THE ASSOCIATION BETWEEN AREA- AND INDIVIDUAL-LEVEL RISK FACTORS AND CHLAMYDIA INFECTION IN A SEXUAL HEALTH CLINIC

by

Mara Habash

A thesis submitted to the Department of Public Health Sciences

in conformity with the requirements for

the degree of Master of Science

Queen's University

Kingston, Ontario, Canada

(October, 2018)

Abstract

Background: Chlamydia is the most common sexually transmitted infection (STI) in Canada. Although the literature has focused on individual-level risk factors as the greatest determinants for chlamydia infection, more recent research has investigated the role of neighbourhood socioeconomic status (SES) on risk for chlamydia infection. The present study aims to investigate the relationship between multiple area- and individual-level risk factors and chlamydia infection in a sexual health clinic.

Methods: Individuals who were tested for chlamydia at the Kingston, Frontenac and Lennox & Addington (KFL&A) Public Health sexual health clinic from April 2016 to March 2017 were included in this study. The four indices of the Ontario Marginalization (ON-Marg) Index; namely, material deprivation, dependency, residential instability and ethnic concentration, were used as measures of neighbourhood SES. Individual-level risk factors included variables that were captured from the questionnaire administered at the time of examination. Logistic regression was used to compute odds ratios (OR) for all risk factor variables. Outcome data was plotted on a geographic information system (GIS) to compare marginalization differences based on chlamydia test result.

Results: A total of 1775 individuals were tested for chlamydia at the Clinic, with 208 (11.7%) testing positive on their first Clinic visit. Age (OR=4.84, 95% CI 2.18-10.74; <20 versus >40 years), number of sexual partners in the previous 2 months (OR=3.11, 95% CI 1.06-9.10; 2 partner versus no partners), condom use (OR=2.09, 95% CI 1.07-4.09; rarely versus always using condoms), and STI contact (OR=6.16, 95% CI 4.35-8.74) were significant individual-level predictors for infection. Apart from ethnic concentration of the ON-Marg Index, there was a trend suggesting an association between the highest levels of marginalization and increased odds of chlamydia infection compared to the lowest levels of marginalization. However, this association was only statistically significant for the dependency index (OR=1.90, 95% CI: 1.05-3.43; most deprived versus least deprived).

Conclusions: Populations living in highly marginalized neighbourhoods, an established marker of low SES, were found to be at a significantly higher odds for chlamydia infection for one of the four ON-Marg indices; namely, dependency. More research is warranted to further clarify the role of neighbourhood SES on the risk of chlamydia infection.

Co-Authorship

This thesis is the work of Mara Habash under the supervision of Dr. Bart Harvey, Dr. Harriet Richardson and Dr. Anna Majury.

The data used are from the KFL&A Public Health sexual health clinic's Electronic Medical Record Database (EMR), as well as from the integrated Public Health Information System (iPHIS). The conceptualization of this thesis came from discussions between Mara Habash and all supervisors after evaluation of the literature and availability of data from the EMR. The writing of the literature review, statistical analysis, and interpretation of results were completed by Mara Habash with guidance and feedback from all supervisors.

Acknowledgments

From the bottom of my heart, I would like to thank every individual who helped me through the last two years of my degree. Firstly, I would like to thank Dr. Bart Harvey, Dr. Harriet Richardson, and Dr. Anna Majury for being great supervisors and consistently answering any questions I had throughout the process. I have thoroughly enjoyed working with the three of you. Additionally, I would like to thank the KFL&A Public Health team, especially Julia Prouse, Paul Belanger, Sean Sweeney and Adam Van Dijk, for providing me with the data, assisting with the data transfer, and answering any questions I had throughout the analysis process.

Thank you to the colleagues I have met and spent much of my time with at Queen's University. I can honestly say that I have made lifelong friends from the MSc Epidemiology and MPH classes of 2017, 2018 and 2019.

I would also like to thank Queen's University and the admissions team for giving me the opportunity to complete my degree in Kingston, and for providing the financial support for my studies.

Lastly, I would like to thank my parents, siblings and friends for believing in me, and for encouraging me to keep moving forward even through the toughest of times. These last two years have been very special and I will never forget the memories I have made with every single person throughout the way.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AOR	Adjusted odds ratio
CHMS	Canadian Health Measures Survey
CAN-Marg	Canadian Marginalization Index
CI	Confidence interval
CT	Chlamydia trachomatis
DA	Dissemination area
EBIC	Economic Burden of Illness in Canada
EMR	Electronic medical record
GC	Gonorrhea
GIS	Geographic Information System
HSREB	Health Sciences Research Ethics Board
HIV	Human immunodeficiency virus
HPPA	Health Promotion and Protection Act
iPHIS	Integrated Public Health Information System
KFL&A	Kingston, Frontenac, and Lennox and Addington
NAAT	Nucleic acid amplification test
ON-Marg Index	Ontario Marginalization Index
OR	Odds ratio
PHO	Public Health Ontario
SES	Socioeconomic status
SIRS	Susceptible-infectious-recovered-susceptible
SP	Superprofile
STI	Sexually transmitted infection

Chapter 1

Introduction

1.1 General Overview

Chlamydia, caused by the bacterium *Chlamydia trachomatis* (CT), is the most common sexually transmitted infection (STI) in Canada [1], with an estimated 325 cases per 100,000 population in 2015 [2]. If left untreated, chlamydia can lead to complications such as genital inflammation, infertility, and ectopic pregnancies in women, as well as infertility and inflammation of the testicles and prostate in men [3,4]. Being infected with chlamydia can also increase the risk of being infected, if exposed, by the human immunodeficiency virus (HIV) [5]. Known risk factors for chlamydia infection include being sexually active before the age of 25, having new and/or multiple sexual partners, having a high-risk partner (includes individuals who have a sex partner(s) infected with chlamydia), not using condoms, and having been diagnosed with a previous STI [4,6,7].

The socioeconomic status (SES) of an individual is comprised of multiple factors which may affect a variety of health outcomes. The association of many health outcomes with SES has been widely demonstrated in multiple epidemiological studies and has become routine in analyses. There is evidence that physical, psychological, social, and spatial neighbourhood characteristics, or an individuals' neighbourhood socioeconomic characteristics, can have a powerful influence on the health of an individual [8–11]. More recently, low neighbourhood SES has been found to be associated with an increased risk for chlamydia infection [12–15]. Previous studies have used a variety of measures to assess an individual's neighbourhood SES, such as using items on a questionnaire, census data, or other composite measures.

The Ontario Marginalization (ON-Marg) Index, derived from the Canadian Marginalization (CAN-Marg) Index, is a data tool that combines a wide range of indicators into four dimensions of marginalization: residential instability (i.e. owning a home, housing status, etc), dependency (i.e. participation in the labour force, etc), ethnic consideration (i.e. immigrants, visible minorities, etc), and material deprivation (i.e. unemployment, education, income, etc) [16]. The index has been validated for health research use in Ontario [17], and is specifically used in research to describe the relationship between marginalization and health outcomes, as greater marginalization tends to be associated with higher rates of many diseases [18].

There are currently no studies published in the literature that examine the association between the ON-Marg Index and any STI, including chlamydia. That said, there have been some studies that have found significant associations between indices of the ON-Marg Index and various negative health outcomes [19–21]. These studies provide some evidence to suggest that the ON-Marg Index is a good measure of neighbourhood SES. Numerous studies have evaluated SES and chlamydia infection [12–14], but none have utilized the ON-Marg Index as a measure of neighbourhood SES. Therefore, use of this tool in STI research for measuring an area-level risk factor for chlamydia infection is warranted.

1.2 Public Health Significance

The knowledge that will come from this study will be novel and will provide evidence for the KFL&A Public Health unit, as well as other health units, in order to better target prevention interventions in specific geographic regions and to vulnerable populations, as prevention strategies are facilitated by understanding the transmission dynamics of the STI.

1.3 Study Objectives

This thesis was composed of three objectives: the first two are descriptive, and the third is the primary analytic objective of the study.

(1) To compute and compare age and sex-specific period prevalence of chlamydia infection at:

   a) the Kingston, Frontenac, and Lennox and Addington (KFL&A) region level (referred to as "iPHIS" hereon) and the KFL&A Public Health sexual health clinic level (referred to as the "Clinic" hereon), and

   b) to describe the Clinic population on other general risk factors.

(2) To visually describe area-level marginalization differences in those who tested positive versus negative for chlamydia infection at the Clinic.

(3) To investigate the association between multiple area- and individual-level risk factors and chlamydia infection within the population attending the Clinic.

It is hypothesized that high marginalization and high risk sexual behaviours are associated with an increased odds for chlamydia infection in the Clinic population.

1.4 Overview of Study Design

This thesis project uses data from the KFL&A Public Health sexual health clinic and from the greater KFL&A region (iPHIS data) from April 1, 2016 to March 31, 2017. The study design of this project is cross-sectional, as the data from the Clinic (the risk factor questionnaire and the chlamydia test) was captured at the same point in time.

1.5 Thesis Organization

This thesis follows the *General Forms of Theses* outline by the Queen's University School of Graduate Studies [22]. Chapter 2 of this thesis is a literature review of the background and rates of chlamydia, STI clinics, the cost burden in Canada, risk factors, KFL&A, dissemination areas, the ON-Marg, and geographic information systems (GIS). Chapter 3 is the Manuscript, which addresses the three objectives presented earlier. Lastly, Chapter 4 is a general discussion of the findings from this study, including a summary of findings, limitations, and implications.

1.6 References

1. Government of Canada. Report on Sexually Transmitted Infections in Canada: 2012. http://www.phac-aspc.gc.ca/sti-its-surv-epi/rep-rap-2012/rep-rap-1-eng.php. Published 2015.
2. Choudhri Y, Miller J, Sandhu J, Leon A, Aho J. Chlamydia in Canada, 2010–2015. *Canada Commun Dis Rep*. 2018;44(2):49-54. doi:10.14745/ccdr.v44i02a03.
3. Wong T, Singh A, Mann J, Hansen L, McMahon S. Gender Differences in Bacterial STIs in Canada. *BMC Womens Health*. 2004;4 Suppl 1(Suppl 1):S26. doi:10.1186/1472-6874-4-S1-S26.
4. Public Health Agency of Canada. Canadian Guidelines on Sexually Transmitted Infections. http://www.phac-aspc.gc.ca/std-mts/sti-its/cgsti-ldcits/section-5-2-eng.php. Published 2013.
5. WebMD. Chlamydia- Topic Overview. http://www.webmd.com/sexual-conditions/tc/chlamydia-topic-overview#1. Published 2017.
6. WebMD. Chlamydia Tests.
7. Mayo Clinic. Chlamydia trachomatis. http://www.mayoclinic.org/diseases-conditions/chlamydia-trachomatis/symptoms-causes/dxc-20315310. Published 2017.
8. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: A critical review. *J Epidemiol Community Health*. 2001;55(2):111-122. doi:10.1136/jech.55.2.111.
9. Sampson RJ, Morenoff JD, Gannon-Rowley T. Assessing “neighborhood effects”: Social processes and new directions in research. *Annu Rev Sociol*. 2002;28:443-478. doi:DOI

10.1146/annurev.soc.28.110601.141114.

