afford that." In the last 12 months, did that happen <u>often</u>, <u>sometimes</u>, or <u>never</u> for your household?

Response	**n**	**%***
Often	7	10
Sometimes	16	22
Never	50	68

SECTION B

124 participants were screened in for Section B.

Q14. [*Answer this question only if there are children under the age of 18 in the household.*] At times, some families might say something like, **"***The children were not eating enough because there wasn't enough food***."** In the last 12 months, did this happen <u>often</u>, <u>sometimes</u>, or <u>never</u> for your household?

Response	**n**	**%***
Often	2	4
Sometimes	11	23
Never	35	73

Q15. Thinking about the past 12 months, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough food?

Response	**n**	**%***

Yes	26	21
No	98	79
Q15a. If yes, how often did this happen?		
Response	**n**	**%***
Almost every month	8	31
Some months but not every month	13	50
Only 1 or 2 months	5	19
Q16. Thinking about the last 12 months, did you ever eat less than you felt you should because there wasn't enough food?		
Response	**n**	**%***
Yes	27	22
No	95	76
Unsure	2	2
Q17. Thinking about the last 12 months, were you ever hungry but didn't eat because you couldn't afford enough food OR were not able harvest food?		
Response	**n**	**%***
Yes	23	18
No	100	81
Unsure	1	1
Q18. In the last 12 months, did your weight change because you didn't eat enough healthy food?		
Response	**n**	**%***
Yes	18	15
No	101	81
Unsure	5	4
Q18a. If yes, did you…		
Response	**n**	**%***
Lose weight	12	67
Gain weight	6	33
SECTION C		
49 participants were screened in for section C		
Q19. Thinking about the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough food?		
Response	**n**	**%***
Yes	7	14
No	42	86

Q19a. If yes, how often did this happen?		
Response	**n**	**%***
Almost every month	1	17
Some months but not every month	3	50
Only 1 or 2 months	2	33
Q20. [*Answer this question only if there are children under the age of 18 in the household.*] Thinking about the last 12 months, did you ever cut the size of the children's meals because there wasn't enough food?		
Response	**n**	**%***
Yes	2	9
No	21	91
Q21. Thinking about the last 12 months, did any of the children ever skip meals because there wasn't enough food?		
Response	**n**	**%***
Yes	2	9
No	21	91
Q21a. If yes, how often did this happen?		
Response	**n**	**%***
Almost every month	1	50
Only 1 or 2 months	1	50
Q22. Thinking about the last 12 months, were the children ever hungry but you just could not get the food that was needed?		
Response	**n**	**%***
No	23	96
Missing data	1	3
Q23. Thinking about the last 12 months, did your children ever not eat for a whole day because there wasn't enough food?		
Response	**n**	**%***
No	23	96
Missing data	1	3
SECTION D		
All participants answered Section D.		
Q24a. Do you know your height?		
Response	**n**	**%***
Yes & Gave an answer	168	86
No	20	10
Declined to answer	7	4
Q24b. Do you know your weight?		

Response	**n**	**%***
Yes & Gave an answer	161	82
No	24	12
Declined to answer	11	6
Q25. Do you want to have your height and weight measured now?		
Response	**n**	**%***
Yes	55	28
No	164	84
No height or weight instrument available	31	16

Overall, the CAN*Help* FSQ was extremely well accepted by participants, with only 1 (less than 1%) "decline to answer" response for six of the 38 questions and sub-questions in sections A through C. The remaining four questions in section D, which exclusively related to BMI, had considerably less acceptability; 4 and 6%, declined to answer questions related to self-reported height and weight, respectively, and only 34% of eligible participants elected to have their height or weight measured.

Further, measurement of the BMI was problematic in the field. Due to baggage constraints, an accurate height-weight scale could not be carried from community to community, and researchers relied on borrowing instruments from health centres. When this was not possible, participants did not have the option of recording their height or weight (this affected participants from Old Crow & Teslin). Finally, though medical instruments are likely to have good accuracy, the differences in the accuracy

of weight scales and height measurements used across communities were likely to have been a source of random error.

*Agreement of the CDI and CAN*Help *FSQ food insecurity measures*

The CDI's ascertainment of food insecurity uses the rapid assessment item: "Did you or other household members worry food would run out before you had money to buy more?" This question was included in the Inuvik pilot FS questionnaire and in the CAN*Help* FSQ. To partially assess the validity of the CDI as a deprivation indicator for Arctic communities, I calculated the agreement between the CDI and CAN*Help* FSQ food insecurity using STATA's kappa measure of agreement function. Overall, the CAN*Help* FSQ scoring demonstrated good agreement with the CDI measure of food insecurity (Table 3.5).

Table 3.5: Agreement of the CDI and CAN*Help* FSQ food insecurity measures

CDI - Food Insecure Prevalence	Agreement with CANHelp FSQ
No	83%
Yes	87%
Total Agreement	84%

Acceptability of other socioeconomic variables collected in CANHelp Working Group community projects

Individual income

Annual individual income was assessed in four of nine CAN*Help* community projects for one representative of each household: 473 participants were asked about their individual income. Of these 473 participants, 275 gave a response; 198 participants either declined to respond or were unsure of their income, so the overall frequency of uninformative responses was 42%. Due to the high frequency of missing data, individual income data was not collected in subsequent community projects.

Household income

Annual household income was also assessed in four of nine CAN*Help* community projects. Of 944 eligible participants, 654 participants belonged to households in which a representative agreed to provide household demographic data. Of these 654 participants, CAN*Help* project staff recorded household income for 183 participants; household representatives of the remaining 471 participants either declined to respond or were unable to answer, with an overall missing data frequency of 72% of participants included in the household survey, and 81% of all eligible participants. Due to the large proportion of missing data, household income data was not collected in subsequent community projects.

Employment status

Employment status was assessed in all CAN*Help* community projects. Of 1422 eligible participants, 927 agreed to provide personal demographic data. Of these 927 participants, 891 participants provided their employment status; 36 participants declined to answer or had missing data, for a nonresponse frequency of 4%. Overall, acceptability of employment status was good relative to personal and household income, and thus this question was retained in the structured interviews for all community projects.

Acceptability of a tablet-based questionnaire in structured interviews

In 6 of the 8 communities where I conducted my research, I gave each participant I interviewed the option to complete either a paper-based or a tablet-based questionnaire. On the first day of data collection in Pelly Crossing, I noticed an error importing questionnaire data into Epi-info and discontinued tablet use until I debugged the problem. This was solved the last day of data collection in Pelly Crossing and was ready for full use again in Carmacks, after which all participants I interviewed could choose between completing a paper-based or tablet-based questionnaire. Participants who were interviewed by another CAN*Help* staff member when I was not available were not given the option to complete a tablet-based questionnaire. Of the 90 participants I interviewed in person who were not from Pelly Crossing, 72 (80%) chose to use the tablet-based questionnaire. The most common

reason offered for this preference was that participants wanted to "choose whatever method is easier [for the interviewer]"; the second most common reason offered was that the large text on the backlit tablet was easier to read compared to the paper version of the questionnaire, particularly for elders.

Due to the potentially sensitive nature of the questions, after explaining the purpose of my research, I gave all participants the option to self-administer the questionnaire either in private or over email; only 2 participants chose to do this over email. After receiving the emailed questionnaires, I checked them for errors and found that both were completed correctly. All participants who were interviewed in person or over the phone were comfortable being directed through the questions by the interviewer.

Overall, 117 (59%) of the 200 participants were interviewed in person or over the phone using a paper-based questionnaire; 79 (40%) of participants used a tablet to complete their interviews, and 2 (1%) self-administered their questionnaire over email.

After preliminary statistical analysis, I scheduled in-person community presentations to share survey results with project planning committees and community members at large. I provided copies of the questionnaire, including the frequency distributions of all responses, in addition to a report describing food insecurity prevalence as well as the crude estimated effect of food insecurity and social deprivation on *Hp* infection.

Community representatives in attendance universally valued the results and approved moving forward with further statistical analyses as planned.

Discussion

The adapted questionnaire was highly acceptable in participating project communities, the adjusted measures of food insecurity were approved by community project planning committees, and preliminary research results were very well-received. As well, tablet-based data collection was also feasible to implement in Canadian Arctic fieldwork. Participants tended to prefer the tablet to the paper-based questionnaire when offered, citing its enlarged text and backlight, or requested the option that was most convenient for the interviewer. I preferred to use the tablet because responses could be recorded directly into a database without the need for data entry, and because it was light-weight and did not require me to ship questionnaires with sensitive health information. Further, the tablet was encrypted and I kept it with me at all times, and thus there was less opportunity for sensitive information to be lost or stolen during the shipping, such as with paper-based documents. This suggests that tablet-based questionnaires may be the preferred option for field research in Arctic Canadian communities, though implementation may be limited by the available research budget.

Though initially flagged by literature review as a useful individual measure of food insecurity in individuals living in Arctic communities, BMI measurements were mostly unacceptable in Arctic community projects. Only 4% of participants declined to self-report their height and weight, but most participants declined to be measured. Further, measuring BMI in field research presents logistic challenges that limit its usefulness; in future iterations or adaptations of the CAN*Help* FSQ, BMI should be removed from the questionnaire.

Conclusion

Currently, most food insecurity research in Arctic communities relies on limited adaptation of the HFSSM. There is agreement in the literature that traditional foods must be incorporated in food security questionnaires, but there is no universally accepted approach to doing so. For this reason, I modified HFSSM questions and incorporated culturally acceptable Arctic Food Security indicators proposed by Nilsson *et al*[106]. Iterative review by community project planning committees and the CAN*Help* Working Group academic team produced a highly acceptable food security evaluation tool, with the exception of height and weight measurements. With minor adjustments, the CAN*Help* FSQ is a useful tool for assessing food insecurity in participating Arctic communities, and may be used in other Indigenous Canadian communities after adaptation based on thorough community consultation.

Chapter 4: Social inequity, gender, and *H. pylori* infection in Arctic Canada

Introduction

Helicobacter pylori are spiral-shaped, gram-negative bacteria that colonize the protective lining of the stomach, nearly always causing gastritis (inflammation of the stomach)[1]. *H. pylori (Hp)*-induced gastritis increases the risk of peptic ulcers, gastric atrophy, and stomach cancer[2,3]. Abundant evidence suggests that most *Hp* infection occurs from contact with the digestive fluids of an infected person, most often during childhood[4]. Much evidence shows that *Hp* prevalence is inversely associated with socioeconomic status (SES), though not consistently across all indicators within geographically defined communities[5]. Broadly, geographic variation in prevalence is associated with disparities in wealth; reported prevalence estimates range from 24% in Australia-New Zealand to 70% in Africa, with prevalence in Canada and the United States estimated at approximately 37%[6], though it should be noted that many available country-level estimates are limited by poor representativeness of screened population samples[7]. While recent evidence suggests prevalence is decreasing in affluent countries, prevalence remains high among disadvantaged groups[8]. Within geographically defined populations with smaller income differentials, education is the SES indicator most consistently associated with *Hp* prevalence; groups with higher levels of education experience substantially lower prevalence of infection[5].

Hp has a disproportionately high prevalence in northern Canada: prevalence >50% has been reported for Arctic communities, while prevalence estimated in southern Canada is closer to 30%[9,10]. The Canadian North *Helicobacter pylori* (CAN*Help*) Working Group is a collaboration of academic scientists, with northern community leaders and health care providers who investigate *Hp* infection to address community concerns. Community-driven projects conducted by this group have shown that Arctic Canadians with *Hp* infection have an elevated prevalence of severe chronic stomach inflammation, consistent with an increased risk of stomach cancer[11]. Residents of participating CAN*Help* communities are predominantly Indigenous, with 90% of community project participants identifying as First Nations, Inuit, or Métis.

Studies from around the world do not show large differences between men and women in *Hp* prevalence[12]. The literature includes scant information, however, on the joint impact of social inequity and gender on the disease burden from *Hp* infection. In Canada, women tend to have lower socioeconomic status than men. According to the most recent census data analysis, using data collected in 2011, women experienced a personal income disparity of approximately $16,100 on average compared to men[13]. While Canadian women are more likely to have a university or college degree than Canadian men, they are less likely to enjoy the benefits of those degrees: women are

less likely to be employed than men with the same qualifications, and are paid less for equivalent work[13].

Indigenous women in Canada experience substantial socioeconomic disadvantages compared to non-Indigenous women. In 2011, 12% of Indigenous women had a university degree compared to 28% of non-indigenous women[13]. Indigenous women and girls are more likely to live in poor quality homes, with 21% living in homes requiring major repairs, compared to 7% of their non-Indigenous counterparts[13]. Further, Indigenous women and girls are almost three times more likely than their non-Indigenous counterparts to live in crowded homes, which is associated with increased incidence of infectious disease and has deleterious effects on academic achievement[13]. Indigenous women in Canada are also more likely to be lone parents than non-Indigenous women. In 2011, 17% of women classified as "Aboriginal" and 8% of "non-Aboriginal" women led lone-parent households[13]. In Canadian surveys of self-reported health, a statistically validated measure of overall health status, less than half of women classified as "Aboriginal" report their health as "excellent" or "very good", a notably lower proportion relative to "Aboriginal" men and "non-Aboriginal" women[14]. In fact, "Aboriginal" women are more likely than "non-Aboriginal" women to be diagnosed with a chronic health condition[14].

As a general health indicator, low socioeconomic status, measured in diverse ways, is linked to poor chronic disease outcomes[15]. Though often used in research, household income is not an optimal indicator of population inequity for several reasons. Ascertainment of income using questionnaires and interviews typically results in low response rates and frequent reporting error[16]. A research participant may feel uncomfortable revealing their income to an investigator; they may report a higher level of income to avoid judgment or decline to respond. A participant may also incorrectly assess their household's income if they are not the primary income earner or if the income fluctuates from sporadic employment. This is particularly so where unemployment and underemployment are high, such as in Arctic communities. There may also be substantial differences between income and wealth across settings with respect to what a participant's income allows them to purchase and what resources are available to them. Further, as an average, static measure, income does not capture events that may influence socioeconomic status, such as instability due to the loss of a household income earner, or the loss of property[17].