10. Ross NA, Tremblay S, Graham K. Neighbourhood influences on health in Montreal, Canada. *Soc Sci Med*. 2004;59(7):1485-1494. doi:10.1016/j.socscimed.2004.01.016.

11. Diez Roux A V. Investigating neighborhood and area effects on health. *Am J Public Health*. 2001;91(11):1783-1789. doi:10.2105/AJPH.91.11.1783.

12. Ford JL, Browning CR. Neighborhoods and infectious disease risk: Acquisition of chlamydia during the transition to young adulthood. *J Urban Heal*. 2014;91(1):136-150. doi:10.1007/s11524-013-9792-0.

13. Sales JM, Smearman EL, Swartzendruber A, Brown JL, Brody G, Diclemente RJ. Socioeconomic-related risk and sexually transmitted infection among African-American adolescent females. *J Adolesc Heal*. 2014;55(5):698-704. doi:10.1016/j.jadohealth.2014.05.005.

14. Monteiro EF, Lacey CJN, Merrick D. The interrelation of demographic and geospatial risk factors between four common sexually transmitted diseases. *Sex Transm Infect*. 2005;81(1):41-46. doi:10.1136/sti.2004.009431.

15. Biello KB, Pettigrew MM, Niccolai LM. Multiple chlamydia infection among young women: comparing the role of individual- and neighbourhood-level measures of socioeconomic status. *Sex Transm Infect*. 2011;87(7):560-562. doi:10.1136/sextrans-2011-050185.

16. Public Health Ontario. Overview of the Ontario Marginalization Index. https://www.publichealthontario.ca/en/LearningAndDevelopment/Events/Pages/Overview-of-the-Ontario-Marginalization-Index-.aspx. Published 2017.

17. Matheson FI, Dunn JR, Smith KLW, Moineddin R, Glazier RH. Development of the Canadian Marginalization index: A new tool for the study of inequality. *Can J Public Heal*. 2012;103(SUPPL.2).

18. St. Michaels Hospital. *Ontario Marginalization Index User Guide Version 1.0*. http://www.torontohealthprofiles.ca/onmarg/userguide_data/ON-Marg_user_guide_1.0_FINAL_MAY2012.pdf.

19. Cummings LAM, Clarke A, Sochett E, et al. Social Determinants of Health Are Associated with Markers of Renal Injury in Adolescents with Type 1 Diabetes. *J Pediatr*. 2018;198:247-253.e1. doi:10.1016/J.JPEDS.2018.03.030.

20. Inman M, Daneman D, Curtis J, et al. Social Determinants of Health Are Associated with Modifiable Risk Factors for Cardiovascular Disease and Vascular Function in Pediatric Type 1 Diabetes. *J Pediatr*. 2016;177:167-172. doi:10.1016/j.jpeds.2016.06.049.

21. Lachaud J, Donnelly P, Henry D, et al. Characterising violent deaths of undetermined intent: a population-based study, 1999–2012. *Inj Prev*. 2017:injuryprev-2017-042376. doi:10.1136/injuryprev-2017-042376.

22. School of Graduate Studies. *General Forms of Theses*. Kingston; 2017.

Chapter 2

Literature Review

2.1 *Chlamydia trachomatis*

STIs are caused by microorganisms (i.e. bacteria and viruses) that can be transmitted through sexual contact [1]. Chlamydia, an infection that is caused by the bacterium CT, is the most commonly-reported STI in Canada [2], although it is believed to be underdiagnosed due to the frequency of asymptomatic infections [3]. If left untreated, chlamydia can lead to complications such as genital inflammation, infertility, and ectopic pregnancies in women, as well as infertility and inflammation of the testicles and prostate in men [3,4]. Fortunately, if diagnosed and treated early, chlamydia rarely causes long-term complications [5].

Being infected with chlamydia can also increase the risk of being infected with HIV if exposed [5]. Known risk factors for chlamydia include being sexually active before the age of 25, having new or multiple sexual partners, having a high-risk partner (includes people who have more than one sex partner or sex partners who are infected with chlamydia), not using condoms, and having been diagnosed with a previous STI [4–6]. While it is estimated that 70% of infected women and 50% of infected men will have no symptoms, symptomatic women may experience manifestations such as vaginal discharge or bleeding, pain during intercourse and urination, genital itching, irregular menstrual bleeding, abdominal pain and swollen glands, while symptomatic men may experience urethral discharge, itching and painful urination [4,7].

Chlamydia is spread primarily by having sex (vaginal, anal, or oral) with an infected individual [7]. It cannot be spread through kissing, touching, or sharing items (apart from sex toys). Chlamydia can be transmitted without ejaculation, and individuals can be re-infected after being treated if re-exposed because having had an infection does not induce immunity [7]. Although less common, a pregnant woman can transfer chlamydia to her baby during childbirth [7]. Complications in newborns include premature delivery and inflammation of the eyes, ears, and lungs [5].

The incubation period, which is the period between exposure and the appearance of symptoms, is 7 to 21 days [8]. The risk of transmission of chlamydia from a single episode of sexual intercourse with an infected individual is estimated to be between 10% to 20% [9].

The risk of being infected with chlamydia can be reduced through safer sex practices, such as avoiding sexual contact with an individual who has STI symptoms, limiting the number of sexual partners, being regularly tested, and using condoms [5].

There are several biological factors that may affect the risk of being infected with, or transmitting chlamydia. Previous studies have shown that breast maturity, infrequent menstrual cycles, and older gynaecological age (year of first menarche) are also associated with a lower risk of infection for women [10].

Testing for chlamydia includes taking a sample (e.g., urine sample, vaginal swab, rectal swab), followed by sample processing and DNA extraction, with detection of chlamydial DNA using a nucleic acid amplification test (NAAT), a molecular test that detects the genetic material of CT [11]. Detection is also performed using culture techniques in some instances. Different treatment regimens exist for non-pregnant adults, children, and pregnant women, but the usual preferred treatment is a 1 gram single oral dose of azithromycin [3].

Because most males and females infected with chlamydia are asymptomatic, and the possibility of a vaccine is still years away, public health plays an important role in the surveillance, prevention and control of this infection. At present, the spread of chlamydia is best controlled by promoting safer sexual practices, providing health services, testing, treatment, and notifying those who have had sexual contact with an infected person.

2.2 Rate of Chlamydia

2.2.1 Canada

Because chlamydia has been notifiable in Canada since 1991 [2], the rates and trends of the infection are well studied and well documented, and despite recent public health interventions, increased rates of reported chlamydia cases have been observed in Canada. It is difficult to identify the cause for increased chlamydia rates, although it is likely due to a combination of factors, with changes in screening practices and testing methods being among them [1,11]. Additionally, it is important to understand that reported rates are an underestimate of true population incidence, as the majority of those infected with chlamydia are asymptomatic and therefore go undiagnosed until they undergo testing [12].

Data from the 2009 to 2011 Canadian Health Measures Survey (CHMS), which has a sample that represents 96% of the adult population, estimates the prevalence of chlamydia to be 0.7% (95% CI 0.4% to 1.3%) of the Canadian population, approximately 158,000 individuals [13]. The reported rate of chlamydia decreased steadily for both genders between 1991 and 1997, but then began a steady rise [2]. Historically, reported chlamydia rates in females have been higher than the rates in males [2]. In 2012, there were double the number of chlamydia cases for females compared to males in Canada, and most reported cases (80.2%) occurred in individuals under the age of 30 years [2].

The rate of chlamydia in Canada in 2012 was 298.7 per 100,000 individuals, a large increase from 189.6 per 100,000 individuals in 2003 [1,12]. The highest reported rates were observed among the 20 to 24 age group [2]. As age increased, the distinction between both sexes was not as pronounced, and was even reversed, such that more men than women were diagnosed with chlamydia in those aged 40 years and over.

2.2.2 Ontario

Between 2003 and 2012, an increase in the number of reported cases of chlamydia was observed in all provinces and territories (except in the Yukon), with Ontario experiencing the greatest increase (74.7%) [2]. Whether this is a true increase or an artefactual one observed by increased screening rates and improved reporting measures is unknown, but the possibility of a true increase cannot be ruled out. Differences in screening behaviours between provinces may explain variations in chlamydia rates, as there is some evidence that higher screening rates in certain provinces may lead to higher chlamydia rates [2].

Public Health Ontario (PHO) [14] reports provincial infectious disease rates, such as chlamydia, for the province of Ontario. Chlamydia incidence rates were at 265.4 cases per 100,000 in 2014, with 35,933 reported cases [12]. This rate increased by 57.3% between 2005 and 2011, but of course could in part be explained by changes in screening practices and testing methods [12]. As more individuals are screened and tested for chlamydia, the rate may appear to increase throughout time. Similar to Canadian findings, more female cases were reported than males, with 61% of reported cases occurring in females in Ontario [12]. The rates were highest in females and in the 20 to 24-year age group for both genders. The chlamydia incidence rates in Ontario were consistently lower than the Canadian rates between 2008 and 2013 [12].

2.2.3 STI Clinics

Those individuals who attend a sexual health clinic can be compared with those who attend other services, such as a family practitioner office, a hospital, or a school clinic. It is expected that the rate of chlamydia will be higher among those tested at a sexual health clinic because individuals who have been notified as an STI contact through public health may choose to get tested at that STI clinic.

One American study which looked at chlamydia incidence among clients of an STI clinic found that 13.8% tested positive after their first visit [15]. Another study found that 13% of women who attended a sexual health clinic tested positive [16]. These clinic percentages are much higher than the typical rate at a state or provincial level. A study in the UK explored whether female patients with chlamydia infection who self-refer to genitourinary medicine clinics (STI clinics) have different demographic characteristics to those who initially attend other agencies [17]. Using data from three different clinics, it was found that there were no significant differences in age or Townsend scores (a measure of deprivation), although more Black Caribbean and single women self-referred to genitourinary clinics compared with other health-care settings [17]. Although there were no significant differences in age and deprivation in this UK population, results may differ in other countries.

2.3 Cost Burden in Canada

In Canada, the reported rate of chlamydia has increased, meaning that the resulting burden of cost has also increased. Prior to developing strategies to prevent and control chlamydia infection, it is important to first evaluate the costs and burden of the infection. Using mathematical models, one study attempted to estimate disease burden using an age and gender-structured mathematical model of chlamydia transmission by creating a "susceptible-infectious-recovered-susceptible" (SIRS) model [18]. This study found that the costs of screening and treatment of asymptomatic infections as a proportion of total chlamydia costs increased over time, while the costs of long-term infection associated with untreated infections declined. Although average estimated costs were $51.4 million per year, enhanced screening is thought to be highly cost-effective [18]. Another study estimated the direct costs of drugs, hospitals, and physician billings for chlamydia and gonorrhea (GC) in the year 2000 using the Economic Burden of Illness in Canada (EBIC) data [19]. It was found that both direct and indirect costs of chlamydia and GC ranges from $31.5 to $178.4 million, which is consistent with the results from the previous study [19]. Finally, a review of gender differences in STI estimates the direct and indirect costs of chlamydia to be $115 million for females and $8 million for males [4].