The Canadian Deprivation Index is a statistically validated measure of material deprivation that does not use income data. Of several SES indices used in research in Canada (Table 4.1), the CDI is the easiest to capture accurately and the most useful for health research in its description of inequality: it has the best agreement with self-reported health, uses indicators highly relevant to health research, and allows

comparison at both individual and community levels[16]. Increased deprivation as measured by the CDI has been shown to have a dose-response relationship with the frequency of health outcomes including chronic disease, self-reported pain, injury, and oral health[16]. All three of the CDI's component measures (food security, education, and home ownership) have high response rates across census and health research surveys[16]. Of these component measures, only food security data had not been collected in CAN*Help* community projects before this research project.

Table 4.1: Indicators of socioeconomic status (SES) used in Canadian health research[16]

Deprivation Index	**Indicators used**
Pampalon[18]	High school completion Employment Average personal income Marital status Living alone (Y/N) Lone-parent (Y/N)
SEFI-2 (Socioeconomic Factor Index 2)[19]	Average household income Lone-parent (Y/N) Employment High school completion
VANDIX (Vancouver Area Neighbourhood Deprivation Index)[20]	High school completion University completion Employment Lone-parent (Y/N) Income Home ownership
OnDep (Ontario Deprivation Index)[21]	Income Level of education completed Employment Citizenship Family structure Home ownership
CDI (Canadian Deprivation Index)[16]	Home ownership Level of education completed Severity of food insecurity

The government of Canada defines food security as a household's financial ability to access an adequate amount of high-quality, healthy food[22, 23]. Food insecurity has been disproportionately high in Indigenous populations in Canada for as long as food security has been monitored in Canada: one of the earliest estimates, collected in 1998 and reported in 2001, demonstrated that Indigenous Canadians had 1.5 [95% CI: 1.1, 2.1] times the odds of being food insecure compared to other Canadian-born ethnicities [17]. Canadian census reports show that the prevalence of food insecurity has increased steadily across Canada since 2001, particularly in northern communities[23]. According to the 2012 census (the most recent census to collect food security data from all provinces and territories), 28% of households classified as Aboriginal reported some level of food insecurity, more than double the national average of 13%[23]. These values are likely to underestimate the food insecurity gap between Indigenous and non-Indigenous Canadians, given that food security data is not collected from on-reserve households - approximately half of the Indigenous population of Canada - and on-reserve households have been shown to have a higher overall prevalence of household deprivation compared to off-reserve households[24]. In a 2011 survey conducted across 16 Northwest Territory Indigenous communities, more than 90% of respondents reported reducing portion size, skipping meals, or remaining hungry after a meal because they could not afford enough food[25].

Other evidence has shown that households with children are more likely to be food insecure (16% of Canadian households with children in 2012); in 2012, 20% of children in Yukon and 32% of children in NWT lived in food insecure households[23]. Food insecurity affects unpartnered women with children disproportionately: in 2012, 34% of unpartnered women living with children or teenagers experience food insecurity, as well as 15% of unpartnered women living with their adult children[23]; in contrast, food insecurity prevalence among partnered adults not living with children was 6%[23]. Food insecurity is also associated with other, non-income indicators of socioeconomic status: in the 2012 census, 22% of renters in Canada reported food insecurity, compared to 6% of homeowners[26]. The Government of Canada defines severe food insecurity as frequently missing meals, reducing food intake, and/or going days without food, as reported by the head of household; as well, severe household food insecurity is the level at which children experience chronic hunger[26]. Nationwide, 2.6% of Canadians were severely food insecure in 2012[23]; in contrast, severe food insecurity affected 18.5% of Nunavut households, 4.4% of NWT households, and 3.7% YT households[23].

Food insecurity is a complex public health concern. According to a 2001 report of national Canadian data, those living in food insecure households were over twice as likely to describe their health as "poor" or "fair" than those living in food secure households[17]. The severity of food insecurity has been reported to have a gradient

effect on several mental health outcomes, including, but not limited to, depression, anxiety, and suicidal behavior[28]. Food insecurity also appears to be associated with development of chronic diseases such as diabetes and heart disease, as well as adverse health outcomes: compared to Canadians living in food secure households, those living in food insecure households were more likely to report having at least three chronic health conditions after adjusting for age, sex, and household income[17].

Food insecurity is also emerging as a cause of chronic infectious diseases. Food insecurity is highly correlated with poor nutrition, and deficiencies in essential nutrients such as vitamins A, C and D, or zinc, copper, and selenium are known to compromise immunity and increase susceptibility to infectious diseases[17]. Compatible evidence suggests that food insecure households are burdened with greater exposure to infectious disease[29] and that food insecurity is associated with both reduced immune suppression and poor treatment adherence, especially for patients who must take medications with food[30]. Recent evidence revealed elevated levels of biomarkers for chronic inflammation among food insecure patients[29]. Thus, food security may influence the onset, severity, and persistence of *H. pylori* infection. However, few reports in the literature present information on the relation of food security to *H. pylori* prevalence.

Objectives

The objective of my research was to address concerns voiced in participating CAN*Help* communities about the effect of socioeconomic deprivation on the prevalence of *Hp* infection. More specifically, I aimed to estimate the effect of socioeconomic deprivation indicators (such as food insecurity, home ownership, household income, and the CDI) as well as other relevant demographic variables (gender, gender stratified by partnership status, ethnicity, age, children in household) on the prevalence of *Hp* infection. I started by describing the food security status of CAN*Help* project participants using newly collected data [Chapter 3], and assessing the validity of the CDI as a deprivation indicator for Arctic communities. Because previous analyses of CAN*Help* data have not investigated gender-based inequities, and because of the vulnerability to poverty of unpartnered women with children, this research examined the frequency of *Hp* infection in women relative to men and in members of households led by unpartnered women relative to members of other households. Finally, I aimed to assess whether gender or gender stratified by partnership status modified the effect of socioeconomic deprivation indicators on the prevalence of *Hp* infection.

Methods

Study Design

My thesis research was conducted as a component of a broader investigation of the disease burden from *Hp* infection carried out in the CAN*Help* Working Group's community projects in northern territories in Canada during 2007-2017. These projects use community-driven participatory research methods in which local planning committees collaborate with academic researchers on the goals and methods of each project. My thesis research uses a cross-sectional design to describe the effect of SES on *Hp* prevalence in study population subgroups in participating Arctic Canadian communities during the time each community project was active.

Setting

Participating communities (with year of project launch in parentheses) include Aklavik (2007), Fort McPherson (2012) and Inuvik (2017) in the Northwest Territories, and Old Crow (2010), Ross River (2016), Teslin (2016), Pelly Crossing (2017) and Carmacks (2017) in Yukon. Of the five Yukon communities, Ross River, Teslin, Pelly Crossing and Carmacks are accessible by road year-round. Old Crow is only accessible by air. Of the three NWT communities, Inuvik is accessible by road year-round. Inuvik serves as the main source of store-bought food for Fort McPherson and Aklavik community members. Fort McPherson and Aklavik are accessible by ice road during winter; in spring and summer, Fort McPherson is accessible by road with a

ferry crossing, while Aklavik is accessible only by air and by private boat or barge service.

Participants

My thesis research uses data collected in community projects approved by the University of Alberta Health Research Ethics Board ("Addressing Community Concerns about Risks from *H. pylori* Infection in the Circumpolar North" (ID: PRO000007868)) and conducted in Yukon and the Northwest Territories, which require territorial licenses. The Northwest Territories Aurora Research Institute (license number 15785) and Yukon Tourism and Culture (Scientist and Explorers License 16-78S&E) approved all questionnaires used in this research. Starting in Spring 2017, I contacted CAN*Help* community project planning committees to discuss my research proposal. Eight of nine CAN*Help* community projects had planning committees who saw value in bringing this research to their communities and agreed to consult on the project design. Tuktoyaktuk did not have a planning committee to consult and the community health representative who served as the Tuktoyaktuk project consultant was not available for consultation; thus, I did not carry out any research activities in this community.

I invited all CAN*Help* project participants with education and home ownership data to participate in my thesis research, as well as other participants who volunteered to be

interviewed about food security. In CANHelp project communities, a large proportion of households had multiple members participate. One representative of each household provided household data, such as home ownership. Individual household members provided individual data such as age, ethnicity, and education. If home ownership or education data was not available for participants who volunteered to be interviewed about food security, these variables were ascertained during the food security interview. To maximize precision, I strived to include as many participants as possible in the available time.

Variables – Definitions and Measurement

Outcomes

H. pylori infection. I use the prevalence of *H. pylori* infection as a disease burden variable. Baseline *H. pylori* infection status was ascertained upon enrollment in CAN*Help* Working Group community projects, during 2008-2017; 1338 participants were screened by urea breth test (UBT) and 407 participants had gastric tissue biopsies examined by histopathology and culture. For participants with multiple tests, *Hp* status was classified by combining results. When results were discordant, an algorithm was used to classify participants based on the probability that their *Hp* status was positive or negative. In an analysis of 272 CAN*Help* participants with data from all three tests, UBT and histopathology had excellent agreement (97%), while

culture diverged from UBT (86%) and histopathology (87%) more frequently.[113] The estimated sensitivity and specificity of UBTs completed in CAN*Help* projects (comparing against histopathology as the gold standard) are 96% [95 CI 94-99%] and 97% (95 CI 94-100%) respectively; the estimated sensitivity and specificity of histopathology in CAN*Help* projects (comparing against UBT as the gold standard) are 99% (95 CI 98-100%) and 91% (95 CI 85-97%), respectively.[113]

Exposures

Food security

Conceptual definition and framework. Food security is a complex, multidimensional socioeconomic phenomenon. While the wording of the Government of Canada's multidimensional definition[22] (financial ability to access an adequate amount of high-quality, healthy food) implies a dichotomous variable (access to an adequate amount or not), 3 dimensions of this definition ("adequate amount", "high-quality", "healthy food") have no straightforward definition; as well, dependence on access facilitated by finances excludes subsistence food sources. Food security can be conceptualized, for households or individuals, in a more straightforward and comprehensive manner as a health-sustaining gradient of the combined quantity and quality of obtainable food. Even with this simplification, however, food security remains multidimensional, requiring consideration of multiple indicators for comprehensive ascertainment.

Measurement. The Government of Canada developed the Household Food Security Survey Module (CHFSSM)[22]. The CHFSSM assesses food security based on how often the following occurs due to insufficient income: food shortages, unbalanced meals, low-quality foods, meals skipped, days spent without food, inadequate portion sizes, and weight loss. While the CHFSSM is a useful tool to measure food security in southern urban centers, it does not reflect the Arctic Canadian context, including subsistence food sources. Participants in pilot food security surveys conducted in Arctic Canadian community-driven research projects, including those with results reported in the literature[105] as well as CAN*Help* projects, have suggested adapting the CHFSSM to include locally harvested and traditional foods. Further recommendations in the literature resulted from a 2012 series of workshop discussions that included representatives from 7 Arctic countries who proposed six indicators of food security for use in developing a universal tool to measure food security in Arctic populations[106]. These indicators were: healthy weight, traditional food proportion in diet, monetary food costs, non-monetary food accessibility, prevalence of food-borne disease, and prevalence of food-related contaminants[106]. Other proposed measures included accessibility of hunting, fishing, collecting, or herding equipment, accessibility of sufficient land area, environmental conditions suitable for obtaining traditional food, and the gifting or exchange of traditional food for other goods or services[106].

Questionnaire Development. Because food security was not assessed in CAN*Help* community projects before 2017, I created my own questionnaire to ascertain food security. I began by conducting a pilot project in conjunction with ongoing data collection in project communities. To collect more nuanced information on food security in Arctic communities for my thesis project, I developed a more comprehensive questionnaire. I selected questions based on recommendations from a literature review that examined community members' assessments of how well food security questions reflect realities in Arctic communities, as well as suggestions from community project participants and interviewers. I used the resulting 34-item CAN*Help* Food Security questionnaire (hereon referred to as the CAN*Help* FSQ) (Appendix B) for my thesis analysis. I described the development of the CAN*Help* FSQ previously [Chapter 3].

Variable Definition. I defined food security in four ways. First, as the CDI Food Security Score, an ordinal variable that classifies the severity of household food insecurity within the past 12 months (Never food insecure / Sometimes food insecure / Often food insecure), based on the question used to ascertain food security status for the CDI: "At times, some families might say something like, *'We worried whether our food would run out before we got money to buy more.'* In the last 12 months, did that happen <u>often</u>, <u>sometimes</u>, or <u>never</u> for your household?" Second, as CDI Food Insecurity Status, a dichotomous classification of the CDI Food Security Score (Never food

insecure/ Ever food insecure). Third, as Household Food Security, an ordinal variable that classifies the severity of household food insecurity within the past 12 months (Never food insecure / Sometimes food insecure / Often food insecure), from the CANHelp FSQ (Appendix B), using the scoring criteria in Table 4.2. Fourth, as Household Food Insecurity Status, a dichotomous classification of Household Food Security (Never food insecure / Ever food insecure).

Table 4.2: Canadian Household Food Security Survey Module Scoring[22]

Food Security Status		
Category Labels	**Category Description**	
	10-Item Adult Food Security Scale	**8-Item Child Food Security Scale**
Food Secure	*no, or one, indication of difficulty with income-related food access* *0 or 1 affirmed response*	*no, or one, indication of difficulty with income-related food access* *0 or 1 affirmed response*
Food Insecure, Moderate	*indication of compromise in quality and/or quantity of food consumed*	*indication of compromise in quality and/or quantity of food consumed*

	2 to 5 affirmed responses	*2 to 4 affirmed responses*
Food Insecure, Severe	*indication of reduced food intake and disrupted eating patterns* *≥ 6 affirmed responses*	*indication of reduced food intake and disrupted eating patterns* *≥ 5 affirmed responses*

Household Status (derived from Adult and Child Status)	
Food Secure	*Both adult and child status are food secure*
Food Insecure, Moderate	*Either adults or children, or both adults and children, in the household are moderately food insecure, and neither is severely food insecure*
Food Insecure, Severe	*Either adults or children in the household are severely food insecure*

CDI

I calculated the CDI value for each participant (Table 4.3) and household using the CDI Food Security Score, Education, and Home Ownership data (see Appendix A for ascertainment details). Education and home ownership were ascertained in

CAN*Help* Working Group community projects during 2007-2017 by interviewer-administered questionnaire (Appendix D, G). I dichotomized home ownership into two categories: home ownership; and rented or band housing, with home ownership reflecting higher SES. I categorized highest educational attainment among all household members into an ordinal scale: less than high school; high school diploma, equivalent, or trades certification; college or university degree.