2.4 Risk Factors

Several risk factors have been reported as contributing to becoming infected with chlamydia, including behavioural, social, and biological factors. Reviews have examined multiple research articles and have summarized the common risk factors for chlamydia infection [20,21]. These risk factors could be considered as either causally related to the disease outcome, such as number of partners or condom use, or an indicator of sexual or health care behaviour that can affect an individuals' risk of infection, such as SES and race. Below is a summary of the most common risk factors identified in these studies.

2.4.1 Age

Several articles have concluded that age is a very important risk factor for chlamydia infection. Individuals in their teens and twenties have an increased risk of chlamydia infection, consequent to the physical development of the cervix for females [22,23], as well as the risky sexual behaviours of both genders. For example, young adults are less likely to correctly use protection or to acknowledge the risks of their sexual behaviour [24]. One review found that 29/34 female specific studies and 5/7 male specific studies showed a significant relationship between age and risk of infection in multivariate analysis [20]. The studies which showed no association had either restricted age groups or age cut-offs that were too high to detect a difference.

2.4.2 Sex

It is evident that females have a higher reported rate of chlamydia in Canada compared to males [25], but causes for this are unclear. It is suspected that women are at a greater risk due to the biology of the cervix [2,23], although uncircumcised males are also at an increased risk for many STIs [4]. The increased rate for females may stem from the fact that males may be less likely than females to get screened for STIs, as screening programs have historically been targeted towards women, particularly in association with cervical cancer screening [4]. Other important factors include sexual behaviours of both genders, such as an early age of sexual debut and high rates of partner change, which may be higher in males [4].

Knowing that males and females have different risks of infection for chlamydia is important, as it means the sexes must be studied separately. Additionally, the sexes may differ in risk factor information, such as condom use, where women may be uncomfortable about insisting on condom use [4].

2.4.3 Number and Type of Partners

Having multiple partners increases the chances of being exposed to an individual with an STI. A review by Navarro et al. (2002) found that in 10/14 studies examining this factor, the number of partners in the past year was an important risk factor for chlamydia infection [20]. That said, while women who reported five to nine partners were found to be five times more likely to have chlamydia than women who reported four or less, women who reported 10 or more partners had a reduced risk [20]. One explanation for this is that individuals who reported 10 or more partners were more likely to use condoms [26]. Another explanation is biased reporting, in this case, individuals might over or under-report their number of partners for social desirability. While men typically over-report their number of sexual partners, women more often under-report [27].

2.4.4 Condom Use

The relationship between condom use and the risk of chlamydia is inconsistent [20]. This is likely due to the inconsistent reporting of condom use in most studies. The relationship between condom use and chlamydia infection therefore needs to be further studied using better reported data. Generally, individuals who report using condoms are expected to be less likely to test positive for chlamydia than individuals who do not report using condoms.

2.4.5 Age at First Intercourse

Age at first intercourse is related to a higher infection rate due to the postulated biological mechanisms that may make adolescents more vulnerable to infection, as well as other factors such as multiple partners/non-regular partners. In one review, 4/7 studies examining this factor found that women who had an earlier age at first intercourse had a higher risk for chlamydia infection in unadjusted analysis, but not in multivariate analysis [20].

2.4.6 Neighbourhood SES

2.4.6.1 Neighbourhood SES Measures

Neighbourhood SES is a term used to assess the SES of an individual based on the neighbourhood in which they reside. It is a concept involving many aspects, such as income, employment, housing, and other social aspects of neighbourhoods [28,29]. There are various ways to measure neighbourhood SES, and different studies have used different methods, such as using census data, delivering a questionnaire, or combining several measurement indices. Since there are multiple dimensions contributing to neighbourhood SES, researchers have attempted to develop a composite index to summarize the many aspects that encompass the concept of neighbourhood SES. This has proved to be difficult, as there is concern for an ecological fallacy if the geographic definition of “neighbourhood” is too vast. Additionally, a restrictive geographic definition could fail to consider the broader environment that may affect the health of an individual. Townsend [30] and Carstairs [31] are two popular examples of composite measures for neighbourhood SES (specifically deprivation) which have been commonly utilized in research. Carstairs' and Townsend's deprivation indices both measure variables such as unemployment, households without a car, and households with more than one person per room. In recent years, these indices have received some criticism by researchers as they were developed 20 years ago and may not take into account modifications over time or across different countries [32]. Additionally, they are both only made up of four variables to measure deprivation. Ideally, the best neighbourhood SES index to use is one that is developed in the same region as the population being studied. For example, a study conducted in Ontario would benefit from a neighbourhood SES measurement tool which is also developed in Ontario. The Ontario Marginalization Index [33] (discussed later in this chapter) is a measure of neighbourhood marginalization using census data in Ontario, and would be a valuable option for studying the effects of neighbourhood SES on health outcomes in an Ontario study population.

2.4.6.2 Neighbourhood SES and Chlamydia Infection in the Literature

No studies were found that explored the effects of neighbourhood SES on chlamydia acquisition in STI clinics in Canada, although, there have been few studies that have examined this relationship in other contexts.

A study of neighbourhoods and the acquisition of chlamydia during the transition to young adulthood found that exposure to neighbourhood poverty during adolescence increased the likelihood of a positive chlamydia test during young adulthood [34]. This study measured SES using census data that looked at racial and ethnic concentration, concentrated poverty, and residential stability. Another study looked at the SES-related risk and STIs among African-American adolescent females and found that SES-related risk significantly predicted STI acquisition over a 36-month follow-up period [35]. This study measured SES using a questionnaire and controlled for variables, such as age, condom use, baseline STI status, substance use, and stress. Another study examined the interrelationship of demographic and geospatial risk factors among four common STIs (i.e., gonorrhea, chlamydia, herpes simplex virus, and human papillomavirus), and found that residence in inner city areas of high deprivation was an independent risk factor for all four STIs [36].

Finally, another study, which looked at chlamydia infection and the role of neighbourhood-level measures of SES among young women, determined that women living in regions of increased poverty were more likely to have multiple episodes of being infected with chlamydia compared to those who lived in low poverty areas [37].

2.4.7 Other Risk Factors

Reviews on this topic have also found that several other risk factors are associated with higher chlamydia infection, such as being single, current pregnancy, women with one or no children, suspected exposure to chlamydia, and having a symptomatic partner [20].

Other studies have identified additional factors associated with an increased risk of chlamydia infection. A study in Ontario found that among HIV-positive men who have sex with men, a chlamydia diagnosis was higher for those who used drugs recreationally as well as for those with greater than five HIV-positive partners [38]. Another Canadian study conducted in Manitoba found that younger age and being indigenous were associated with chlamydia infection in women [39]. The same study also noted that each additional $1,000 in neighbourhood annual income was associated with a 4% decrease in risk of co-infection with both chlamydia and gonorrhea, suggesting that low SES is associated with increased risk of these STIs. Further, it determined that women who live in urban areas are less likely to be co-infected with both STIs compared to women who live in more rural areas.

In a multi-city Canadian study of street youth, risk factors for chlamydia infection were higher in females if they were Aboriginal, had been in foster care, jail, or a detention facility in the past, had a probation/parole officer, or were homeless. In addition, females who reported no use of condoms and who were involved in the sex trade were at a higher risk for chlamydia infection [40]. A study in Montreal looked at the risk behaviours and prevalence of chlamydia and gonorrhea among street youth and found that the prevalence of chlamydia was 6.6% and was associated with a history of pregnancy. Among those with a history of pregnancy, the risk of chlamydia infection was three times higher [41].

2.5 The Kingston, Frontenac and Lennox & Addington (KFL&A) Region

The KFL&A region, which includes the Kingston, Frontenac, and Lennox & Addington counties, had a population of just over 200,000 individuals in 2013 [42]. The largest municipality, the City of Kingston, with a population of just over 117,000 individuals in 2016 [43], and a population percent increase of 2.4% from 2011 to 2016, is the second largest city in Eastern Ontario, after the City of Ottawa [44]. This area is desirable to study chlamydia risk factors as it has a very demographically diverse population. Annually, over 20,000 students attend Queen's University [45], over 7,000 students attend St. Lawrence College [46], and thousands of students attend the

Royal Military College of Canada. In addition, there are six correctional institutions in the region and a Canadian Forces Base [47]. These predominantly young adult populations are particularly susceptible to STIs because of the potential opportunities for sexual contact.

The average total income in 2010 for the population aged 15 and over in KFL&A was $39,398 [48]. The SES range in the City of Kingston is diverse with 44.2% of individuals earning under $20,000 annually, while 11.8% earned over $60,000 in 2000. This percentage of low-income earners is higher than every other comparator city outside the region, and similarly, the percentage of high-income earners (11.8%) is higher than comparable cities outside the region [44]. The unemployment rate in Kingston is higher than most other comparator cities, although the rate slightly declined between 2001 to 2006 [44]. In other words, the marginalization index, which is defined later in this chapter, ranges from low to high in this city, providing for a diverse setting for research questions to be addressed.

The KFL&A Public Health sexual health clinic in Kingston is a service that provides confidential and non-judgemental counselling, testing, and treatment for STIs, including chlamydia [49]. Although there are other clinics in the region that provide similar services, this clinic diagnoses about 20% of the chlamydia cases in KFL&A. It is of interest to differentiate the individuals who attend this clinic compared to other centres, as the population who attends an STI clinic may be different in demographics and risk factors compared to other populations.

The iPHIS is a web-based reportable disease database that is used by Ontario's 36 public health units to record and track communicable disease incidence and prevalence in the province. The system is mandated under the *Health Protection and Promotion Act* (HPPA), requiring each public health unit to collect information on reportable diseases occurring within their area [50]. The information collected is used for the surveillance of diseases and for research purposes. It is known that the reported chlamydia cases in iPHIS are an underestimate, since not all individuals seek treatment, and therefore the disease in many individuals is unreported. Both the iPHIS (KFL&A-specific data only) and the KFL&A Public Health sexual health clinic databases will be used in this study to estimate the applicable rates of chlamydia.