Table 4.3: The Canadian Deprivation Index[16].

Education	**Home Ownership**	**Food Security**
0: Degree higher than high school	0: Owns home	0: Always secure
1: High school diploma or equiv.	1: Does not own home	1: Sometimes insecure
2: Less than high school	--	2: Often insecure

Raw Score	**CDI Score**	**Interpretation**
0	1	Least Deprived
1	2	
2	3	
3	4	

4,5[a]	5	Most Deprived

[a] Raw scores of 4 and 5 are grouped together because very few Canadians have a raw score of 5[16].

Other socioeconomic deprivation indicators

Additional socioeconomic indicators (sex, children in household, unpartnered female head of household) were ascertained in CAN*Help* Working Group community projects during 2007-2017.

Effect Modifiers

In my analysis, I assessed whether gender, and/or gender stratified by partnership status, modifies the effect of socioeconomic deprivation. This analysis used sex (male, female) as a surrogate variable for gender. A component of this analysis considers the influence of gender on socioeconomic status; while sex and gender are not always congruent, CAN*Help* projects did not collect information on gender identity separate from sex. Thus, sex was used as a surrogate variable for gender. Other variables assessed as modifiers include whether the household was led by an unpartnered woman (households with an adult [age 18 or older] or teenage female resident and no other adult resident under age 65), and whether there were children in the household (any, none).

To assess whether gender or gender stratified by partnership status modified the effect of socioeconomic deprivation on the prevalence of *H. pylori* infection, I compared the effect of deprivation as measured by the CDI on *Hp* infection across strata of sex, households led by unpartnered women compared to other households, and households with children compared to households without children. I then estimated unadjusted ORs for the effect of deprivation, as measured by the CDI, on *Hp* infection prevalence separately for men, women, participants in households led by unpartnered women, participants from households not led by unpartnered women, participants in households with children, and participants in households without children. I assessed effect-measure modification by comparing ORs across strata to see if stratum-specific ORs differed in value beyond what would be expected by random variation. I then conducted tests of homogeneity to assess the precision of stratum-specific effects.

Potential Confounders

As potential confounders, I examined the following variables, ascertained in CAN*Help* Working Group community projects during 2007-2017 by interviewer-administered questionnaire (Appendix D): age at project enrollment (categorized using mid-decade boundaries, with ages 0-14 grouped in one category, as 0-14, 15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75+), and ethnicity (Indigenous and mixed ethnicities that include Indigenous; Non-Indigenous). In the literature, age has a strong positive association

with *Hp* prevalence in most studies that include broad age ranges, though some reports show declines or plateaus in *Hp* prevalence among the elderly. While a monotonic positive trend has not been observed in CAN*Help* community project participants, *Hp* infection prevalence is higher in adults than in children[30]. Age may confound the relationship between socioeconomic status (as measured by the CDI) and *Hp* infection, because age is also related to socioeconomic indicators; for example, Canadian census data from 2016 demonstrates that the proportion of those who have obtained a high school diploma or university-level education decreases with increasing age. [114] Similarly, the frequency of home ownership and food insecurity are likely to differ by age, though these relationships have not been investigated in CAN*Help* project analyses to date.

Among CAN*Help* project participants, Indigenous ethnicity is strongly associated with having been born in a Canadian Arctic community. Few non-Indigenous participants were native to the participating communities or to northern Canada in general. Further, non-Indigenous participants mainly comprised nurses and other professionals on short-term employment contracts, residing in rented housing, thus excluding them from CDI Category 1 (Least Deprived). Previous analysis of CAN*Help* data has shown that non-Indigenous participants have a much lower *Hp* prevalence than Indigenous participants. Given these circumstances, ethnicity is likely to confound the relationship between CDI level and *Hp* prevalence. In preliminary

analyses (see section *Study size and precision), H. pylori* prevalence was higher in CDI Category 1 (Least Deprived) than in the reference category (CDI Category 2), a result that may reflect confounding by ethnicity.

Strategies for Safeguarding Validity

The questionnaire-building component of my thesis research incorporated strategies to maximize construct validity in ascertaining food security. In addition to piloting a preliminary food security questionnaire and incorporating pilot feedback to construct the final version of the CAN*Help* FSQ, I consulted community partners on the content of the questionnaire to ensure appropriateness and completeness. I also conducted a literature search for validated questions proposed by Indigenous informants and questions used in other community-driven projects. Finally, I circulated the CAN*Help* FSQ for research team and planning committee review to ensure each question was designed optimally to measure its intended indicator before using it to collect data.

With the help of research team members, I invited all participating CAN*Help* communities to engage in my project to maximize the extent to which the study population represents the participating Arctic communities in Northern Canada. To reduce the potential for selection bias, the pilot questionnaire was incorporated into data collected when participants enrolled in new community projects, allowing for

many households to participate. I also arranged opportunities for participants to respond to the 34-item CAN*Help* FSQ through in-person interviews in each community, or alternately over the phone or by email, to make participation as accessible as possible. To maximise engagement in long-term follow up activities, I called all eligible participants in each community and encouraged them to participate regardless of *Hp* infection status, and included a prize draw as an incentive.

In July 2017, CAN*Help* Working Group leads held a two-hour workshop on best practices for interviewing participants using questionnaires in epidemiological research, which I attended along with other previously untrained CAN*Help* staff who would be interviewing project participants. As well, we received training on the CAN*Help* Working Group's general data collection procedures. These best practices and procedures were available to me in the CAN*Help* Working Group's Manual of Procedures. Further, I trained all field staff who would be administering the 34-item questionnaire on how to screen for eligibility for sections B, C and D of the questionnaire.

After data collection concluded, I assessed the frequency of missing data in the CAN*Help* FSQ [Chapter 3] to assess the potential for selection bias. I also examined differences in key demographic variables, as well as the proportions of missing data, between subgroups in my analysis and all CAN*Help* community project participants.

I shared preliminary results with community project planning committees and community members for feedback on how well the frequency distribution of deprivation measured by the CDI reflected the distribution of socioeconomic status within their communities. I completed iterative model building, outlined in Statistical Methods below, and conducted goodness-of-fit tests to assess model validity.

Statistical Methods

My analysis uses the prevalence odds ratio as the measure of association for the effect of the exposures of interest on *Hp* prevalence for reasons articulated by Pearce (2004)[115]. Pearce proposed the prevalence odds ratio (POR) as a standard effect measure for analysis in cross-sectional (prevalence) studies over the prevalence ratio (PR) for two reasons: first, if the exposure of interest has no effect on the average duration of disease in a steady-state population, the POR provides an unbiased estimate of the incidence rate ratio, the effect measure of interest in studies that seek to identify risk factors for disease when comparing risks (incidence proportions) is not warranted. The outcome of interest must be rare for the PR to provide unbiased estimation of the risk ratio. Second, using the POR provides analytic consistency, and thus permits direct comparison, between the prevalence study and any future case-control studies that may be conducted from the same study population.

I used Hosmer and Lemeshow's purposeful selection method as outlined by Bursac et al[116] to construct a multivariable logistic regression model to estimate ORs for the measure of the effect of selected variables on *Hp* prevalence while controlling for the effects of other variables. I entered each variable separately into a logistic regression model with *Hp* infection as the outcome; those with a Wald p-value <0.25 were selected as candidates for multivariable analysis. I assessed categorical variables, both nominal and ordinal, for purposeful selection using the likelihood ratio (LR) chi-squared test. I further assessed ordinal variables using STATA's contrasts of marginal linear predictions function. I then conducted iterative variable selection in a logistic regression model with all candidate variables included, selecting covariates to be removed from the model if their p-values were <0.1; I removed each such covariate one at a time and retained those that appeared to be confounders based on a change in estimates criteria (any remaining parameter estimate is greater than 15% compared to the full model). I then added any variable not selected for the original model back in one at a time with the covariates and confounders that were retained in the model to identify variables that improve the model in combination with other variables and retained those with p-values <0.15 to arrive at the main model.

Because one of the assumptions of the logistic regression model is that all outcomes are independent of one another, an assumption that is violated by *Hp* infection clusters within household and communities, I assessed whether random effects

parameters improved the fit of the model using an LR test. I conducted all statistical analyses using STATA IC 14 statistical software, combining the pilot data with the CAN*Help* FSQ data wherever this was feasible to maximize statistical precision.

Data Collection and Entry

Interviewers administered the CAN*Help* FSQ during project recruitment at the time of project launch in two communities (Pelly Crossing, Carmacks). In six other communities, project staff invited participants in long-term follow-up activities to respond to a questionnaire that explored the relation of food security to *H. pylori* infection. In Teslin, Ross River, Inuvik and Fort McPherson, food security data was collected during post-treatment activities when participants who tested positive for *H. pylori* and underwent treatment had post-treatment breath tests to ascertain treatment success. In the six previously established community projects, I recruited participants during September 2018 through May 2019, targeting households with existing home ownership and education data. Four other CAN*Help* Working Group team members helped me conduct interviews. I uploaded directly to a database the questionnaire responses collected by tablet. To reduce data entry error, I arranged for double entry of all 113 paper questionnaires into two separate databases and compared the datasets for discrepancies before merging them with the tablet database.

Results

Study population

Table 4.4 describes the frequency distributions and data availability of key study variables in the following study populations: all participants in the 9 CANHelp projects; participants with pilot food security data; participants with CANHelp FSQ data; participants with CDI data. Of the 1422 total eligible participants, 292 participants from 205 households had pilot questionnaire data; a group of 366 participants from 194 households had complete CANHelp FSQ data; 32 participants were removed for missing CDI data and 71 of the 292 pilot participants with data from the Inuvik version of the Pilot FSQ, which ascertained CDI food security data, were added to this group, for a total of 396 participants with CDI data (Figure 4.1 illustrates participant inclusion criteria). In general, the frequency distribution of key demographic variables (age, sex, ethnicity, home ownership, children in household) was similar across all four groups. Due to the inclusion of additional participants from the Inuvik pilot questionnaire, participants from Inuvik were overrepresented among participants with complete CDI data (23%) relative to other communities; participants from Inuvik only represented 9% of all CAN*Help* participants.

Figure 4.1: Food Security Questionnaire (FSQ) Data Collection and Participant Inclusion Flowchart