2.6 Dissemination Areas

Census data in Canada is composed of dissemination areas (DAs), which are small geographic units composed of one of more adjacent dissemination blocks [51]. It is the smallest geographic area for which all census data are disseminated. For example, the City of Kingston is defined by 43 distinct neighbourhoods, with about 5 to 7 geographic "blocks" in each neighbourhood, and 400 to 700 persons in each block [52]. These blocks are called DAs, which are uniform to one another in terms of population size. Therefore, DAs with a lower population density will be geographically larger in size compared to DAs with a higher population density. An example neighbourhood profile map of the city of Kingston from the 2011 census (Appendix B; Figure B.1) and a reference map showing an example of a DA (Appendix C; Figure C.1) is appended to this thesis.

2.7 Marginalization and the ON-Marg Index

Marginalization is "the process by which individuals and groups are prevented from fully participating in society" [53]. A population that is marginalized may experience barriers in terms of health services, employment, housing, education, and other social determinants of health [54].

In Ontario, the ON-Marg Index [54] is used by researchers to learn more about marginalization between different neighbourhoods in the province. It is a geographically and census-based index plotting differences in marginalization among geographic areas. The ON-Marg Index is specifically used in research to describe the relationship between marginalization and health outcomes, as greater marginalization tends to be associated with higher rates of many diseases [33]. The ON-Marg Index contains four dimensions to measure an area's marginalization: residential instability (i.e. owning a home, housing status, etc), dependency (i.e. participation in the labour force, etc), ethnic concentration (i.e. immigrants, visible minorities, etc), and material deprivation (i.e. unemployment, education, income, etc) [55]. A description of each dimension of marginalization and their respective indicators is presented in Figure D.1 in Appendix D.

The four ON-Marg indices can be combined into a composite index score and categorized into 5 quintiles, from 1 (least marginalized) to 5 (most marginalized). The goal of the index is to combine related variables into a single measure which can be used largely for research purposes. Although, the combination of the indices is cautioned if the association between each index and the outcome is not consistent for all indices. Additionally, if there is no reason to believe that all four indices are comparably related to the outcome of study, it is not recommended to combine them. Many researchers therefore opt to analyze the ON-Marg Index as four separate indices, or will only use certain indices which are believed to be associated with the outcome.

The ON-Marg Index can be used to examine differences in marginalization among the DAs in the KFL&A region. The index can be used to approximate neighbourhood SES by assigning a score (1-5) to each individual based on the DA in which they reside [33]. This method is especially helpful when individual data on SES is not available. It is important to note that this method should not be used to make inferences about individual-level marginalization. Rather, results should be interpreted accordingly, such as “the effect of living in a marginalized area” rather than “the individual’s SES”. Since the DA is the smallest spatial area available, it is more likely that an individual’s neighbourhood SES will be reasonably reflected by the score of the area in which he or she lives.

There are currently no studies published in the literature which examine the association between the ON-Marg Index and any STI. Additionally, no studies have validated the ON-Marg Index against other measures of neighbourhood SES. That said, there have been few studies which have used the ON-Marg Index to measure associations with other health outcomes. One study used a combined score of the ON-Marg Index to assess its association with renal injury in adolescents with Type 1 diabetes, and found that there was an association [56]. Another study looked at the ON-Marg indices separately and the associations with cardiovascular disease risk factors. Significant results in this study were only examined for the material deprivation index [57]. Finally, another study examined specifically two indices of the ON-Marg (material deprivation and residential stability) and found that both were associated with increased undetermined intent deaths and suicide [58].

With the results of the few studies which have examined associations between the ON-Marg Index and various health outcomes, there is some evidence to suggest that the ON-Marg Index is a good measure of neighbourhood SES. Therefore, it would be worthwhile to use this tool in STI research for measuring an area-level risk factor for chlamydia infection.

2.8 Geographic Information Systems

Geographic information system (GIS) analysis and spatial epidemiology has become an important tool for public health analysis and planning. It is a system that displays and examines spatial data by creating computerized maps, tables, and graphs to assist with observing trends [59]. It allows researchers to visualize, analyze, and interpret data to understand spatial relationships between variables of interest. GIS is being used to better understand the geography and epidemiology of STIs, and to examine localized spatial clusters [60]. These clusters, or high-risk areas, are usually the result of similar SES profiles, and therefore targeting interventions in these areas will hopefully reduce future infections in populations that are high-risk. Although there are different units of geography which can be used with a GIS system, KFL&A Public Health generally analyzes based on the DA [59].

The most popular use for the GIS software in STI epidemiology is to map the incidence of infections [54,33,55]. Recently, this method was used in studies to look at area-based socioeconomic measures and individual risk factors associated with STIs. The SES of an individual has been found to be an important predictor for contracting STIs [22,24,26]. Using geo-mapping in two genitourinary medicine clinics in the UK, it was found that being under the age of 20 years, being male, being of black ethnicity, and living in neighbourhoods designated as lower SES was correlated with higher rates of both gonorrhea and chlamydia [61]. Results of an American study also used geocoding to examine area-based socioeconomic measures associated with women infected with chlamydia. The study found that having less than a high school education, living below the poverty level, living in the same residence for over five years, and receiving food stamps were independently associated with an increased risk of chlamydia infection among females [62]. In a Canadian study, GIS was used to map the rates of gonorrhea and chlamydia. It was found that those infected with chlamydia were generally younger and female compared to those with gonorrhea, and infection of both STIs was positively correlated with having a low SES, as defined by the Canadian 2001 Census [63]. In addition, a UK study examined the interrelationship between demographic and geospatial risk factors for four common STIs (gonorrhea, chlamydia, HPV warts, and herpes) and found that chlamydia screening in women under 25 years could detect 70% of chlamydia cases in the community.

In conclusion, GIS technology can visually illustrate populations according to various factors, including disease burden and living conditions. Lower SES levels are associated with higher STI rates, but what is less clear is whether and how other risk factors might affect this relationship. To date, using GIS in this fashion has not yet been used to describe the geospatial distribution and risk factors of chlamydia based on data from any Ontario sexual health clinic, and information from such a study could inform public health units in Ontario regarding the interrelationship between demographic, sexual and geospatial risk factors for chlamydia infection. It is also novel to compare test positive and negative rates spatially.

2.9 Study Rationale

Chlamydia occurs in many different populations, and age and sexual behaviour are two of the most important risk factors. However, less studied factors such as neighbourhood SES may also be important markers for predicting the risk of infection. Navarro et al. (2002) concluded their review by stating that "as more control programs are implemented, people with limited access to preventive and treatment programs will become more dominant in the epidemic, and chlamydia may become concentrated in lower-income minority groups with high rates of partner change" [20]. This statement speaks to the idea that SES needs to be considered when studying the relationship among risk factors for chlamydia infection.

This study aimed to measure the various individual and area-level risk factors for chlamydia infection in clients who attended the KFL&A Public Health sexual health clinic. This research is novel as it integrates the ON-Marg Index with traditional risk factors to determine a risk profile for chlamydia infection in an STI clinic. The result of this study will provide evidence for the KFL&A Public Health unit to better target prevention interventions in specific geographic regions, as prevention strategies are facilitated by understanding the transmission dynamics of the STI. It will also be beneficial to compare the available demographics of individuals who attend a sexual health clinic with those who are tested elsewhere.

2.10 References

1. World Health Organization. Sexually transmitted infections (STIs). http://www.who.int/en/news-room/fact-sheets/detail/sexually-transmitted-infections-(stis). Published 2016.
2. Government of Canada. Report on Sexually Transmitted Infections in Canada: 2012. http://www.phac-aspc.gc.ca/sti-its-surv-epi/rep-rap-2012/rep-rap-1-eng.php. Published 2015.
3. Public Health Agency of Canada. Canadian Guidelines on Sexually Transmitted Infections. http://www.phac-aspc.gc.ca/std-mts/sti-its/cgsti-ldcits/section-5-2-eng.php. Published 2013.
4. Wong T, Singh A, Mann J, Hansen L, McMahon S. Gender Differences in Bacterial STIs in Canada. *BMC Womens Health*. 2004;4 Suppl 1(Suppl 1):S26. doi:10.1186/1472-6874-4-S1-S26.
5. WebMD. Chlamydia- Topic Overview. http://www.webmd.com/sexual-conditions/tc/chlamydia-topic-overview#1. Published 2017.
6. Mayo Clinic. Chlamydia trachomatis. http://www.mayoclinic.org/diseases-conditions/chlamydia-trachomatis/symptoms-causes/dxc-20315310. Published 2017.
7. CDC. Chlamydia - CDC Fact Sheet. 2017. https://www.cdc.gov/std/chlamydia/stdfact-chlamydia.htm.
8. Whelan, M., Pritchard J. *PHO Rounds: Sexually Transmitted Infections in Ontario: Chlamydia and Gonorrhea*. http://www.publichealthontario.ca/en/LearningAndDevelopment/EventPresentations/P

art 2 of the Sexually Transmitted Infection (STI) Series_Chlamydia and Gonorrhea.pdf.

9. Price MJ, Ades AE, Soldan K, et al. The natural history of Chlamydia trachomatis infection in women: a multi-parameter evidence synthesis. *Health Technol Assess*. 2016;20(22):1-250. doi:10.3310/hta20220.

10. Brabin L, Fairbrother E, Mandal D, et al. Biological and hormonal markers of chlamydia, human papillomavirus, and bacterial vaginosis among adolescents attending genitourinary medicine clinics. *Sex Transm Infect*. 2005;81(2):128-132. doi:10.1136/sti.2004.010223.

11. AACC. Chlamydia Testing. https://labtestsonline.org/understanding/analytes/chlamydia/tab/test/.

12. Public Health Ontario. *Reportable Disease Trends in Ontario*.; 2014. https://www.publichealthontario.ca/en/eRepository/Reportable_Disease_Trends_in_Ontario_2014.pdf.

13. Rotermann M, Langlois KA, Severini A, Totten S. Prevalence of chlamydia trachomatis and herpes simplex virus type 2: Results from the 2009 to 2011 canadian health measures survey. *Heal Reports*. 2013;24(4):10-15.

14. Public Health Ontario. No Title. http://www.publichealthontario.ca/en/Pages/default.aspx.

15. Rietmeijer CA, Van Bemmelen R, Judson FN, Douglas JM. Incidence and repeat infection rates of Chlamydia trachomatis among male and female patients in an STD clinic: implications for screening and rescreening. *Sex Transm Dis*. 2002;29(2):65-72. http://www.ncbi.nlm.nih.gov/pubmed/11818890.

16. D C Burns, S Darougar, R N Thin, L Lothian CSN. Isolation of Chlamydia from women attending a clinic for sexually transmitted disease. *Sex Transm Infect*. 51(5):314-318. http://sti.bmj.com/content/sextrans/51/5/314.full.pdf.

17. Huengsberg M, Ahmed-Jushuf I, Rogstad KE, et al. Are women with chlamydia infection who self-refer to genitourinary medicine clinics different? *Int J STD AIDS*. 2005;16(10):681-685. doi:10.1258/095646205774357370.