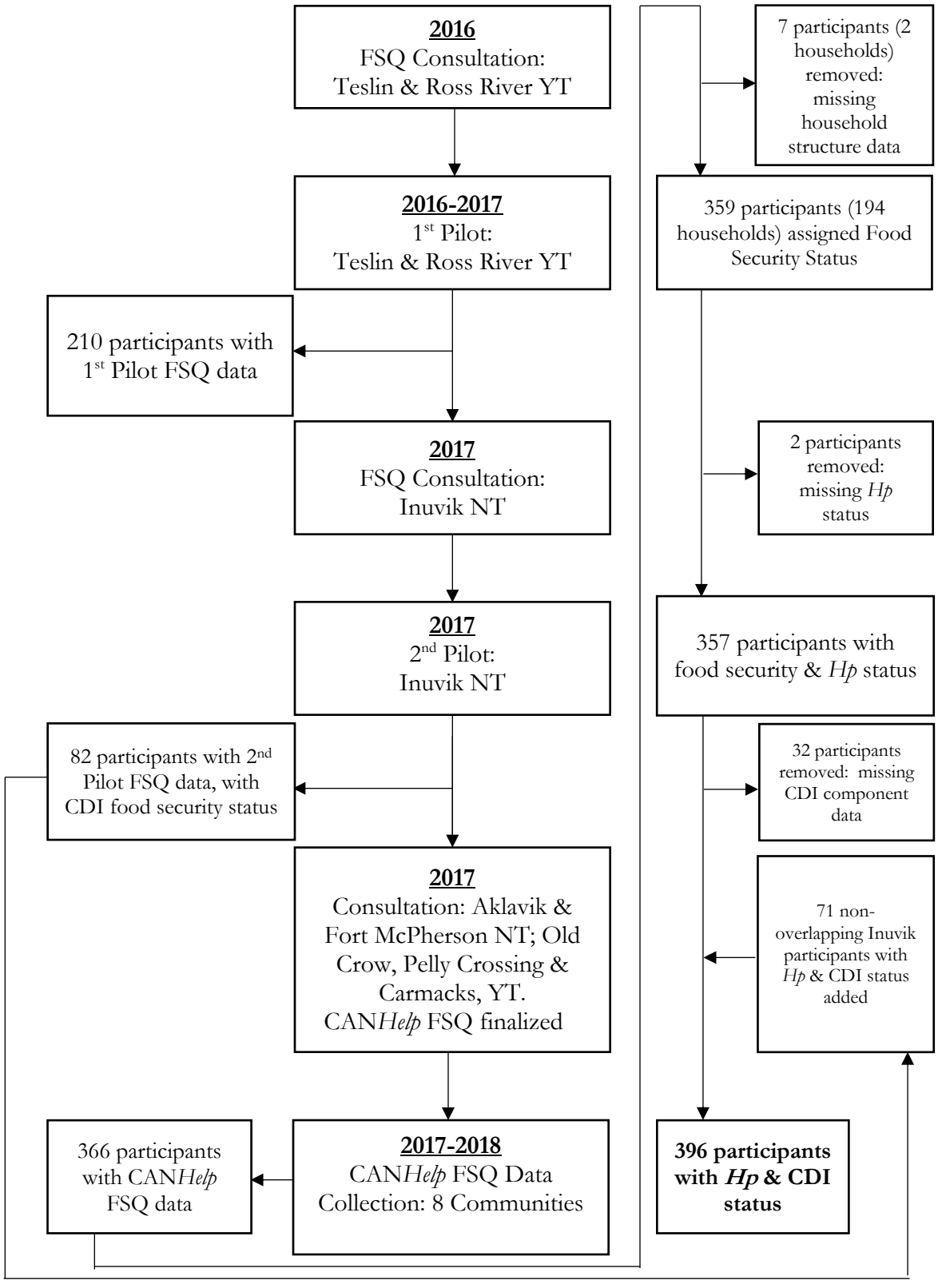

Table 4.4: Distribution of key variables for subsets of the study population

		Study Population Subset							
		All CAN*Help* participants		**Members of households with Pilot FSQMembers of households with Pilot FSQ**		**Members of households with CAN*Help* FSQ**		**Members of households with CDI data**	
		n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
	Totals:	1422	100	292	100	366	100	396	100
Age									
	0-14	171	**12**	7	**9.5**	50	**14**	43	**11**
	15-24	180	**13**	20	**7.0**	46	**13**	38	**10**
	25-34	209	**15**	40	**14**	36	**10**	42	**11**
	35-44	211	**15**	53	**19**	54	**15**	65	**16**
	45-54	259	**18**	56	**20**	72	**20**	78	**20**
	55-64	227	**16**	54	**19**	74	**20**	89	**22**
	65-74	115	**8**	29	**10**	28	**7.7**	41	**10**
	74-84	39	**3**	6	**2**	6	**1.6**		
	85-94	8	**1**	0	**0**	**0**	**0**		
	95+	1	**0.07**	0	**0**	**0**	**0**		
Sex									
	Male	609	**43**	110	**37**	156	**43**	153	**39**
	Female	813	**57**	182	**62**	210	**57**	**243**	**61**
Ethnicity									
	Non-Indigenous	209	**16**	86	**30**	45	**12**	**67**	**17**
	Indigenous	1127	**84**		**70**	318	**87**	**327**	**83**
	Inuit/Inuvialut	348		23		53			
	First Nations					239			
	Gwichin	425		16		102			
	Kaska	59		54		26			
	Tinglit	52		50		15			
	NorthernTutchone	80		1		71			
	Slavey	8		2		2			
	Dene	7		1		1			
	Other FN	7		4					
	Multiple FN	35		17		15			
	Not specified	16		**0**		7			
	Metis	17		**0**		3			
	Mixed Inuit, Metis, or FN	17		1		3			
	Indigenous, Not Specified	6		2		2			
	Mixed Indigenous and Non	50		27		18			
	Missing	86		**4**		3		**2**	
Community									
	Aklavik	392	**28**	**--**		73	**20**	59	**15**
	Old Crow	208	**15**	**--**		41	**11**	32	**8**

	Fort McPherson	237	**17**	**--**		57	**16**	49	**12**
	Tuktoyaktuk	107	**8**	**--**		**--**		**--**	**--**
	Ross River	107	**8**	94	**32**	39	**11**	34	**9**
	Teslin	124	**9**	116	**40**	32	**8.7**	30	**8**
	Inuvik	127	**9**	82	**28**	19	**5.2**	90	**23**
	Pelly Crossing	56	**4**	**--**		55	**15**	54	**14**
	Carmacks	64	**4**	**--**		50	**14**	48	**12**
Education									
	CDI – 2								
	Less than Grade 12	550	**43**	65	**22**	140	**38**	141	**36**
	CDI – 1								
	High School or Equiv.	169	**13**	31	**11**	39	**11**	152	**38**
	<HS, plus trade or cert	279	**22**	85	**29**	110	**30**		
	CDI – 0								
	College or uni <Bachelors	127	**10**	45	**15**	39	**11**	103	**26**
	Bachelors or higher	153	**12**	61	**21**	28	**10**		
	Missing data	144		5		10		**--**	
Home Ownership									
	Owns Home	473	**42**	128	**44**	151	**41**	176	**44**
	Rent Public Housing	421	**37**	102	**35**	198	**54**	220	**56**
	Rent Private Housing	114	**10**	55	**19**				
	Other	122	**11**	3	**1**	0		0	
	Unsure	4		0		0		0	
	Declined to respond	3		0		0		0	
	Missing data	9		4		17		**-**	
Children under 15 in Household									
	Yes	506	**45**	114	**39**	157	**45**	165	**41**
	No	610	**55**	178	**61**	195	**55**	230	**58**
	Missing data	306		5		14		1	
***H. pylori* Status**									
	Negative	627	**46**	181	**63**	138	**38**	184	**46**
	Positive	727	**53**	102	**36**	219	**60**	212	**54**
	Uncertain	24	**2**	3	**1**	9	**2**	0	
	Missing data	44		**0**		0		0	

Food Insecurity as defined for the Canadian Deprivation Index

Table 4.5 describes the frequency distributions of CDI Food Insecurity Scores in 429 CAN*Help* participants from households that completed either the CAN*Help* FSQ or the Inuvik pilot questionnaire (regardless of CDI data completeness); Table 4.6 describes the overall prevalence of CDI Food Insecurity among CAN*Help*

participants. Overall, 68% of participants were never food insecure, and severe food insecurity was rare (9%).

Table 4.5: CDI Food Security Scores for 429 participants with complete Food Security CDI Data,[a] Western Arctic Communities, Canada, 2017-2018

Food Security (CDI Deprivation Score)	**n**	***(%)***
0 – Never food insecure	293	68
1 – Sometimes food insecure	97	23
2 – Often food insecure	39	9

[a]Answered FS Question: "did you or other household members worry food would run out before you had money to buy more?"

Table 4.6: CDI Food Insecurity Status for 429 participants with complete Food Security CDI Data,[a] Western Arctic Communities, Canada, 2017-2018

Food Security (Dichotomized CDI Score)	**n**	***(%)***
0 – Never food insecure	293	68
1 – Ever food insecure	136	23

[a]Answered FS Question: "did you or other household members worry food would run out before you had money to buy more?"

Social deprivation as measured by the CDI

Table 4.7 describes the distribution of participants with complete data for CDI scoring. Of note, the distribution of the five CDI levels among CAN*Help* participants was bell-shaped, with Level 3 as the mode, distinct from the mode across Canada, which is Level 2.

Table 4.7: CDI Score for all participants with complete data for scoring

CDI Score	Number of participants	Proportion (%)[a]
1	43	11%
2	100	25%

3	112	28%
4	105	26%
5	44	11%
Total:	404	

[a]Does not add to 100 due to rounding

*Food Insecurity as defined for the CAN*Help *FSQ*

Table 4.8 describes adult food insecurity in participating households using the Canadian Household Food Security Survey Module Scoring of CAN*Help* FSQ responses. Most adults in participating households (60%) were food secure by this measure. Severe food insecurity was rare (11%).

Table 4.8: Adult Food Security Results for 194 households from the CAN*Help* FSQ, Western Arctic Communities, Canada, 2017-2018

	Households	
Food Security	**n (households)**	**Proportion (*%*)**
Always Food Secure	116	60
Sometimes Food Insecure	56	29
Often Food Insecure	22	11

Table 4.9 describes child food insecurity scores using the Canadian Household Food Security Survey Module Scoring of CAN*Help* FSQ responses. Of 72 households that had children under the age of 18, 52 (74%) households were always food secure. There was no severe food insecurity among children in participating households.

Table 4.9: Child Food Security Results for 72 households with children under the age of 18 from the CAN*Help* FSQ, Western Arctic Communities, Canada, 2017-2018

	Households	
Food Security	**n**	**Proportion (*%*)**
Always Food Secure	52	74
Sometimes Food Insecure	19	26
Often Food Insecure	0	0

Table 4.10 describes Household Food Security. 59% of households were always food secure; severe food insecurity was rare (11%).

Table 4.10: Household Food Security Results for 194 households, from the CAN*Help* FSQ, Western Arctic Communities, Canada, 2017-2018

	Households	
Food Security	**n (households)**	**Proportion (*%*)**
Always Food Secure	115	59
Sometimes Food Insecure	57	30
Often Food Insecure	22	11

Responses to CANHelp FSQ items not included in scoring are described in Appendix H and I.

To further assess food insecurity in participants, I compared the prevalence of household food insecurity across categories of food-related variables deemed relevant by community partners: traditional food proportion in diet; having family members who fish, hunt, pick berries, garden, trade goods or resources for food, or receive it

from another household; and BMI; Appendix I describe the frequency distribution of food insecurity across these variables. In general, households that had access to traditional foods and the means to access them were less likely to be food insecure, though these prevalence estimates were imprecise. Food insecurity prevalence did not appear to differ meaningfully across categories of BMI.

Table 4.11 presents the distributions of Household Food Security and Household Food Insecurity Status for 359 individuals from 194 participating households, with each individual assigned the household value. The distribution of food insecurity across individuals was very similar to the distribution across households (within 1%). CAN*Help* FSQ results demonstrated good agreement (84%) with the CDI measure of food insecurity. Thus, the CDI measure of food insecurity seems viable as a rapid-assessment method.

Table 4.11: Food Security Score and Food Insecurity Status for 359 individuals from 194 participating households, Western Arctic Communities, Canada, 2017-2018

Food Security Score	**n**	***(%)***
Never food insecure	215	60
Sometimes food insecure	99	28
Often food insecure	45	12
Food Insecurity Status	**n**	***(%)***
0 – Never food insecure	215	60
1 – Ever food insecure	144	40

Food insecurity as measured by the CANHelp FSQ and Hp infection prevalence

Table 4.12 describes *Hp* infection prevalence within categories of Household Food Security among individuals in participating households. *Hp* infection prevalence was modestly elevated among food insecure participants, though this estimate was imprecise due to the relatively small number of participants who were often food insecure.

Table 4.12: *Hp* prevalence by Household Food Security Status for 350 participants with *Hp* status data, Western Arctic Communities, Canada, 2017-2018

Food Security	n (total: 350)	*H. pylori* + (%)	95% CI
Always Food Secure	212	58%	52, 65
Sometimes Food Insecure	95	68%	58, 78
Often Food Insecure	43	60%	44, 75

Social deprivation indicators and Hp infection prevalence

Table 4.13 compares the unadjusted prevalence odds ratios for the association of key demographic variables with *Hp* infection in three subpopulations (participants with Pilot FSQ data, participants with CAN*Help* FSQ data, and participants with complete CDI data). The addition of participants who had Pilot FSQ data with complete CDI data to the subpopulation of participants who had CAN*Help* FSQ data increased the

precision of the estimated odds ratios. The direction of association reflected by the estimated odds ratios generally remained similar across all three subpopulations, with few exceptions. The estimated odds ratio comparing participants in Teslin compared to participants in Aklavik was 1.4 [95% CI: 0.54, 3.7] in the largest subpopulation and 0.7 [95% CI: 0.41, 1.2] in the pilot FSQ subpopulation, reflecting instability from poor precision of weak community-level estimates. As well, the inclusion of six communities in the largest subpopulation revealed increased *Hp* prevalence odds among households with children relative to households without children (1.9 [95% CI: 1.3, 2.8]), while this association was null in the pilot FSQ subpopulation, and weak in the CAN*Help* FSQ subpopulation. The largest subpopulation was used for analysis.

Table 4.14 presents the estimated effects of the key demographic variables included in Table 4.13, as well as relevant deprivation indicators, on *Hp* prevalence for the final subpopulation selected for analysis.

Table 4.13: Unadjusted odds ratios for the association of selected variables with *Hp* prevalence for three subpopulations, Western Arctic Communities, Canada, 2017-2018.

		Participants from households with *Hp* status and…											
		Pilot FSQ data				CAN*Help* FSQ data				CDI data			
		n	*Hp*+%	OR	95% CI	n	*Hp*+%	OR	95% CI	n	*Hp*+%	OR	95% CI
	Totals:	**285**	**36**			**357**	**61**			**396**	**53**		
Age													
	0-14	26	15	0.4	0.12, 1.2	48	44	0.6	0.29, 1.1	43	47	0.9	0.46, 1.8
	15-34	62	34	1.1	0.56, 2.1	78	73	1.9	1.1, 3.5	80	61	1.6	0.95, 2.8
	35-44	53	55	2.6	1.3, 5.0	53	68	1.5	0.8, 2.9	65	60	1.6	0.87, 2.8
	45-64	109	32	Ref	--	144	58	Ref	--	167	49	Ref	--
	65-94	35	43	1.6	0.73, 3.5	34	61	1.2	0.54, 2.5	41	54	1.2	0.6, 2.4
Sex													
	Male	104	40	Ref	--	151	64	Ref	--	153	64	Ref	--
	Female	179	34	0.8	0.46, 1.3	206	60	0.8	0.55, 1.3	243	60	0.71	0.46, 1.1
	Missing	2	50	--	--	--	--	--	--	--	--	--	--
Ethnicity													
	Non-Indigenous	84	8	Ref	--	44	27	Ref	--	67	19	--	--
	Indigenous	198	49	11	4.6, 24	310	66	5.3	2.61, 11	327	61	6.5	3.4, 12
	Missing	3	--	--	--	3	--	--	--	**2**	--	--	--
Community													
	Aklavik	**--**	--	--	--	72	65	Ref	--	59	66	Ref	--
	Old Crow	**--**	--	--	--	40	78	1.8	0.75, 4.4	32	81	2.2	0.78, 6.3
	Fort McPherson	**--**	--	--	--	54	57	0.7	0.35, 1.5	49	59	0.74	0.34, 1.6
	Tuktoyaktuk	**--**	--	**--**	**--**	--	--	**--**	**--**	**--**	**--**	**--**	**--**
	Ross River	92	48	Ref	--	37	68	1.1	0.48, 2.6	34	64	0.94	0.39, 2.3
	Teslin	112	39	0.7	0.41, 1.2	32	69	1.2	0.48, 2.9	30	73	1.4	0.54, 3.7
	Inuvik	81	20	0.3	0.14, 0.53	19	63	0.9	0.32, 2.6	90	26	0.18	0.08, 0.36
	Pelly Crossing	**--**	--	--	--	55	49	0.5	0.25, 1.0	54	50	0.51	0.24, 1.1
	Carmacks	**--**	--	--	--	48	50	0.5	0.25, 1.1	48	50	0.51	0.23, 1.1
Education													