18. Tuite AR, Jayaraman GC, Allen VG, Fisman DN. Estimation of the Burden of Disease and Costs of Genital Chlamydia trachomatis Infection in Canada. *Sex Transm Dis*. 2012;39(4):260-267. doi:10.1097/OLQ.0b013e31824717ae.

19. Smylie L, Lau P, Lerch R, et al. The economic burden of chlamydia and gonorrhoea in Canada. *Sex Transm Infect*. 2011;87(Suppl 1):A156-A156. doi:10.1136/sextrans-2011-050108.135.

20. Navarro C, Jolly A, Nair R, Chen Y. Risk factors for genital chlamydial infection. *Can J Infect Dis*. 2002;13(3):195-207. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2094865&tool=pmcentrez&rendertype=abstract.

21. Kucinskiene V, Sutaite I, Valiukeviciene S, Milasauskiene Z, Domeika M. Prevalence and risk factors of genital Chlamydia trachomatis infection. *Medicina (Kaunas)*. 2006;42(11):885-894.

22. Berman SM, Hein K. Adolescents and STDs. In: *Sexually Transmitted Diseases*. ; 1999:1454.

23. Sedlecki K, Markovic M, Rajic G. Risk factors for Clamydia infections of the genital organs

in adolescent females . *Srp Arh Celok Lek*. 2001;129(7-8):169-174. https://www.scopus.com/inward/record.uri?eid=2-s2.0-0035411976&partnerID=40&md5=9ea53db52cdf3cf1b98edf7eb8f6c61e.

24. Cates Jr. W. Epidemiology and control of sexually transmitted diseases: strategic evolution. *InfectDisClinNorth Am*. 1987;1(1):1-23.

25. Government of Canada. Executive Summary: Report on Sexually Transmitted Infections in Canada: 2012. https://www.canada.ca/en/public-health/services/infectious-diseases/surveillance-epidemiology-sexually-transmitted-infections-hep-b-c/report-2012/report-on-sexually-transmitted-infections-canada-2012-8.html. Published 2015.

26. Tanfer K. Sex and disease. Playing the odds in the 1990s. *Sex Transm Dis*. 1994;21(2 Suppl):S65-72.

27. Anderson JE, Dahlberg LL. High-risk sexual behavior in the general population. Results from a national survey, 1988-1990. *Sex Transm Dis*. 1992;19(6):320-325.

28. Braveman PA, Cubbin C, Egerter S, et al. Socioeconomic Status in Health ResearchOne Size Does Not Fit All. *Jama*. 2005;294(22):2879-2888. doi:10.1001/jama.294.22.2879.

29. Gordon D. Census based deprivation indices: Their weighting and validation. *J Epidemiol Community Health*. 1995;49(SUPPL. 2). doi:10.1136/jech.49.Suppl_2.S39.

30. Townsend P, Davidson N. *Health and Deprivation: Inequalities and the North*. Vol 19.; 1988.

31. Carstairs V, Morris R. Deprivation: explaining differences in mortality between Scotland and England and Wales. *BMJ*. 1989;299(6704):886-889. doi:10.1136/bmj.299.6704.886.

32. Lalloué B, Monnez JM, Padilla C, et al. A statistical procedure to create a neighborhood

socioeconomic index for health inequalities analysis. *Int J Equity Health*. 2013;12(1). doi:10.1186/1475-9276-12-21.

33. St. Michaels Hospital. *Ontario Marginalization Index User Guide Version 1.0*. http://www.torontohealthprofiles.ca/onmarg/userguide_data/ON-Marg_user_guide_1.0_FINAL_MAY2012.pdf.

34. Ford JL, Browning CR. Neighborhoods and infectious disease risk: Acquisition of chlamydia during the transition to young adulthood. *J Urban Heal*. 2014;91(1):136-150. doi:10.1007/s11524-013-9792-0.

35. Sales JM, Smearman EL, Swartzendruber A, Brown JL, Brody G, Diclemente RJ. Socioeconomic-related risk and sexually transmitted infection among African-American adolescent females. *J Adolesc Heal*. 2014;55(5):698-704. doi:10.1016/j.jadohealth.2014.05.005.

36. Monteiro EF, Lacey CJN, Merrick D. The interrelation of demographic and geospatial risk factors between four common sexually transmitted diseases. *Sex Transm Infect*. 2005;81(1):41-46. doi:10.1136/sti.2004.009431.

37. Biello KB, Pettigrew MM, Niccolai LM. Multiple chlamydia infection among young women: comparing the role of individual- and neighbourhood-level measures of socioeconomic status. *Sex Transm Infect*. 2011;87(7):560-562. doi:10.1136/sextrans-2011-050185.

38. Grewal R, Allen VG, Gardner S, et al. Serosorting and recreational drug use are risk factors for diagnosis of genital infection with chlamydia and gonorrhoea among HIV-positive men who have sex with men: results from a clinical cohort in Ontario, Canada.

Sex Transm Infect. 2017;93(1):71-75. doi:10.1136/sextrans-2015-052500.

39. Jolly, A., Orr, P., Hammond, G., Young T. Risk factors for infection in women undergoing testing for Chlamydia trachomatis and Neisseria gonorrhoeae in Manitoba, Canada. *Sex Transm Dis*. 1995;22(5):289-295.

40. Shields, S., Wong, T., Mann, J., Jolly, A., Haase, D., Mahaffey, S., Moses, S., Morin, M., Patrick, D., Predy, G., Rossi, M., Sutherland D. Prevalence and Correlates of Chlamydia Infection in Canadian Street Youth. *J Adolesc Heal*. 2004;34:384-390.

41. Haley, N., Roy, E., Leclerc, P., Lambert, G., Boivin, J., Cedras, L. VJ. Risk behaviours and prevalence of Chlamydia trachomatis and Neisseria gonorrhoeae genital infections among Montreal street youth. *Int J STD AIDS*. 2002;13:238-245.

42. KFL&A Public Health. Population by Age and Sex. https://www.kflaph.ca/en/research-and-reports/population-by-age-and-sex.aspx. Published 2013.

43. Government of Canada. Census Profile, 2016 Census. http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=POPC&Code1=0415&Geo2=PR&Code2=47&Data=Count&SearchText=Kingston&SearchType=Begins&SearchPR=01&B1=All&TABID=1. Published 2016.

44. Natural Capital Resources Inc. *A Socio-Economic Profile of Kingston, Ontario*.; 2008.

45. Queen’s University. Quick Facts. http://www.queensu.ca/about/quickfacts. Published 2016.

46. St. Lawrence College. Enrollment at St. Lawrence College remains strong in 2015. https://www.stlawrencecollege.ca/news/2015/enrollment-sept-2015/. Published 2015.

47. Correctional Service Canada. Ontario Region. http://www.csc-scc.gc.ca/institutions/001002-3000-eng.shtml. Published 2014.

48. KFL&A Public Health. Income. https://www.kflaph.ca/en/research-and-reports/income.aspx. Published 2013.

49. KFL&A Public Health. Sexual Health Clinics. https://www.kflaph.ca/en/clinics-and-classes/Sexual-Health-Clinics.aspx. Published 2016.

50. Simcoe Muskoka. Integrated Public Health Information System (iPHIS). http://www.simcoemuskokahealthstats.org/resources/data-sources/iphis.

51. Statistics Canada. Dissemination Area Reference Maps, by Census Tracts, for Census Metropolitan Areas and Census Agglomerations. http://www12.statcan.gc.ca/census-recensement/2011/geo/map-carte/ref/ct-sr/download-telecharger-eng-2011.cfm?YEAR=2011&MAP=2011-92147-521-000200-00&PRCODE=35&CACODE=521&CT_NAME=0002.00. Published 2015.

52. City of Kingston. Neighbourhood & Community Profiles. https://www.cityofkingston.ca/city-hall/neighbourhood-profiles.

53. Toronto Community Health Profiles Partnership. ON-Marg FAQs. http://www.torontohealthprofiles.ca/onmarg_faq.php.

54. Profiles TCH. Ontario Marginalization Index (ON-Marg). 2017. http://www.torontohealthprofiles.ca/onmarg.php.

55. Public Health Ontario. Overview of the Ontario Marginalization Index. https://www.publichealthontario.ca/en/LearningAndDevelopment/Events/Pages/Overview-of-the-Ontario-Marginalization-Index-.aspx. Published 2017.

56. Cummings LAM, Clarke A, Sochett E, et al. Social Determinants of Health Are Associated with Markers of Renal Injury in Adolescents with Type 1 Diabetes. *J Pediatr*. 2018;198:247-253.e1. doi:10.1016/J.JPEDS.2018.03.030.

57. Inman M, Daneman D, Curtis J, et al. Social Determinants of Health Are Associated with Modifiable Risk Factors for Cardiovascular Disease and Vascular Function in Pediatric Type 1 Diabetes. *J Pediatr*. 2016;177:167-172. doi:10.1016/j.jpeds.2016.06.049.

58. Lachaud J, Donnelly P, Henry D, et al. Characterising violent deaths of undetermined intent: a population-based study, 1999–2012. *Inj Prev*. 2017:injuryprev-2017-042376. doi:10.1136/injuryprev-2017-042376.

59. Andruszkiewicz N. *User Manual for the GIS Portal at KFL&A Public Health: Version 1.0*. Kingston; 2013.

60. Zulu, L., Kalipeni, E., Johannes E. Analyzing spatial clustering and the spatiotemporal nature and trends of HIV/AIDS prevalence using GIS: the case of Malawi, 1994-2010. *BMC Infrectious Dis*. 2014;14(285).

61. Shahmanesh, M., Gayed D., Ashcroft, M., Smith, R., Roopnarainsingh, R., Dunn, J., Ross J. Geomapping of chlamydia and gonorrhoea in Birmingham. *Sex Transm Infect*. 2000;76:268-272. http://sti.bmj.com/content/sextrans/76/4/268.full.pdf.

62. Bernstein, K., Goldring, S., Marcus, J., & Philip S. Area-based socioeconomic measures associated with female chlamydia and gonorrhoea, San Francisco, 2009. *Sex Transm Infect*. 2011;87(1). doi:10.1136/sextrans-2011-050109.84.

63. Bush, K., Henderson, E., Dunn, J., Read, R., Singh A. Mapping the Core: Chlamydia and Gonorrhea Infections in Calgary, Alberta. *Sex Transm Dis*. 2008;35(3):291-297.

http://journals.lww.com/stdjournal/Abstract/2008/03000/Mapping_the_Core__Chlamydia_and_Gonorrhea.15.aspx.

Chapter 3

The association between area- and individual-level risk factors and chlamydia infection in a sexual health clinic in Ontario, Canada

3.1 Abstract

Background: Chlamydia is the most common sexually transmitted infection (STI) in Canada. Although the literature has focused on individual-level risk factors, such as number of sexual partners and condom use, as the greatest determinants for chlamydia infection, more recent research has investigated the role of neighbourhood socioeconomic status (SES) on risk for chlamydia infection. The present study aims to investigate the relationship between multiple area- and individual-level risk factors and chlamydia infection in a sexual health clinic in Kingston, Ontario.