	CDI – 0												
	College or uni	116	40	Ref	--	67	51	Ref	--	103	32	Ref	--
	CDI – 1												
	HS or Equiv.	61	59	5.5	2.7, 11	146	64	1.7	0.95, 3.1	152	62	3.4	2.0, 5.8
	CDI – 2												
	>Grade 12	106	21	2.5	1.4, 4.6	134	65	1.8	0.99, 3.3	**141**	60	3.2	1.9, 5.5
	Missing data	2	--	--	--	10	--	--	--	-	--	--	--
Home Ownership													
	Owns Home	128	35	Ref	--	151	58	Ref	--	176	48	Ref	--
	Rents Home or Band housing	149	38	1.1	0.70, 1.9	191	63	1.2	0.87, 1.9	220	58	1.5	0.98, 2.2
	Missing data	--	--	--	--	15	--	--	--	-	--	--	--
Children under 15 in Household													
	Yes	110	36	1.0	0.61, 1.7	155	65	1.4	0.94, 2.2	165	63	1.9	1.3, 2.8
	No	174	36	Ref	--	190	56	Ref	--	230	47	Ref	--
	Missing data	1	--	--	--	12	--	--	--	1	--	--	--

Table 4.14: Unadjusted odds ratios for the association of socioeconomic status, female head of household, children in household, and candidate adjustment variables with *Hp* prevalence; Western Arctic Communities, Canada, 2017-2018.

		n	Hp+ (%)	Crude OR	95% CI	P[a]
	Totals:	396	53	--	--	--
Age						
	0-14	43	47	0.9	0.46, 1.8	--
	15-34	80	61	1.6	0.95, 2.8	--
	35-44	65	60	1.6	0.87, 2.8	--
	45-64	167	49	Referent	--	--
	65-94	41	54	1.2	0.61, 2.4	--
					Likelihood ratio chi-square test*	0.26
Sex						
	Male	151	64	Referent	--	--
	Female	206	60	0.71	0.46, 1.1	0.095
Ethnicity						
	Non-Indigenous	67	19	Referent	--	--
	Indigenous	327	61	6.5	3.4, 12	<0.001
	Missing	2				
Community						
	Aklavik	59	66	Referent	--	--
	Old Crow	32	81	2.2	0.78, 6.3	--
	Fort McPherson	49	59	0.74	0.34, 1.6	--
	Ross River	34	64	0.94	0.39, 2.3	--
	Teslin	30	73	1.4	0.54, 3.7	--
	Inuvik	90	26	0.18	0.08, 0.36	--
	Pelly Crossing	54	50	0.51	0.24, 1.1	--
	Carmacks	48	50	0.51	0.23, 1.1	--
					Likelihood ratio chi-square test*	<0.001
Education						
	<Grade 12	141	60	3.2	1.9, 5.5	--
	HS or equiv	152	62	3.4	2.0, 5.8	--
	University	103	32	Referent	--	--
					Likelihood ratio chi-square test*	<0.001
Home Ownership						
	Owns home	176	48	Referent	--	--
	Rents, or has band housing	220	58	1.5	0.98, 2.2	0.062
Children (under 15) in Household						
	No	230	47	Referent	--	--
	Yes	165	63	1.9	1.2, 2.8	0.002
Led by an Unpartnered Woman						
	No	288	56	Referent	--	--
	Yes	98	48	0.72	0.46, 1.6	0.17

CDI						
	1	43	35	0.77	0.36, 1.6	--
	2	100	41	Referent	--	--
	3	111	58	2.5	1.2, 5.3	--
	4	101	66	3.7	1.7, 7.8	--
	5	41	61	2.9	1.2, 7.1	--
					Likelihood ratio chi-square test*	<0.001
CDI – Collapsed into 3 Categories						
	1 and 2	143	39	Referent	--	--
	3	111	58	2.1	1.2, 3.5	--
	4 and 5	142	65	2.8	1.8, 4.6	--
					Likelihood ratio chi-square test*	<0.001
Food Security – CANHelp FSQ						
	Never Insecure	204	59	Referent	--	--
	Sometimes Insecure	87	69	1.5	0.89, 2.6	--
	Often Insecure	34	59	0.98	0.47, 2.0	--
	Missing	71				
					Likelihood ratio chi-square test*	0.27
Food Security – CDI Measurement						
	Never Insecure	279	51	Referent	--	--
	Sometimes Insecure	90	64	1.8	1.2, 2.9	--
	Often Insecure	27	48	0.91	0.41, 2.0	--
					Likelihood ratio chi-square test*	0.058
Food Security Prevalence- CANHelp FSQ						
	Never Insecure	204	59	Referent	--	--
	Sometimes or Often Insecure	121	66	1.3	0.84, 2.1	0.22
	Missing	71				
Food Security Prevalence – CDI						
	Never Insecure	279	51	Referent	--	--
	Sometimes or Often Insecure	117	61	1.5	0.97, 2.3	0.065

[a] Used for purposeful selection for building logistic regression model

The crude odds ratio for socioeconomic status measured by the CDI generally demonstrated a trend of increasing odds of *Hp* infection as deprivation level increased; collapsing the five CDI categories into three, combining the lower two levels and the upper two levels with the mode (also the median) left separate, maintained the trend and made the estimated odds ratios more precise.

Because few participants were often food insecure there was inadequate precision for estimating the effect of increasing levels of food insecurity on *Hp* infection. To address this, the "sometimes" and "often" Food Insecurity categories were collapsed for a dichotomization as "Food Secure/Food Insecure". Household Food Insecurity Status had an unadjusted OR showing a weak association with a somewhat wide confidence interval (1.3 [0.84, 2.1]); CDI Food Insecurity Status had a slightly larger OR with slightly greater precision (1.5 [0.97, 2.3]).

Contrary to expectations based on literature, members of households led by unpartnered women appeared to be potentially less vulnerable to *Hp* infection compared to other households (0.72, [0.46, 1.6]). To assess whether members of households led by unpartnered women were also less vulnerable to deprivation, I conducted ordered logistic regression with trichotomized CDI scores as the outcome variable. Ordered logistic regression revealed that members of households led by unpartnered women were more vulnerable to higher levels of deprivation (1.2 [0.81, 1.9] increase in odds ratio per ordered level increase) relative to other households, though this estimate was imprecise. Adjusting this measure for education revealed a stronger relation between deprivation and unpartnered female heads of households (1.7 [1.0, 2.9]).

The model-building protocol selected the following variables for inclusion as a fixed effect in multivariable models: CDI in three categories; sex; ethnicity; community; children in household; and whether the household was led by an unpartnered woman. The models also included a random effects parameter for household.

Because food insecurity, home ownership and education are components of the CDI, each of these variables was assessed in a separate model to compare model results when including each component separately to model results when including just the composite index. LR tests for inclusion of each of the three components alone revealed that only the inclusion of home ownership alone improved the fit of the mode to a greater degree than the CDI indicator. However, feedback from CAN*Help* Planning Committees cautioned against the use of home ownership as the sole indicator of socioeconomic status, because the relation between home ownership and deprivation may vary across communities. For this reason, the model with the composite index rather than any one indicator appeared optimal.

Consistent with previous CAN*Help* analyses, age-specific *Hp* prevalence (Table 4.14) was highest in young adults relative to children and older adults; tests of orthogonal polynomial contrasts revealed a cubic-shaped trend of *Hp* prevalence with age. LR tests indicated that a cubic spline with three knots (set manually) was the optimal

choice among various categorical and continuous options. Age was included in the model as a cubic spline with knots set at ages 15, 30 and 60.

Table 4.15: Estimated effects of socioeconomic status, female head of household, and children in household on *Hp* prevalence, mutually adjusted for all variables in table and for age[a]; Western Arctic Communities, Canada, 2017-2018.

		n	Hp+ (%)	Adjusted OR	95% CI
	Totals:	383	53	--	--
Sex					
	Male	147	60	Referent	--
	Female	236	50	0.80	0.43, 1.50
Ethnicity					
	Non-Indigenous	67	19	0.10	0.02, 0.30
	Indigenous	327	61	Referent	--
Community					
	Aklavik	59	66	Referent	--
	Old Crow	32	81	2.6	0.47, 14
	Fort McPherson	49	59	0.44	0.11, 1.8
	Ross River	34	64	0.55	0.13, 2.3
	Teslin	30	73	6.93	1.1, 44
	Inuvik	90	26	0.14	0.03, 0.58
	Pelly Crossing	54	50	0.27	0.07, 1.1
	Carmacks	48	50	0.45	0.11, 1.7
Children under 15 in Household					
	No	230	47	Referent	--
	Yes	165	63	1.9	0.89, 3.9
Led by an Unpartnered Woman					
	No	288	56	Referent	--
	Yes	98	48	0.91	0.46, 2.0
CDI – Collapsed into three categories					
	1 and 2	143	39	Referent	--
	3	111	58	2.0	0.88, 4.6
	4 and 5	142	65	3.5	1.4, 8.3

[a] Multivariable logistic regression model includes all variables in table, a cubic spline for age in years (knots at 15, 30, 60), and a random effects parameter for household.

Observed odds ratios for sex and female head of household were compatible with an imprecisely estimated modest protective effect on *Hp* prevalence after the adjustment in the multivariable model (Table 4.15). However, these two variables were kept in the model as variables of key interest and because they appeared to confound the relation with *Hp* infection, of children in household, in the case of female head of household, and female head of household in the case of sex.

Alternative classification of community

Because community can be assessed with fewer categories by year of enrollment relative to geographic location, I compared two models with different categorizations of community to determine which was optimal. LR tests for both categorizations had p-values <0.0001. Iterative model building with community categorized by enrollment year produced similar results (see Appendix J Table 1) to those in Table 4.15, though the association between increasing levels of deprivation and *Hp* prevalence was slightly weaker.

Alternative assessment of social deprivation for home ownership in Old Crow

Community feedback from Old Crow recommended scoring home ownership in reverse order for calculating the CDI in that community (see Discussion); results of this change (see Appendix J Table 2 & Table 3) were similar to the validated CDI classification.

Modification of the effect of deprivation on Hp prevalence by gender-related variables

Table 4.16: The estimated effect of socioeconomic status on *Hp* infection prevalence, stratified by sex; Western Arctic Communities, Canada, 2017-2018.

CDI Score	Men				Women				Test of Homogeneity of stratum-specific ORs	
	n	*Hp*+	OR	95% CI	n	*Hp*+	OR	95% CI	χ^2	p
1 and 2	49	39	Referent	--	94	39	Referent	--	--	--
3	36	64	2.8	1.1, 7.0	75	55	1.9	1.0, 3.5	0.52	0.47
4 and 5	68	71	3.8	1.7, 8.6	74	59	2.3	1.2, 4.2	0.96	0.33

Table 4.17: The estimated effect of socioeconomic status on *Hp* infection prevalence, stratified by household lead; Western Arctic Communities, Canada, 2017-2018.

CDI Score	Unpartnered Female-Led Households				Other Households				Test of Homogeneity of stratum-specific ORs	
	n	*Hp*+	OR	95% CI	n	*Hp*+	OR	95% CI	χ^2	p
1 and 2	33	30	Referent	--	109	42	Referent	--	--	--
3	27	56	2.9	0.96, 8.7	83	59	2.0	1.1, 3.6	0.35	0.56
4 and 5	38	58	3.2	1.1, 8.6	96	69	3.0	1.7, 5.5	0.01	0.94

Table 4.18: The estimated effect of socioeconomic status on *Hp* infection prevalence, stratified by presence of children in household; Western Arctic Communities, Canada, 2017-2018.

CDI Score	Children in Household				No Children in Household				Test of Homogeneity of stratum-specific ORs	
	n	*Hp*+	OR	95% CI	n	*Hp*+	OR	95% CI	χ^2	p
1 and 2	48	48	Referent	--	95	35	Referent	--	--	--
3	52	67	2.2	1.0, 5.1	58	48	1.8	0.90, 3.4	0.20	0.65
4 and 5	65	69	2.5	1.1, 5.4	77	61	2.9	1.5, 5.6	0.13	0.72

Stratification by sex, female head of household, and children in household yielded insufficient precision to assess modest differences in the odds ratios across strata. Contrary to expectations, the estimated effects of deprivation on *Hp* prevalence were greater in men in this dataset than in women; though the differences were not dramatic and tests of homogeneity of ORs did not indicate beyond-random differences by sex. The estimated effects of deprivation on *Hp* prevalence were greater in unpartnered female heads of households in this dataset than in other households, though again these differences were modest, and there was insufficient statistical precision to detect observed degree of difference in odds ratios. There were no meaningful differences between the estimated effects of deprivation on *Hp* prevalence in participants from households with children and participants from households without children. There were only 28 participants from unpartnered female households with children, precluding specific estimates for this group. In

summary, this analysis did not provide compelling evidence of effect-measure modification after stratification of the relationship of socioeconomic status and *Hp* infection by sex, children in household, or household lead.

Discussion

This thesis research represents a novel investigation of the effects of gender and socioeconomic deprivation on the prevalence of *Hp* infection in Arctic Canada, starting with assessment of the CDI, as an indicator of socioeconomic deprivation. After adjustment for age, sex, ethnicity, community, children in household, and whether the household was led by an unpartnered woman, *Hp* prevalence was higher among participants at higher deprivation levels. While food insecurity was uncommon, it was modestly associated with increased odds of *Hp* infection. Though there was insufficient evidence to support effect measure modification by gender-related variables of the effect of deprivation on *Hp* infection prevalence, nonetheless, the *Hp*-associated disease burden seems related to social and gender inequities within Indigenous communities in Arctic Canada.

Systematic searches in health databases EMBASE and Medline did not reveal any published research on the joint effects of gender and socioeconomic deprivation on the prevalence of *Hp* infection in Arctic Canada, nor investigations of the CDI and its

relation to health outcomes in Indigenous populations in Canada; though my search revealed an investigation by Pampalon et al (2010) that utilizes a composite index described in the article as "a Canadian deprivation index" to investigate the relation of deprivation and health incomes in Indigenous populations, primarily from southern urban centres in Canada, this index is unrelated to the CDI developed by Alberta Health [117].

Among notable limitations of this research is the varied timing of food security data collection relative to collection of other data. Home ownership, education, and *Hp* status data was collected near the time of enrollment in each community project. While food security was ascertained within 1 year of project enrollment in Ross River, Teslin, Pelly Crossing, Carmacks and Inuvik, it was collected 4-8 years after enrollment in Aklavik, Fort McPherson and Old Crow. Because food security questionnaire items assessed food security within the last year, for some communities, the food security ascertainment may not have captured the food security status at the time of *Hp* testing. Additionally, the long lag between baseline data collection and food security data collection in Aklavik, Fort McPherson and Old Crow led to underrepresentation in the dataset because many participants could not be found at the time of food security data collection. Beyond reduced representativeness, participants lost to follow-up due to not being traceable or death may have been lost

for reasons related to both *Hp* infection and low SES; a potential source of selection bias.

It is possible that food-insecure participants, especially those with children, were less inclined to respond to the CAN*Help* FSQ due to the sensitivity of the topic, which may have led to underestimation of the prevalence of food insecurity in communities. It is also possible that participants with low SES were prevented from participating in the study for reasons such as being unable to take time off from work. Conversely, participants with previous *H. pylori* infection that was cured in CAN*Help* treatment trials may have been more motivated to follow up with researchers than other participants, especially if they and their healthcare providers had been advised by the project gastroenterologist to monitor their stomach health, and thus may have become overrepresented in the dataset.

The accuracy of *Hp* ascertainment methods were good overall; however, because they are imperfect, disease misclassification could bias results to some degree. Because *Hp* status was ascertained by screening all participants in the same manner, it does not seem likely that its classification was influenced by other study variables or dependent on errors in their classification. Given this, disease misclassification is likely to be nondifferential; nondifferential misclassification of a binary disease outcome typically

produces bias towards the null assuming that the disease misclassification is independent of misclassification of exposure and adjustment variables.

Because food security data was collected during post-treatment activities in four communities, interviewers in these communities were not blinded to the infection status of participants, and may have inadvertently led participants to alter their responses. Participants in all but two communities were not blind to their *H. pylori* infection status at the time of food security data collection. Among participants who knew their *H. pylori* infection status, *Hp*-positive participants may have been more likely than *Hp*-negative participants to recall food insecurity in the past year, if they believed food insecurity increased the risk of *Hp* infection, which may have biased the estimated measures of effect away from the null. As well, it is possible that participants with low socioeconomic status were less likely than participants with higher socioeconomic status to report any SES indicator variable accurately; thus, participants who were food secure may have reported their status more accurately than participants who were food insecure.

While temporal ambiguity is a limitation of cross-sectional studies in general, it is not likely to be a major threat to the validity of this study. *Hp* infection status is not likely to influence social deprivation; no published evidence suggests that *Hp* infection causes reduced SES. In the absence of peptic ulcer disease, which is uncommon in the

study population, *Hp* infection is usually asymptomatic; when symptoms do occur, they are common symptoms of indigestion, not normally debilitating[1]. The observed inverse association between socioeconomic status and *Hp* infection is, therefore, likely due to effects of socioeconomic deprivation that increase susceptibility to chronic *Hp* infection. The assessment of current status for SES indicators, however, could misclassify SES status during the etiologically relevant time period. This would be a problem even if FS had been assessed at the time of *Hp* testing. Because *Hp* infection typically has its onset in childhood, SES in childhood is most relevant to the initial acquisition of this infection. Various SES-associated factors are likely to influence persistence of chronic *Hp* infection in adulthood, for example, access to healthcare for digestive symptoms, adherence to multidrug antibiotic treatment and the risk of reinfection in the area of residence; thus, SES over the life course has relevance to *Hp* status. Because SES is determined by access to opportunities for education and employment, it often remains static throughout the life course. In particular, the participating communities have had lower average SES, based on any indicators, relative to Canada as a whole during the lifespan of all participants.

While this research was limited by challenges inherent in community-based research, and classifying SES indicators in particular, it also had noteworthy strengths. The population-based community-driven research design allowed for the estimation of the effects of deprivation on *Hp* infection in community settings. All study methods and

results were reviewed by each community's planning committee members, who provided local knowledge for grounding the research in the study population's sociocultural and physical context. I also returned preliminary results in person for additional insight for interpreting data. Community feedback on results was mostly positive; in particular, community members agreed that the Canadian Deprivation Index was a more useful measure of deprivation relative to income. There was some concern regarding the use of home ownership as a component of the index because home ownership is rare in some communities for reasons unrelated to deprivation. Additionally, community members in Old Crow expressed concern that home ownership may lead to deprivation under circumstances when home owners do not have the means to maintain their homes after purchase, and the homes may then fall into a state of disrepair; conversely, rented band housing offers prompt services for damage or in emergencies, thus rented homes may be maintained better than owned homes. Community members advised careful examination of the relation between home ownership and deprivation. Reversing deprivation scores for home ownership in Old Crow, based on this advice, produced similar results to the validated order of deprivation.

While this research investigates how socioeconomic deprivation should be measured in Arctic Canadian contexts, the estimated effects of socioeconomic status, and in particular relevant indicators such as education, home ownership and food security,

on *Hp* infection, are likely generalizable to populations beyond Arctic Canada as the relationship between socioeconomic deprivation and *Hp* infection has been observed in many settings [Chapter 2]. Whether gender or partnership status modifies these effects may depend on social support structures that were not assessed in this research and may vary across settings.

Ultimately, this research addresses concerns of residents of CAN*Help* project communities about the effect of socioeconomic deprivation on the disease burden from *Hp* infection. Additionally, the assessment of the validity and practical usefulness of the CDI and its component variables as indicators of socioeconomic deprivation for Arctic communities, relative to more conventional indicators, has the potential to advance research on social determinants of health in such communities.

Chapter 5: Conclusions

This thesis research adds to a body of literature that achieves key goals of the Canadian North *Helicobacter pylori* (CAN*Help*) Working Group, which conducts community projects in the Northwest Territories and Yukon to address community concerns about *Hp* infection. Specifically, my thesis research addresses concerns voiced in participating CAN*Help* communities about the effect of socioeconomic deprivation on the prevalence of *Hp* infection.

My literature review on the association between *Hp* infection and socioeconomic status provides a comprehensive summary of evidence from a major health literature database. Compared to accessible published reviews, it provides greater detail on the various indicators or indices used to measure socioeconomic status in *Hp* research. The overall weight of the evidence suggests that deprivation has a positive association with *Hp* prevalence, though the strength of this association varies by population, place, time, and the indicator or index used to measure SES. However, my results identified a western-centric publication bias in the body of literature, as well as an overwhelming lack of SES investigation of measures that are relevant to the population, place or time of the included studies.

My adaptation of the Canadian Household Food Security Survey module produced a highly acceptable food security evaluation tool for use in Arctic Canadian contexts. My questionnaire, the CAN*Help* Food Security Questionnaire, was administered in eight CAN*Help* community projects, and was substantially more successful than previous measures of social deprivation in terms of participant willingness to respond and relevance to the research questions put forward by community leaders. With minor adjustments, the CAN*Help* Food Security Questionnaire will contribute substantially to the body of literature that aims to assess food insecurity outside of non-Indigenous urban centres in Canada and elsewhere.

Finally, my research includes a novel analysis of the effects of gender and socioeconomic deprivation on the prevalence of *Hp* infection in Arctic Canada. My analysis estimated higher *Hp* prevalence odds at higher levels of social deprivation among CAN*Help* community project participants, after adjusting for selected confounders. It also demonstrates the usefulness of the CDI for investigating effects of socioeconomic deprivation on health outcomes in Arctic Canadian Indigenous communities. Overall, my thesis project contributes to the crucial body of public health research on the social determinants of health in the Indigenous peoples of Canada.

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Appendices

Appendix A: Canadian Deprivation Index Questionnaire[16]

Q1. What is the highest certificate, diploma or degree that you/they have completed?

- ❑ Less than a high school diploma or its equivalent
- ❑ High school diploma or high school equivalency certificate
- ❑ Trade certificate or Diploma
- ❑ College, or other non-university certificate or diploma
- ❑ University certificate or diploma below the bachelor's level
- ❑ Bachelor's degree (eg. BA, BSc, LLB)
- ❑ University certificate, diploma or degree above the bachelor's level

Q2. Now a question about the dwelling in which you live. Is the dwelling…? Owned by you or a member of this household, even if still being paid for, rented, or other?

- ❑ Owned by you or a member of this household, even if it is still being paid for
- ❑ Rented, even if no cash rent is being paid
- ❑ Other

Q3. Now I'm going to read you a statement that may be used to describe the food situation for a household. You and other household members worried that food would run out before you got money to buy more. Was that often true, sometimes true, or never true in the past 12 months?

- ❑ Often
- ❑ Sometimes
- ❑ Never

Appendix B: CAN*Help* Working Group Food Security Questionnaire

Date: Day __ __ Month __ __ Year __ __ __ __ Interviewer Name: _____

Participant Name: _____ ID number: __ - __ __ __ -__ __

Date of Birth: Day __ __ Month __ __ Year __ __ __ __

Section A.

The following questions are about the food situation for your household in the past 12 months. I'm going to read you some statements that may be used to describe the food situation for a household. These questions are used by Statistics Canada and researchers over the country. Some people feel sensitive about answering them, but we are asking them so we can find out how the food situation in your community might impact stomach health.

1. We'd like to know to what extent your household, that is, you and everyone living in your house, relies on store-bought food. Would you say that most weeks the amount of store-bought food is…

❑ Half or more of the total food your household eats;
❑ Less than half of the total food your household eats;
❑ Unsure ❑ Declined to answer

1a. Precisely what percent of your total food is store-bought, would you say?
_____% ❑ Unsure ❑ Declined to answer

1b. So, would you say locally harvested food (from fishing, hunting, trapping, or gathering) your household eats makes up around [*subtract percent listed above from 100*] _____% of your total food?
❑ Yes ❑ No → If no, please edit the answer to 1a. until the percents match.

2. Is there someone in your household or extended family who brings in food by:

a. Fishing	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer
b. Hunting or trapping	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer
c. Berry picking	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer
d. Gardening (household or community)	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer
e. Trading goods or resources	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer
f. Receiving it from another household	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer

3. Do you think that you are eating more, less, or about the same amount of traditional food than 5 years ago?
❑ More Now
❑ Less Now
❑ About the Same Amount
❑ Unsure ❑ Declined to answer

3a. Were you living in this community 5 years ago?
❑ Yes ❑ No ❑ Unsure ❑ Declined to answer

4. Do you think that you are eating more, less, or about the same amount of traditional food than 15

years ago?
❑ More Now
❑ Less Now
❑ About the Same Amount
❑ Unsure ❑ Declined to answer

4a. Were you living in this community 15 years ago?
❑ Yes ❑ No ❑ Unsure ❑ Declined to answer

5. Have you noticed any recent changes in the quality or health of traditional plants or meals of land animals, birds or fish?
❑ Yes; Specify your concerns:

_____

❑ No
❑ Unsure ❑ Declined to answer

6. How concerned are you about the environmental contaminants in the game, fish or other meats that you eat?
❑ Not at all concerned
❑ Somewhat concerned
❑ Very concerned
❑ Unsure ❑ Declined to answer

7. In your experience, how often do people you know get sick from eating store-bought food?
❑ Often
❑ Sometimes
❑ Never
❑ Unsure ❑ Declined to answer

8. In your experience, how often do people you know get sick from eating traditional food?
❑ Often
❑ Sometimes
❑ Never
❑ Unsure ❑ Declined to answer

9. At times, some families might say something like, ***"****We worried whether our food would run out before we got money to buy more."* In the last 12 months, did that happen <u>often</u>, <u>sometimes</u>, or <u>never</u> for your household?
❑ Often
❑ Sometimes
❑ Never
❑ Unsure ❑ Declined to answer

10. At times, some families might say something like, "*We could not get the food we wanted to eat because of a lack of resources*." (By lack of resources, we mean your household did not have what you needed to hunt, fish, gather, or buy food.) In the last 12 months, did that happen <u>often</u>, <u>sometimes</u>, or <u>never</u> for your household?
❑ Often
❑ Sometimes
❑ Never

❑ Unsure ❑ Declined to answer

11. At times, some families might say something like, *"The food that we bought or harvested just didn't last, and we were not able to get more.***"** In the last 12 months did that happen often, sometimes, or never for your household?
❑ Often
❑ Sometimes
❑ Never
❑ Unsure ❑ Declined to answer

12. At times, some families might say something like, **"***We couldn't afford to eat healthy meals," or "Healthy meals just weren't available."* In the last 12 months did this happen often, sometimes, or never for your household?
❑ Often
❑ Sometimes
❑ Never
❑ Unsure ❑ Declined to answer

13. Are there children under 18 in your household?
❑ Yes ➔ ➔ ➔
❑ No
❑ Unsure
❑ Declined to answer

If yes:
13a. At times, some families might say something like, *"We could only feed our children less expensive foods because we were running out of money to buy food."* In the last 12 months did this happen often, sometimes, or never for your household?
❑ Often ❑ Sometimes ❑ Never ❑ Unsure ❑ Declined to answer

13b. At times, some families might say something like, "We couldn't feed our children a healthy meal, because healthy food wasn't available" or "because we couldn't afford that." In the last 12 months, did that happen often, sometimes, or never for your household?
❑ Often ❑ Sometimes ❑ Never ❑ Unsure ❑ Declined to answer

If you checked "Often" or "Sometimes" for any of Questions 9-12 & 13a-13b, continue onto Section B. Otherwise, skip to Section D.

Section B.