Methods: Individuals who were tested for chlamydia at the Kingston, Frontenac and Lennox & Addington (KFL&A) Public Health sexual health clinic (Clinic) from April 1, 2016 to March 31, 2017, were included in this study. The four indices of the Ontario Marginalization (ON-Marg) Index; namely, material deprivation, dependency, residential instability and ethnic concentration, were used as measures of neighbourhood SES for the area-level risk factors. Individual-level risk factors included variables that were captured from the questionnaire administered at the time of the examination. Logistic regression was used to compute odds ratios (OR) for all risk factor variables. Outcome data was plotted on a geographic information system (GIS) to compare marginalization differences based on chlamydia test result.

Results: A total of 1775 individuals were tested for chlamydia at the Clinic, with 208 (11.7%) testing positive on their first Clinic visit. Age (OR=4.84, 95% CI 2.18-10.74; <20 versus >40 years), number of sexual partners in the previous 2 months (OR=3.11, 95% CI 1.06-9.10; 2 partner versus no partners), condom use (OR=2.09, 95% CI 1.07-4.09; rarely versus always using condoms), and STI contact (OR=6.16, 95% CI 4.35-8.74) were significant individual-level predictors for infection. Except for the ethnic concentration index, there was a trend suggesting an association between the highest levels of marginalization and increased odds of chlamydia infection compared to the lowest levels of marginalization. However, this association was only statistically significant for the dependency index (OR=1.90, 95% CI: 1.05-3.43; most deprived versus least deprived). Furthermore, there was no clear dose-response observed with increasing marginalization in any of the ON-Marg indices.

Conclusions: Populations living in highly marginalized neighbourhoods, an established marker of low SES, were only found to be at a significantly higher odds for chlamydia infection for one of the ON-Marg indices; namely, dependency. Additional research is therefore warranted to further clarify the role of neighbourhood effects on the risk of chlamydia infection, and could provide public health units with information that may inform targeted neighbourhood-level prevention interventions for vulnerable populations in specific geographic regions.

This manuscript is formatted for submission to the *Canadian Journal of Public Health*.

3.2 Introduction

Chlamydia, caused by the bacterium *Chlamydia trachomatis* (CT), is the most common sexually transmitted infection (STI) in Canada [1], with an estimated 325 cases per 100,000 population in 2015 [2]. If left untreated, chlamydia infection can lead to complications such as genital inflammation, infertility, and ectopic pregnancies in women, as well as infertility and inflammation of the testicles and prostate in men [3,4]. Being infected with chlamydia can also increase the risk of being infected, if exposed, by the human immunodeficiency virus (HIV) [5]. Known risk factors for chlamydia infection include being sexually active before the age of 25, having new and/or multiple sexual partners, having a high-risk partner (includes individuals who have a sex partner(s) infected with chlamydia), not using condoms, and being previously diagnosed with an STI [4,6,7].

The socioeconomic status (SES) of an individual is comprised of multiple factors which may affect a variety of health outcomes. The association of SES with many health outcomes has been widely demonstrated in multiple epidemiological studies and has become routine in analyses. There is evidence that physical, psychological, social, and spatial neighbourhood characteristics, or an individuals' neighbourhood socioeconomic characteristics, can have a powerful influence on the health of an individual [8–11]. More recently, low neighbourhood SES has been found to be associated with an increased risk for chlamydia infection [12–15]. It is hypothesized that there are mechanisms in which the social environment of an individual may affect the risk of contracting chlamydia, or other STIs. Figure 3.1 (adapted from Carpiano's proposed conceptual model of neighbourhood social capital processes on individual health outcomes [16] and from Jennings' depiction of Carpiano's model [17]) depicts this conceptual framework linking neighbourhood SES and chlamydia infection. In general, these neighbourhood factors may be associated with chlamydia infection, as they may alter the sexual network and availability of infected sexual partners. Although individual-level demographics and sexual behaviours may directly affect an individual's risk for chlamydia infection, neighbourhood and interpersonal factors may also impact these factors. For this reason, it is important to study both area- and individual-level risk factors when measuring the risk for chlamydia infection in a population.

Previous studies have used a variety of measures to assess SES, including questionnaires or census data. The Ontario Marginalization (ON-Marg) Index measures multiple indicators of neighbourhood-level marginalization in Ontario, including economic, ethno-racial, age-based, and social marginalization, and combines data from the short and long-form census [18,19]. The index has been validated for health research use in Ontario [20], and is specifically used in research to describe the relationship between neighbourhood-level marginalization and health outcomes, as greater marginalization tends to be associated with higher rates of many diseases [21]. The ON-Marg Index combines a wide range of demographic indicators into four dimensions of marginalization: residential instability (i.e. owning a home, housing status, etc.), dependency (i.e. participation in the labour force, etc.), ethnic concentration (i.e. immigrants, visible minorities, etc.), and material deprivation (i.e. unemployment, education, income, etc.) [18]. Details of the indicators, dimensions, and use of the ON-Marg Index are available from the ON-Marg Index User Guide [21].

As of the writing of the manuscript, there are no studies published in the peer reviewed scientific literature which examine the association between the ON-Marg Index and any STI, including chlamydia. While some studies have found significant associations between indices of the ON-Marg Index and various negative health outcomes, such as renal injury, cardiovascular disease, and violent deaths [22–25], other studies have found non-significant associations with some indices of the ON-Marg index and various health outcomes, such as out-of-hospital cardiac arrest outcomes [26]. The studies which have found positive associations provide evidence to suggest that the ON-Marg Index can be a reasonable measure of neighbourhood SES for some health outcomes. Previous studies have evaluated neighbourhood SES and chlamydia infection and have found significant associations [12–14], but none have utilized the relatively new research tool, the ON-Marg Index, as a measure of neighbourhood SES in Ontario. Therefore, this tool was chosen for measuring an area-level risk factor for chlamydia infection.

3.3 Methods

3.3.1 Study Population

The Kingston, Frontenac, and Lennox and Addington (KFL&A) region is located in Ontario, Canada, with a population of about 200,000 [27]. A large portion of this region is served by the KFL&A Public Health sexual health clinic (referred to as the "Clinic" hereon), located in the City of Kingston. This study used participant data from the Clinic's electronic medical record (EMR) database. The Clinic provides confidential counselling, testing opportunities, and treatment for STIs, including chlamydia [28]. There was no population sampling method employed in this study, as the participants included were all individuals who visited the Clinic and who subsequently underwent one or more tests for chlamydia during the study period. A total of 2396 tests for chlamydia were conducted during the 12-month period between April 1, 2016 and March 31, 2017. All chlamydia positive and negative test results for patients at the Clinic during this period were available for use. For the purpose of this study, individuals who tested positive for CT using any of the laboratory tests (culture cervical, culture rectal, culture throat, culture urethral, nucleic acid amplification test (NAAT) cervical, and NAAT urine) are defined as testing positive for chlamydia infection, and similarly for testing negative for chlamydia infection (see Table E.1 in Appendix E for CT tests conducted at the Clinic).

The small number of tests (n=7) that were classified as neither positive nor negative for chlamydia infection, but rather as "other" in the database were excluded from analysis. Additionally, participants who identified as transgender (3) were also excluded from the data set, as three participants would not be a sufficient sample size to investigate the role of transgender on chlamydia infection. To assign participants to a dissemination area (DA) (the smallest geographic area for which all census data are disseminated) for the ON-Marg Index, a postal code from each participant was required. Participants with no reported postal code (n=219) were excluded from the geographic analysis, but remained in all descriptive tables and multivariate analyses; included in a "missing" category. Figure 3.2 displays the data creation flow diagram for the Clinic population in this study.

In addition to the Clinic data, the integrated Public Health Information System (iPHIS) data was also used to compare the Clinic rates with the KFL&A region rates. The iPHIS is a web-based reportable disease database that is used by Ontario's 34 public health units to record and track communicable disease incidence and prevalence in the province. The system is mandated under the *Health Protection and Promotion Act* (HPPA), requiring each public health unit to collect information on reportable diseases occurring within their area [29]. Only the KFL&A region data in the Ontario iPHIS database (referred to as simply "iPHIS" hereon) was anonymously extracted for use. All cases with a positive chlamydia test (iPHIS does not record negative results) reported in the iPHIS database during the same 12-month period were extracted for analysis.

3.3.2 Data Collection

Data from the Clinic is available from the KFL&A Public Health EMR database. Individuals who were tested for chlamydia, like all other Clinic clients, were interviewed by a clinic nurse and questioned regarding various risk factors prior to being tested (see Figure F.1 in Appendix F for the Clinic questionnaire). The data collected includes information on general demographics, presenting concern, sexual orientation, condom use, sexual partners in the last 2 months, various STI symptoms, various STI risks and tobacco/alcohol use. All samples collected from individuals at the Clinic were sent to the Public Health Ontario (PHO) Laboratory for testing. All tests, whether positive or negative, are reported to the Clinic by the PHO Laboratory.

The iPHIS database is a reportable disease database and includes every individual who tested positive for chlamydia in a specific region (in this case, the KFL&A region). The data was collected from all clinics in the KFL&A region, with all positive results being reported to KFL&A Public Health for case management, contact tracing, and partner notification. The Clinic EMR and iPHIS datasets were anonymized, removing all personal identifiers and translating postal codes to the applicable DAs. All analyses were conducted by a researcher on a secure server at Queen's University.

Ethics approval for this study was obtained from the Health Sciences Research Ethics Board (HSREB) at Queen's University.

3.3.3 Study Design

The primary analytic objective of this study employed a cross-sectional design, since both the risk factor data collected and testing for chlamydia infection was initiated on the same day. This objective considers only those who were tested for chlamydia infection at the Clinic during the study period. For patients who attended the Clinic multiple times during the study period and had multiple chlamydia tests, only the test result of the first visit in the study period was used. In the case that an individual's first test result was recorded as "other" and they received a follow-up test at a later date, that later test was used instead. Individuals who tested positive will be compared to those who tested negative on multiple area- and individual-level risk factors.

A spatial epidemiology design using GIS methodology was implemented to map and compare the geographic distribution of test-positive and test-negative cases from the Clinic only.

3.3.4 Risk Factor Assessment

The potential individual-level risk factors considered in this study were age, sex, student status, reported number of sexual partners in the prior 2 months, condom use, STI contact, STI symptoms and history of a previous STI. These variables were selected based on a literature review that identified risk factors that were significantly associated with chlamydia infection in other studies, were available from the Clinic questionnaire, and were either associated with chlamydia infection in bivariate analysis ($p<0.20$) or were included *a priori.*

The variable “STI contact” was created as a combination of those who a) stated they were coming in for contact tracing as a presenting concern or b) stated they had an STI contact under the risk factors section of the questionnaire. Additionally, the variable “STI symptoms” was created as a combination of those who a) stated they were coming in for STI symptoms as a presenting concern or b) listed any one of the symptoms under the STI symptoms section of the questionnaire.