14. [*Answer this question only if there are children under the age of 18 in the household.*] At times, some families might say something like, **"***The children were not eating enough because there wasn't enough food***."** In the last 12 months, did this happen often, sometimes, or never for your household?
❑ Often
❑ Sometimes
❑ Never
❑ Unsure ❑ Declined to answer

15. Thinking about the past 12 months, did you or other adults in your household ever cut the size of

your meals or skip meals because there wasn't enough food?

❑ Yes ➔ ➔ ➔ ➔

❑ No
❑ Unsure
❑ Declined to answer

If yes:

15a. How often did this happen?
❑ Almost every month ❑ Some months but not every month
❑ Only 1 or 2 months ❑ Unsure ❑ Declined to answer

16. Thinking about the last 12 months, did you ever eat less than you felt you should because there wasn't enough food?
❑ Yes
❑ No
❑ Unsure ❑ Declined to answer

17. Thinking about the last 12 months, were you ever hungry but didn't eat because you couldn't afford enough food OR were not able harvest food?
❑ Yes
❑ No
❑ Unsure ❑ Declined to answer

18. In the last 12 months, did your weight change because you didn't eat enough food?

❑ Yes ➔ ➔ ➔ ➔
❑ No
❑ Unsure
❑ Declined to answer

If yes:
18a. Did you…
❑ Lose or ❑ Gain weight?

If you checked "Often" or "Sometimes" to Question 14 or "Yes" to any of Questions 15-18, continue onto <u>Section C.</u> Otherwise, skip to <u>Section D.</u>

<u>Section C.</u>

19. Thinking about the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough food?

❑ Yes ➔ ➔ ➔ ➔

❑ No
❑ Unsure
❑ Declined to answer

If yes:

19a. How often did this happen?
❑ Almost every month ❑ Some months but not every month
❑ Only 1 or 2 months ❑ Unsure ❑ Declined to answer

20. [*Answer this question only if there are children under the age of 18 in the household.*]

20a. Thinking about the last 12 months, did you ever cut the size of the children's meals because there wasn't enough food?
❑ Yes
❑ No

❑ Unsure ❑ Declined to answer

20b. Thinking about the last 12 months, did any of the children ever skip meals because there wasn't enough food?

❑ Yes ➔ ➔ ➔ ➔
❑ No
❑ Unsure
❑ Declined to answer

If yes:
20b. How often did this happen?
❑ Almost every month ❑ Some months but not every month
❑ Only 1 or 2 months ❑ Unsure ❑ Declined to answer

20c. Thinking about the last 12 months, were the children ever hungry but you just could not get the food that was needed?
❑ Yes
❑ No
❑ Unsure ❑ Declined to answer

20d. Thinking about the last 12 months, did your children ever not eat for a whole day because there wasn't enough food?
❑ Yes
❑ No
❑ Unsure ❑ Declined to answer

Please continue onto <u>Section D.</u>

<u>Section D.</u>

The following questions are about height and weight. Your answers will be used to calculate your Body Mass Index (BMI). This is used to determine body fat; low and very high levels of body fat may indicate that a person does not have access to enough healthy food. As with all of the information you have given me, I will protect your privacy and keep your height and weight confidential.

21. Do you know your height?

❑ Yes ➔ ➔ ➔ ➔
❑ No
❑ Unsure
❑ Declined to answer

If yes:

21a. Your height is _____ ❑ Centimeters ❑Feet and Inches

21b. Do you know your weight?
❑ Yes, _____ ❑ Kilograms ❑ Pounds
❑ No ❑ Declined to answer

22. Do you want to have your height and weight measured now?

❑ Yes ➔ ➔ ➔ ➔

❑ No
❑ Unsure
❑ Declined to answer

If yes:

Height: _____ ❑ Centimeters ❑ Feet and Inches
Weight: _____ ❑ Kilograms ❑ Pounds

Thank you for participating!

Appendix C: Canadian Household Food Security Survey Module Scoring[22]

Food Security Status		
Category Labels	**Category Description**	
	10-Item Adult Food Security Scale	**8-Item Child Food Security Scale**
Food Secure	*no, or one, indication of difficulty with income-related food access* *0 or 1 affirmed responses*	*no, or one, indication of difficulty with income-related food access* *0 or 1 affirmed responses*
Food Insecure, Moderate	*indication of compromise in quality and/or quantity of food consumed* *2 to 5 affirmed responses*	*indication of compromise in quality and/or quantity of food consumed* *2 to 4 affirmed responses*
Food Insecure, Severe	*indication of reduced food intake and disrupted eating patterns* *≥ 6 affirmed responses*	*indication of reduced food intake and disrupted eating patterns* *≥ 5 affirmed responses*

Appendix D: CAN*Help* Working Group Education and Home Ownership Assessment

What is the highest grade or level of schooling (diploma or degree) you completed?

- ❑ Never attended school
- ❑ ____ Grade (less than 12)
- ❑ High school equivalency certificate
- ❑ High school diploma
- ❑ College, CEGEP or other post high school academic certificate or diploma
- ❑ University certificate or diploma **below** the bachelor's level
- ❑ Bachelor's degree (e.g. B.A., B.Sc., LL.B.)
- ❑ University degree, certificate, diploma **above** the bachelor's level
- ❑ Unsure ❑ Declined to answer

Did you complete any additional trade or other certificate?

- ❑ Yes; specify:

_____

❑ No ❑ Unsure ❑ Declined to answer

Does one of your household members own your home or is it rented? *Don't voice the options.*

- ❑ Own
- ❑ Rent public housing
- ❑ Rent private housing
- ❑ Other; specify: _____
- ❑ Unsure
- ❑ Declined to answer

Appendix E: Ross River and Teslin Pilot Food Security Questionnaire

The following questions are about the food situation for your household in the past 12 months. I'm going to read you some statements that may be used to describe the food situation for a household.

1. The food that you [or other household members] bought just didn't last, and there wasn't any money to get more. In the past 12 months, was that true almost every month, some months but not every month, one or two months or never?

   ❑ Almost every month
   ❑ Some months but not every month
   ❑ One or two months
   ❑ Never
   ❑ Unsure ❑ Declined to answer

2. You [or other household members] couldn't afford to eat balanced meals. In the past 12 months, was that true almost every month, some months but not every month, one or two months or never?

   ❑ Almost every month
   ❑ Some months but not every month
   ❑ One or two months
   ❑ Never
   ❑ Unsure ❑ Declined to answer

3. You [or other household members] cut the size of your meals or skipped meals because there wasn't enough money for food. In the past 12 months, was that true almost every month, some months but not every month, one or two months or never?

   ❑ Almost every month
   ❑ Some months but not every month
   ❑ One or two months
   ❑ Never
   ❑ Unsure ❑ Declined to answer

4. You [or other household members] were hungry but didn't eat because you couldn't afford enough food? In the past 12 months, was that often true, sometimes true or never true?

   ❑ Often true
   ❑ Sometimes true
   ❑ Never true
   ❑ Unsure ❑ Declined to answer

Appendix F: Inuvik Pilot Questionnaire

The following questions are about the food situation for your household in the past 12 months. I'm going to read you some statements that may be used to describe the food situation for a household. These questions are used by Statistics Canada over the country. Some people feel sensitive about answering them, but we are asking them so we can find out how the food situation in your community might impact stomach health.

5. We'd like to know to what extent your [household], that is, you and everyone living in your house, relies on store-bought food. Would you say that most weeks the amount of store-bought food is…

   ❑ Half or more of the total food your household eats;
   ❑ Less than half of the total food your household eats;
   15a. Precisely what percent of your total food is store-bought, would you say? _____%
   15b. So, would you say locally harvested food (from fishing, hunting, trapping, or gathering) your household eats makes up around [*subtract percent listed above from 100*] _____% of your total food?
   [*If no, probe until arriving on matching percents of store-bought and locally harvested food.*]
   ❑ Unsure ❑ Declined to answer

6. Is there someone in your household or extended family who brings in food by:

16a. Fishing	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer
16b. Hunting or trapping	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer
16c. Berry picking	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer
16d. Gardening (household or community)	❑ Yes	❑ No	❑ Unsure	❑ Declined to answer

7. Thinking about the past 12 months, we'd like to know how often, if at all, you [or other household members] worried that food would run out before you got money to buy more. In the past 12 months, would you say that was often true, sometimes true, or never true?
   ❑ Often
   ❑ Sometimes
   ❑ Never
   ❑ Unsure ❑ Declined to answer

8. Thinking about the past 12 months, we'd like to know how often, if at all, you [or other household members] cut the size of your meals or skipped meals because there wasn't enough food. In the past 12 months, would you say that was true almost every month, some months but not every month, one or two months or never?
   ❑ Almost every month
   ❑ Some months but not every month
   ❑ One or two months
   ❑ Never
   ❑ Unsure ❑ Declined to answer

Appendix G: CAN*Help* Working Group Household Questionnaire Household Census

To achieve the goals of the *H. pylori* Project, we need to compare households of people with and without *H. pylori* to see how they differ. The purpose of our household questionnaire is to ask some of questions about each household. Some of these questions are similar to those we ask individuals, but it is important for the research to find out about families as well as individuals. Please answer each question as accurately you can.

Name	Relation to respondent	Lives away for part of the year[1] *If yes, where; if no, enter N/A*	Age at last birthday	Older sibs[2]	School Level[3]
1 Respondent	Respondent		-		*Check participant registry questions*
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					

[1] Spends part of the year away from the community including on the land or other surrounding areas

[2] Number of older siblings born to the mother who raised this family member

[3] Highest grade or level completed: **GR#** - less than grade 12 (Gr4, Gr6…); **GR#+** - less than high school plus certificate (Gr7+, Gr11+…); **HS** - high school diploma or equivalency certificate; **HS+** - high school equivalence/diploma plus certificate; **COL** - college, CEGEP or other post high school, academic certificate or diploma; **UCert** - university certificate or diploma below the bachelor's level; **Bach** - bachelor's degree; **Grad** - university degree, certificate, diploma above bachelor's

Appendix H: Identified categories of concerns about changes in quality and quantity of traditional foods by community

Community	Recurring categories of concerns	Number of concerns in category*	% of total number of concerns
Aklavik (11 respondents)			
	Fish health & invasiveness	9	32
	Beaver & beaver fever	2	7.1
	Caribou population & health	8	29
	Climate Change	6	21
	Pollution affects animal health	1	3.6
	Other concerns (less whales, poorer traditional meat taste)	2	7.1
	Total concerns mentioned	28	
	Main Themes: Poorer quality of fish meals due to poor fish health, less caribou, sometimes no caribou available*		
Old Crow (14 respondents)			
	Fish health & invasiveness	8	26
	Caribou population & health	8	26
	Climate change	6	19
	Berries and traditional plants	5	16
	Other (Less animals (2), ducks not as fat, poorer traditional meat taste)	4	13
	Total concerns mentioned	31	
	Main themes: Worms and other diseases affecting fish, invasive fish species, Less caribou, sometimes no caribou available*		
Fort McPherson (22 respondents)			
	Caribou	13	31
	Fish	10	24
	Climate change	4	9.5
	Traditional plants and berries	6	14
	Parasites & other diseases	2	4.7
	Pollution	1	2.4
	Other (less birds and animals)	6	14
	Total concerns mentioned	42	
	Main theme: Less or no caribou recently*		
Inuvik (1 respondents)			
	Less Caribou	1	50
	Decline in fish	1	50
	Total concerns mentioned	2	
	Participant noted no changes to health or quality of plants or animals*		
Ross River (8 respondents)			
	Caribou & moose population	16	62
	Parasites & other diseases	3	12

	Pollution	1	3.8
	Fish	2	7.7
	Traditional plants	1	3.8
	Other (less animals)	3	12
	Total concerns mentioned	26	
	Main theme: Less moose, less caribou, and caribou meat is not as healthy*		
Teslin (9 respondents)			
	Fish health	3	18
	Climate change	2	12
	Moose health & population	5	29
	Traditional plants	1	5.9
	Beaver population	1	5.9
	Pollution	1	5.9
	Other (Less traditional animals, less of TF available in general, hunters from other provinces are taking harvest)	4	24
	Total concerns mentioned	17	
	Main theme: Less traditional food animals in general, especially moose*		
Pelly Crossing (20 respondents)			
	Fish health & population	16	38
	Moose	12	29
	Climate change	2	4.8
	Traditional plant health	2	4.8
	Pollution	2	4.8
	Other (traditional species)	8	19
	Total concerns mentioned	42	
	Main theme: Less fish available, quality of fish are not as good as it used to be*		
Carmacks (7 respondents)			
	Fish health	3	30
	Traditional plant health	3	30
	Climate change	1	10
	Moose	2	20
	Other (Missing bird species)	1	10
	Total concerns mentioned	10	
	Main theme: Less traditional food (both plants and animals) in general*		

***See Main Themes for detailed description of concerns**

Main Themes

Caribou & Moose		
Subcategory	**Description**	**Examples**

Less or no caribou	Aklavik, Old Crow, Fort McPherson, and Inuvik participants reported that there are less- or almost no- caribou in caribou herds. Participants in Old Crow and Fort McPherson attributed this to forest fires. In Aklavik, a participant reported that the recent appearance of more muskox caused this decline, and others mentioned that changes in herd migrations was also responsible.	"Less caribou because of [changes in] migration patterns." "There are no caribou because they are afraid of the muskox." "The Caribou didn't come back this year; just a few harvested in August." "Lots of forest fires discouraged the caribou from settling."
Less or no moose	Ross River, Teslin and Pelly Crossing participants reported that there were less or no moose. Ross River participants attributed this to overhunting, a Pelly Crossing participant attributed this to the moose being chased out by species that are overpopulating.	"Moose numbers are declining due to overhunting." "Not as many moose recently." "The elk and deer are chasing out the moose."
Caribou and Moose are diseased	Aklavik participants reported that Caribou have spots on liver; Old Crow and Ross River participants reported that there are tumours and worms appearing in the herd. A participant from Carmacks reported that the moose have spots on their livers, another reported that the meat had a metallic hue when cut. Pelly Crossing participants reported that the moose are skinny, smaller, and have cysts in the muscles.	"More lumps or tumours in the joints of Caribou and moose." "The caribou have cysts in their liver." "The caribou have worms that survive freezing." "The caribou have problems in the meat – not sure what it is. I have to cut around it."
Overhunting	Aklavik participants reported that hunters are not allowing Caribou leaders to pass during migrations. Ross River participants reported that a lack of land claims meant that hunters from other places were overhunting traditional animals, and that trophy hunting was a big problem. Teslin participants reported that moose were being overhunted in their community as well.	"There are no land claims, so everybody can come in and hunt in Ross River." "The population of moose is dropping due to trophy hunters – there are not many mature bulls anymore." "[There is an] overharvesting of moose – too many hunters."
Meat Quality has decreased	Aklavik participant reported that Caribou have much less meat now. Old Crow, Teslin and Carmacks participants reported that the quality of caribou meat has decreased. Pelly Crossing participants reported that	"There is mercury inside the caribou's stomachs, especially in the females. Do not eat the kidney, liver or tongue." "The moose meat is much more fatty."