The area-level risk factor exposures in this study are the four indices (material deprivation, dependency, residential instability, and ethnic concentration) of the ON-Marg Index, which will be used as a marker of neighbourhood marginalization, or SES. In this study, the “neighbourhood” of an individual is defined by the DA in which they reside. The 2006 version of the ON-Marg Index, adapted from the long-form census in 2006, was used for this study. The ON-Marg Index is divided into quintiles (Q), ranked from Q1 (least marginalized) to Q5 (most marginalized). It was therefore studied as an ordinal exposure with five ordered levels. The postal code for each participant, if available, was translated to a DA by KFL&A staff, and the corresponding ON-Marg Index scores for individuals in each DA were computed.

3.3.5 Outcome Assessment

The outcome of interest for this study was a positive chlamydia test during the study period. For the Clinic sample, chlamydia status was based on a laboratory confirmation test result that was recorded in the EMR database. The test was either positive or negative for chlamydia infection, and therefore the outcome was explored as a binary variable. Various methods of testing for chlamydia infection were used, such as culture of a cervical, rectal, throat, or urethral swab, NAAT of a cervical or urine sample. Around 70% of the tests in this Clinic sample used the NAAT urine method, 20% used the NAAT cervical method, and 10% used one of the other listed methods.

The iPHIS database was used to compare Clinic rates to the entire KFL&A region. The iPHIS database only records positive chlamydia test results, therefore the outcome of interest for the iPHIS database was a positive chlamydia test.

3.3.6 GIS Methodology

For the GIS component of this study, the platform ArcGIS was used [30] . The EMR data from the Clinic was provided by KFL&A Public Health with each individual linked to a DA, based on their reported postal code. Individuals with no postal code recorded in the EMR (n=219) could not be mapped. The score (from 1 to 5) of each of the four ON-Marg indices were matched to the corresponding DA to create a colour gradient of a score of 1 to 5 on the GIS. Rates of positive and negative chlamydia tests per 100,000 population were calculated at the DA level and plotted on the map of the KFL&A region.

3.3.7 Statistical Analysis

Descriptive statistics were used to assess the counts and percentages of all variables. The central tendency (means; medians) and dispersion (standard deviations) were described for continuous variables, and frequency tables (counts; percentages) were described for categorical variables. Unadjusted bivariate logistic regression analyses were performed to assess the relationship between the area- and independent-level risk factors and chlamydia infection. Multivariable logistic regression models were built for all final adjusted models. A backwards deletion approach was used to assess and control for confounding and to determine which variables to include in the final model. Age and sex were included *a priori* in all models, as these two variables are considered to be two of the most important predictors for chlamydia infection. Other variables were removed one at a time beginning with the least significant variable, using a liberal cut-off ($p<0.15$). Odds ratios (OR) and 95% confidence intervals (CI) were used to estimate the risk between the exposure variables and chlamydia infection. All statistical analyses for this study were conducted using SAS version 9.4.

3.4 Results

3.4.1 Geospatial Distribution

Figures 3.3 and 3.4 present the chlamydia positive and negative rates per 100,000 from the Clinic during the study period for all four indices of the ON-Marg Index. The figures presented only capture the City of Kingston and surrounding areas, and not the entire KFL&A region, because of the difficulty to observe patterns given the large geographic size of DAs outside of the City of Kingston. Most individuals (64%) who tested at the KFL&A Public Health sexual health clinic live in the City of Kingston, where the Clinic is located, and thus, a large proportion of individuals are captured in Figures 3.3 and 3.4. Overall, the mapped test positive and negative individuals appear to be clustered in similar regions, specifically clustered closer to the downtown Kingston region and spread out in the surrounding areas (although, a formal cluster analysis was not performed). These regions appear to be generally more marginalized on all four indices, as indicated by a darker green shade, but no conclusions can be made about an association between the ON-Marg indices and chlamydia infection solely using these descriptive plots.

3.4.2 Demographic and Risk Factor Characteristics

A total of 1775 individuals attended the Clinic for testing between April 1, 2016 and March 31, 2017, and 208 of the 1775 (11.7%) tested positive for chlamydia infection on their first visit. A total of 905 individuals tested positive at least once in the KFL&A region as recorded by iPHIS, meaning that the Clinic diagnosed 23% of the total chlamydia cases in the KFL&A region during the study period. Of the test-positive individuals at the Clinic, 43% were male, and similarly, 41% of the individuals in the iPHIS database were male. The age of the total Clinic population was a mean of 26.8 ± 9.5 years and a median of 23.6 years [test positive (mean 24.1 ± 6.6 years; median 22.0 years); test negative (mean 27.1 ± 9.7; median 23.8 years]. This was comparable to the age of those who tested positive for chlamydia infection in the KFL&A region, as recorded in the iPHIS database (mean 24.3 ± 6.9 years; median 22.1 years). The gender distribution of the Clinic population was relatively equal (male total (48.9%); male test positive (42.8%)), and similarly 41.1% of the individuals who tested positive in iPHIS were male. Table 3.1 presents additional demographic and risk factor characteristics of the Clinic population in total and by chlamydia test status (see Table G.1 in Appendix G for more detailed risk factor characteristics for the Clinic; see Table G.2 in Appendix G for more detailed demographic characteristics for iPHIS and the Clinic).

3.4.3 Individual-Level Risk Factors

Table 3.2 presents the multivariate analysis of each individual-level risk factor for chlamydia infection among those who presented at the Clinic. Age, sex, student status, number of sexual partners in the last 2 months, condom use, STI symptoms and STI contact were included in the final parsimonious multivariate model after backwards elimination. Each variable was adjusted for one another. Tobacco use, excessive alcohol use, STI history and sexuality were not significant at the $p<0.20$ level in bivariate analysis and therefore were not included in the final model.

Overall, being a reported sexual contact of an individual with an STI was the strongest and most significant predictor for chlamydia infection (AOR= 6.16; 95% CI 4.35-8.74). Younger age was associated with testing positive for the youngest (<20 years) compared to the oldest (>40 years) age group. A less pronounced, but still significant, association was found for the 20-25-year age group. As age increases in this population, the odds of testing positive for chlamydia infection decreases, showing a clear dose-response relationship (p-test for trend= <0.0001). Being female was associated with testing positive for chlamydia infection, but the relationship was not significant at a $p<0.05$ level. Being a student was not significantly associated with testing positive for chlamydia infection in both the crude and adjusted analyses.

An increase in sexual partners in the last 2 months was associated with chlamydia infection for those who had 1, 2, or ≥3 partners in the last 2 months compared to reference (no partners), but was only significant for the 1 and 2 partner groups compared to reference (no partners). There was no dose-response relationship observed.

There was a significant association between rarely and sometimes using condoms and chlamydia infection compared to the reference (always using condoms). Although an effect was examined for the usually and never condom use groups, the relationships were not significant at the $p<0.05$ level. Those without an answer to the condom use question, classified as “missing”, had the highest odds for chlamydia infection. There was no dose-response relationship observed for condom use.

Finally, having STI symptoms was associated with an increased risk for chlamydia infection in adjusted analysis, but the relationship was not statistically significant.

3.4.4 Area-Level Risk Factors

Table 3.3 summarizes the four ON-Marg indices (material deprivation, dependency, residential instability, ethnic concentration), and ORs are presented for each quintile, with Q1 (least marginalized) used as the reference. Each index of the ON-Marg Index was run as a separate model with all individual-level risk factors in Table 3.2 (age, sex, student status, partners in the last 2 months, condom use, STI contact and STI symptoms) adjusted for as confounders.

In the multivariable analyses, there was an increased odds of chlamydia infection associated with high dependency (AOR= 1.90; 95% CI 1.05-3.43; Q5) compared to the lowest dependency category (Q1), but there was no clear dose-response relationship observed. Although there was the suggestion of an association between the highest material deprivation category (AOR= 1.21; 95% CI 0.73-2.01; Q5) and the highest residential instability category

(AOR= 1.27; 95% CI 0.67-2.39; Q5) and chlamydia infection compared to the lowest material and residential marginalization categories (Q1), these relationships were not statistically significant, and there were no clear dose-responses with either index. There was the suggestion of an increasing protective effect associated with the ethnic concentration index. The strongest protective association was between the highest ethnicity marginalization category (AOR= 0.77; 95% CI 0.38-1.56; Q5) compared to the lowest ethnicity marginalization category (Q1), although this relationship was not statistically significant.

3.5 Discussion

This study examined the effects of area- and individual-level risk factors and chlamydia infection among an STI Clinic sample in Kingston, Ontario. The purpose of this study was to identify which individual-level risk factors were the strongest predictors for chlamydia infection, and whether markers of low neighbourhood SES, as measured by the ON-Marg Index, were associated with an increased risk for chlamydia infection. This study is important, as there is a lack of literature examining the relationship between area- and individual-level risk factors on STI acquisition, and there have been no studies that have used the ON-Marg Index as a neighbourhood SES risk factor for chlamydia infection.

While the prevalence of persons who tested positive for chlamydia was much higher in this Clinic population compared to Canada (12% in this population versus 0.3% in Canada[1]), it is important to note that this population consisted of individuals who attended an STI clinic. The prevalence of persons who tested positive for chlamydia infection examined in this study is quite similar to the range reported in other studies (12-14%) that have looked at chlamydia infection at an STI clinic [31,32].

STI contact was the strongest and most significant predictor for chlamydia infection in this study. This is expected, as individuals who visit the clinic due to being told that they had sexual contact with an infected individual will have a higher chance of having contracted the infection.

Young age was a strong and statistically significant predictor of chlamydia infection in this Clinic sample. This is consistent with the findings of other studies. A review that identified risk factors for chlamydia infection found that 29 of 34 studies of females and 5 of 7 studies of males showed a significant relationship between young age (mostly adolescents and young adults) and chlamydia infection [33].

As hypothesized, the number of recent sexual partners and reported condom use were also statistically significant predictors for chlamydia infection in this STI Clinic population. However, there was not a clear dose-response observed for either of these risk factors. There was no threshold associated with the number of reported sexual partners and the magnitude of risk for chlamydia infection associated with 1, 2 or ≥3 sexual partners in the last two months was similar. One possibility for this counter-intuitive finding is related to protective factors that may coincide with increase engagement in sexual activity. Within this Clinic population, a greater proportion of individuals who reported ≥3 sexual partners (19.9%) in the last two months always used a condom in comparison to the proportion of individuals reporting 1 (16.6%) or 2 (14.8%) partners in the last two months. Perhaps those who have more sexual partners understand the risks associated with multiple sexual partners and are more likely to always use condoms compared to those with fewer partners. However, tempering this hypothesis is the observation that the highest proportion of individuals that always used condoms were among those individuals with no reported sexual partners in the last two months (29.6%).