	the moose meat was not as healthy as it used to be (grey fat deposits, not as much healthy fat, cysts in meat).	"Cutting the meat, it looked as if it was contaminated."
Beaver		
Subcategory	**Description**	**Examples**
Overpopulation threaten humans with beaver fever	An Aklavik participant identified that the increase in beaver populations threatens human health due to beaver fever.	"Be careful of beavers – because of lots of beaver, there is [a higher risk of] beaver fever."
Less beaver	A participant in Teslin reported that there is less beaver hunting in their community.	"There is less beaver hunting in Teslin."
Fish		
Subcategory	**Description**	**Examples**
Fish are unhealthy	Aklavik, Old Crow, Ross River, Pelly Crossing Carmacks participants reported that fish are diseased; especially that fish have spots on their liver, or that they now have worms. Participants Pelly Crossing reported that the skin of the fish (especially salmon) looks unhealthy, and that they have worms.	"Some fish have spots on the liver and their eggs now." "The fish are internally discolored." "I heard that fish insides are grey or black – it is supposed to be white." "There are worms in the gills of the fish." "The fish have white worms."
Fish meat quality decreased	Aklavik, Old Crow, and Fort McPherson, Teslin and Pelly Crossing participants reported that fish meat tastes worse now, was soft, and was less safe to eat.	"The water is warmer for the fish, so they are not as good." "This summer, the fish meat was soft because of warm temperatures, which caused a lower water level." "The fish were soft and had a [bad] smell when cooked. Most people who had stomach cancer in the last 30 years were fish-eating people."
Overgrowth of certain species	Aklavik participants reported that there are much more fish lately; some of them invasive species. Old Crow participants reported that Salmon species respond differently to changes in the environment.	"Some salmon seem bigger and healthier, but other types of salmon are discolored or have parasites."
Decline in certain species	Old Crow participants reported that Salmon species respond differently to changes in the environment. Inuvik and Carmacks participants reported decline in fish in general. A Ross River and Pelly Crossing participant noted that a staple fish is	"[Some] fish are less abundant, especially king salmon." "Decline in fish – getting way less now, barely any."

	now gone from the community. Teslin Tlingit people decided not to harvest salmon because the count is down.	"We used to camp up by canol road and ate dollnose whitefish, but it is no longer there." "A lot less salmon and lake fish."
Traditional Plants		
Subcategory	**Description**	**Examples**
Less or no traditional plants	Old Crow, Fort McPherson, Ross River, Teslin and Carmacks participants reported less plants and berries available.	"There were less plants last year due to no rain." "Cranberries and Mossberries are missing in the wild." "There are less berries, especially cranberries."
Plants are small or dried up	Old Crow and Carmacks participants reported that traditional plants are smaller now.	"There are hardly any rosehips – they are very small and dried up."
Plants ripen or bloom at different times	Old Crow participants reported that berries do not ripen when expected.	"Berries are supposed to be ripe in the middle of July, but sometimes they aren't."
Diseased traditional plants	A participant from Pelly Crossing described disease in local plants.	"The plant leaves have worms, and the trees are eaten by moths."
Climate Change		
Subcategory	**Description**	**Examples**
Increased natural disasters	There are increased incidences of forest fires in Old Crow & Fort McPherson due to climate change.	--
Weather patterns change and affect traditional foods	Participants in Fort McPherson mentioned that climate change has impeded the preparation of traditional meals.	"Because of climate change, in the summertime when we fish and dry our fish, the weather is too hot to dry fish." "The timeline to harvest is narrower; the meat becomes soft if not harvested in this window."
Climate change is changing migration patterns	Participants from Old Crow and Carmacks mentioned changes in migration patterns due to climate change.	"Migratory species routes are changing due to global warming, and [hunters] need to travel farther." "Animal seasonal patterns have changed."
TF no longer sustainable due to climate change	A Pelly Crossing participant noted that due to the effects of climate change, TF is no longer sustainable.	"There is not enough meat in our fish now for our community, and for generations to come."
Climate change causing a cascade of changes in traditional foods	Participants in Fort McPherson and Teslin ascribed the changes in traditional foods to climate change.	"There are less fish and caribou maybe because of climate change." "The fish is mushy due to warm waters."

Pollution		
Subcategory	**Description**	**Examples**
Environmental contamination	A participant in Fort McPherson mentioned that the smoke caused by climate change is a threat to health. Oil contamination in Ross River destroyed a staple food source. A participant in Teslin reported that they eat less TF because of environmental contamination.	"Because of the forest fires, it is too smoky, making it hard for the elders to breathe." "[Nearby lake] used to supply fish for the winter for the community, but due to oil contamination, no one fishes there anymore." "[I] eat less traditional food because of contamination from the Alaska Highway."
Pollution is poisoning animals	Aklavik participants reported that pollution is poisoning animals. A Pelly Crossing participant attributed deformities in local fish to the local mine.	"There is pollution in the air and the ground; the animals eat off of the ground."
Parasites & disease of traditional food animals		
Subcategory	**Description**	**Examples**
Worms	Participants in Aklavik, Old Crow, Ross River and Pelly Crossing reported worms in local animals, especially fish and caribou.	"There are worms in the gills of fish." "Caribou have worms that survived freezing."
Avian flu	A participant in Ross River was concerned about avian flu in local birds.	"We're concerned that ducks and geese may have avian flu."
Beaver fever	A participant from Aklavik noted that beaver fever was a concern.	"Be careful of beavers – because of lots of beaver, there is [a higher risk of] beaver fever."
Tumors	Aklavik, Old Crow, Fort McPherson, and Pelly Crossing participants found tumors and other growths in meats of traditional animals.	"Animals have parasites and growths." "The moose have cysts the size of rocks in the muscle."
Ticks	A Pelly Crossing participant noted the appearance of ticks in moose.	"The moose are not around as much and have ticks."
Other traditional food health concerns		
Subcategory	**Description**	**Examples**
Harvested food is poorer quality	Participants from Old Crow and Pelly Crossing reported that the taste of TF is poorer recently.	"Traditional food isn't as tasty as it used to be."
Some animals are not as fat	A participant in Old Crow and in Pelly Crossing reported this change.	"Ducks are not as fat." "The rabbits are not as fat."

Less TF animals in general	An Aklavik participant reported less whales. An Old Crow and several Pelly Crossing participants noted that there were less TF animals in general. A Ross River participant reported less sheep. A Teslin participant reported less game animals. A Pelly Crossing participant reported that the grouse are disappearing.	"There are less of pretty much all traditional animals." "There is less traditional food available in general."
Invasive species	Participants from Fort McPherson noted that there were different species of animals. A participant from Teslin and from Pelly Crossing noted that there were new species not native to the area appearing in the community.	"There are different birds and fish." "Different species are coming to the area – not sure if it has to do with climate change. [There are new] bugs, birds, and other animals."
Staple foods gone	A Ross River participant reported that a staple food had disappeared due to contamination. A Teslin participant noted that it is harder to get traditional foods because of southerners taking it. A participant in Carmacks mentioned that they no longer trust it is safe to eat parts of birds in their community.	"The [fish] kept the community alive during hard times." "Sometimes traditional food can be hard to find because people from BC and Alberta take it instead."
Species have disappeared	Old Crow and Carmacks participants noted the disappearance of some species.	"There are a lot less animals – birds, geese, species – that used to be abundant are not around." "Ptarmigan [are missing in the wild], they are usually seen everywhere."

Appendix I: Household Food Insecurity Prevalence for 196 households across categories of food-related variables deemed relevant by community partners

Proportion of store-bought food in diet			
	Number of households	**Food insecurity prevalence (%)**	**95% CI**
Half or more is storebought	167	43	35, 50
Less than half is storebought	28	36	19, 56
Unsure	1	0	--
Total	196	41	34, 49
Member of household fishes			
	Number of households	**Food insecurity prevalence (%)**	**95% CI**
Yes	169	43	36, 51
No	27	30	14, 50
Member of household hunts or traps			
	Number of households	**Food insecurity prevalence (%)**	**95% CI**
Yes	172	43	36, 51
No	24	29	12, 51
Member of household picks berries			
	Number of households	**Food insecurity prevalence (%)**	**95% CI**
Yes	158	41	33, 49
No	38	42	26, 59
Member of household gardens			
	Number of households	**Food insecurity prevalence (%)**	**95% CI**
Yes	97	31	22, 41
No	98	51	41, 61
Unsure	1	100	--
Member of household trades goods for food			
	Number of households	**Food insecurity prevalence (%)**	**95% CI**
Yes	50	52	37, 66
No	144	38	30, 47
Unsure	1	0	--
Declined to answer	1	0	--
Receives food from other households			
	Number of households	**Food Insecurity prevalence (%)**	**95% CI**
Yes	153	45	37, 53
No	43	28	15, 44

Body Mass Index (BMI)[a]			
	Total	**Food Insecurity Prevalence (%)**	**95% CI**
Not overweight	50	48	34, 63
Overweight	65	35	24, 48
Obese	71	42	31, 55
Declined	10	--	--

[a-] Calculated by using measured height and weight, or using stated height or weight if the participant declined to be measured or if a scale was not available.

Appendix J: Estimated effect of socioeconomic status, female head of household, and children in household on *Hp* prevalence, adjusted by candidate adjustment variables with alternate categorizations for Community and Home Ownership

Table 1: Estimated effect of socioeconomic status, female head of household, and children in household on *Hp* prevalence, adjusted by candidate adjustment variables with an alternate categorization for Community.[a]

		n	Hp+ (%)	Adjusted OR	95% CI
	Totals:	383	53	--	--
Sex					
	Male	147	60	Referent	--
	Female	236	50	0.81	[0.43, 1.5]
Ethnicity					
	Non-Indigenous	67	19	0.10	[0.02, 0.30]
	Indigenous	327	61	Referent	--
Community by year of enrollment					
	2007 (Aklavik)	59	66	Referent	--
	2010 (Old Crow)	32	81	2.4	[0.26, 13]
	2012 (Fort McPherson)	49	59	0.43	[0.11, 1.7]
	2016 (Ross River, Teslin)	64	69	1.5	[0.40, 5.4]
	2017 (Inuvik, Pelly Crossing, Carmacks)	192	39	0.23	[0.07, 0.75]
Children under 15 in Household					
	No	230	47	Referent	--
	Yes	165	63	1.8	[0.86, 3.6]
Led by an Unpartnered Woman					
	No	288	56	Referent	--
	Yes	98	48	0.86	[0.40, 1.9]
CDI – Collapsed into three categories					
	1 and 2	143	39	Referent	--
	3	111	58	1.82	[0.88, 4.6]
	4 and 5	142	65	2.89	[1.4, 8.3]

[a] – Multivariable logistic regression model includes all variables in table, a cubic spline for age in years (knots at 15, 30, 60), and a random effects parameter for household.

Table 2: Estimated effect of socioeconomic status (reclassified for Old Crow), female head of household, and children in household on *Hp* prevalence.

		N	Hp+ (%)	Crude OR	95% CI	P*
	* Used for purposeful selection for building logistic regression model					
	Totals:	396	54	--	--	--

CDI						
	1	43	35	Referent	--	--
	2	102	43	1.4	[0.68, 3.0]	0.356
	3	107	58	2.6	[1.23, 5.4]	0.012
	4	109	66	3.6	[1.7, 7.6]	0.001
	5	35	55	2.2	[0.89, 5.5]	0.088
CDI – Collapsed into 3 Categories						
	1 and 2	145	41	Referent	--	--
	3	107	58	2.0	[1.2, 3.3]	0.007
	4 and 5	144	63	2.5	[1.6, 4.0]	0.000

Table 3: The estimated effect of socioeconomic status (reclassified for Old Crow), female head of household, and children in household on *Hp* prevalence, adjusted by candidate adjustment variables.[a]

		n	**Hp+ (%)**	**Adjusted OR**	**95% CI**
	Totals:	383	53	--	--
Sex					
	Male	147	60	Referent	--
	Female	236	50	0.80	[0.42, 1.48]
Ethnicity					
	Indigenous	67	19	Referent	--
	Non-Indigenous	316	61	0.07	[0.02, 0.29]
Community					
	Aklavik	52	67	Referent	--
	Old Crow	31	81	2.5	[0.46, 14]
	Fort McPherson	48	60	0.42	[0.10, 1.8]
	Ross River	34	65	0.54	[0.12, 2.4]
	Teslin	30	73	6.4	[0.99, 41]
	Inuvik	87	26	0.14	[0.03, 0.55]
	Pelly Crossing	53	51	0.27	[0.07, 1.1]
	Carmacks	48	50	0.43	[0.11, 1.7]
Children under 15 in Household					
	No	219	48	Referent	--
	Yes	164	62	1.9	[0.90, 4.0]
Led by an Unpartnered Woman					
	No	286	56	Referent	--
	Yes	97	48	0.95	[0.43, 2.1]
CDI – Collapsed into three categories					
	1 and 2	143	41	Referent	--
	3	106	58	1.8	[0.79, 4.2]
	4 and 5	134	64	2.7	[1.1, 6.5]

[a] - Multivariable logistic regression model includes all variables in table, a cubic spline for age in years (knots at 15, 30, 60), and a random effects parameter for household.