Similarly, in contrast to the findings of other studies, those who never used condoms had a weaker, non-significant association with chlamydia infection compared to those who usually or sometimes used condoms. Measuring condom use is complex and highly susceptible to misclassification. Some individuals may use condoms for STI protection, whereas others may use it for contraception. Additionally, it is difficult for individuals to distinguish between usually/sometimes/rarely using condoms in the questionnaire and therefore these categories may be prone to misclassification. A systematic review that looked at condom use and risk of gonorrhea and chlamydia assessed design and measurement factors in epidemiologic studies [34]. This review discussed methodological limitations that likely underestimate condom effectiveness in studies, such as the inability to assess consistent condom use, correctness of use and condom use problems, choice of study design, and selection of a population with an STI. These limitations contribute to weaker ORs in studies that assess the relationship between condom use and STIs. Interestingly, in this Clinic sample, a greater proportion of individuals who reported never using condoms had only 1 partner in the last 2 months (21.1%) compared to individuals with 2 partners (11.5%) or >3 partners (7.4%). It is possible that a proportion of those who declared having only a single partner in the last 2 months are monogamous, long-term relationships and thus, at lower risk of STIs. Therefore, the “never” category of condom users may be a mixture of new sexual partners who are at higher risk for transmission of an STI and established, monogamous partners who are at lower risk of an STI, resulting in an attenuation of the effect estimate for chlamydia infection in this study.

In this sample, sex, student status, and STI symptoms were not statistically significantly associated with increased risk for chlamydia infection.

In the general Canadian population, the prevalence of chlamydia infection is much higher in females than males [1]. Although female sex was not a statistically significant predictor in this population, it is important to note that this is an STI clinic population sample. In a similar study which looked at risk factors for chlamydia infection in an STI clinic, male gender was a significant predictor for infection [2]. A large number of individuals who attend this Clinic come because they are symptomatic or have been contacted by an infected partner, which makes this population different than the general population. Although female sex was not a statistically significant predictor for chlamydia infection in this sample, the unadjusted and AOR pointed in the direction for females to have an increased risk for chlamydia infection, which is consistent with the findings of other studies. It may be that after adjusting for other risk factors, the effects of sex on chlamydia infection are less pronounced in this STI Clinic population.

Student status has not been frequently studied as a risk factor for STIs, possibly due to a lack of information on that variable, although it was hypothesized that students would be expected to have an increased risk for chlamydia infection because they have greater exposure to other young adults and thus have greater opportunity for sexual encounters. Although being a student was not statistically significantly associated with chlamydia infection in this study, it is important to note that about 7% of the study population was missing information on student status. As seen in Table 3.2, there was a statistically significant relationship between the “missing” student status group and risk of chlamydia infection in the unadjusted analysis (OR= 2.69; 95% CI 1.70-4.27). While this relationship was not statistically significant in the adjusted analysis, it did point in that direction. It is possible that the individuals who had a missing student status mostly consisted of younger individuals, possibly students or drop-outs, which may be why they were found to have an increased risk compared to those who are not students.

Many studies in the literature do not look at STI symptoms as a predictor for chlamydia infection. Although it is assumed that having STI symptoms would be associated with an increased risk for chlamydia infection, there was no statistically significant association between presence of STI symptoms and chlamydia infection, after adjusting for other risk factors. The lack of a statistically significant relationship could be due to several reasons. First, many women do not experience STI symptoms, and therefore many women who tested positive may have answered “no” to all the symptom-related questions in the questionnaire. Second, individuals who experienced STI symptoms may have tested positive for other STIs, and not necessarily chlamydia infection. Lastly, women may experience symptoms similar to those that occur when one has an STI, when in actuality these women may be experiencing a non-STI condition, such as a yeast infection. Therefore, the STI symptom variable is prone to high misclassification, attenuating the effect estimate.

This study found that of the four ON-Marg indices, only dependency appeared to be a significant predictor for chlamydia infection. The dependency ON-Marg index is based on area-level data that estimates the proportion of individuals aged 0 to 14, 65 and older, or those who are ≥15 and not participating in labour force. In this study, DAs with a greater proportion of dependency were at a significantly higher risk for chlamydia infection. At least one other study has observed that individuals who are unemployed tend to have a higher risk for chlamydia infection, although the mechanisms for this relationship are unclear [35]. To our knowledge, no previous studies have examined the relationship between the ON-Marg Index and any STI, making it difficult to compare the results of this study to others. That said, there are multiple studies that have examined the effects of low neighbourhood SES on chlamydia and other STIs and have found some associations [12–14]. For example, one study measured the relationships between the neighborhood context (poverty, residential instability, and racial/ethnic concentration) of exposure during adolescence and young adults' acquisition of chlamydia, and found that exposure to neighbourhood poverty, but not residential instability or racial/ethnic concentration, increased the likelihood of chlamydia infection [12]. Another study measured SES-related risk using items on a questionnaire which asked about neighbourhood conditions and found that SES-related risk was predictive of both STI acquisition and reinfection among young African-American females [13]. Finally, another study used a similar method to the ON-Marg Index (the Superprofile classification – an indicator of SES using the postal code of residence), and found that residence in inner city areas of deprivation were independent risk factors for multiple STIs, including chlamydia [14].

Additionally, other studies that have used the ON-Marg Index for research with different outcomes such as renal injury, cardiovascular disease, and violent deaths have found some significant relationships [22–25], which suggests that the measure is sufficiently sensitive for health research. That said, other studies have found non-significant associations with some indices of the ON-Marg index and various health outcomes [26]. The studies which found significant positive associations between the ON-Marg and various health outcomes either used a summary score of the ON-Marg (combining two or more of the indices) [22] or found significant associations with some of the indices and not the others [23,24]. As suggested by the ON-Marg User Guide [21], it was not possible to use a summary score of the ON-Marg Index in this study, as the associations were not all positively or all negatively associated with chlamydia infection.

A neighbourhood measure of SES, specifically using the ON-Marg Index, could be a significant risk factor for some health outcomes, and not others. Additionally, some indices of the ON-Marg Index may be more associated with a specific health outcome compared to other indices. This is evident in several of the studies which have found associations between the ON-Marg Index and a health outcome.

Although the results of this study did not indicate a statistically significant association between material deprivation, residential instability and ethnic concentration with chlamydia infection, it is important to note that 12% of the Clinic sample population did not have a postal code recorded, and therefore these individuals could not be linked to a score on the ON-Marg Index. As seen in Table 3.3, those in the "missing" category for material deprivation, residential instability and ethnic concentration had elevated ORs higher than the other quintiles when compared to their reference category. Although the relationships were not statistically significant, the elevated ORs suggest that the individuals who did not have a postal code recorded may come from more marginalized areas, with possibly no fixed address, which may explain the absence of a postal code. Further studies on the effects of neighbourhood SES (as measured by the ON-Marg Index) on chlamydia infection, with limited missing data, may be required to understand the full extent of the relationships. Unfortunately, for individuals who do not have a postal code, it is not possible to study this relationship. A suggestion for future researchers and clinics is to indicate whether an individual has a fixed address in the questionnaire, rather than to simply not list a postal code.

This study should be considered with knowledge of its limitations. First, the population for this study includes only individuals who attended KFL&A Public Health's sexual health clinic during the study period. Therefore, caution should be exercised when generalizing these results, since they are likely only generalizable to other Ontario STI clinic populations, specifically cities with similar demographics and distributions of the ON-Marg indices to the KFL&A region. Future studies using the ON-Marg Index may choose to include a wider sample which may include all individuals in a certain region, rather than to focus on a single STI clinic.

Second, all questionnaire data in this study were self-reported, and individuals may under or over-report certain aspects of their sexual history, such as number of sexual partners or condom use, for reasons associated with social desirability. While men typically over-report their number of sexual partners, women more often under-report [35]. Although there is a risk for information bias, it is not expected to differ based on chlamydia status, as individuals did not know their test status at the time the information was collected and recorded. That said, an individual may suspect they have an infection, especially if they presented at the Clinic after learning they were an STI contact. This non-differential misclassification of the exposure may explain, at least in part, the ORs trending towards the null.

Lastly, it is important to not misinterpret the meaning of the ON-Marg Index. Although the ON-Marg Index is a measure of SES, it is not a measure of individual SES, but rather an average for those living within a geographic area. This interpretation would result in an ecological fallacy. Therefore, the ON-Marg Index must be interpreted as neighbourhood SES, or the effect of living in a given geographic area, rather than the SES of an individual.

3.6 Conclusion

Area- and individual-level risk factors both affect the risk of becoming infected with chlamydia. In this study, multiple individual-level risk factors were associated with chlamydia infection. Since STI contact was the strongest and most significant predictor for chlamydia infection, STI clinics such as the KFL&A Public Health sexual health clinic should continue to put efforts to correctly tracking sexual contacts of those who tested positive for chlamydia. Additionally, social network analysis programs should be considered to further identify sexual contacts.

The results of this study do not show with certainty that area level markers of SES increase the odds for chlamydia infection. It may be possible that although individual-level SES has been established as a risk factor for chlamydia infection, neighbourhood SES as measured by the ON-Marg Index may not be. Future research should focus on examining this relationship in a wider population range using both neighbourhood and individual-level SES to further develop and implement neighbourhood-level population health intervention strategies in specific geographic regions and populations to reduce the risk of chlamydia infection.

3.7 References

1. Government of Canada. Report on Sexually Transmitted Infections in Canada: 2012. http://www.phac-aspc.gc.ca/sti-its-surv-epi/rep-rap-2012/rep-rap-1-eng.php. Published 2015.

2. Choudhri Y, Miller J, Sandhu J, Leon A, Aho J. Chlamydia in Canada, 2010–2015. *Canada Commun Dis Rep*. 2018;44(2):49-54. doi:10.14745/ccdr.v44i02a03.

3. Wong T, Singh A, Mann J, Hansen L, McMahon S. Gender Differences in Bacterial STIs in Canada. *BMC Womens Health*. 2004;4 Suppl 1(Suppl 1):S26. doi:10.1186/1472-6874-4-S1-S26.

4. Public Health Agency of Canada. Canadian Guidelines on Sexually Transmitted Infections. http://www.phac-aspc.gc.ca/std-mts/sti-its/cgsti-ldcits/section-5-2-eng.php. Published 2013.

5. WebMD. Chlamydia- Topic Overview. http://www.webmd.com/sexual-conditions/tc/chlamydia-topic-overview#1. Published 2017.

6. WebMD. Chlamydia Tests.

7. Mayo Clinic. Chlamydia trachomatis. http://www.mayoclinic.org/diseases-conditions/chlamydia-trachomatis/symptoms-causes/dxc-20315310. Published 2017.

8. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: A critical review. *J Epidemiol Community Health*. 2001;55(2):111-122. doi:10.1136/jech.55.2.111.

9. Sampson RJ, Morenoff JD, Gannon-Rowley T. Assessing “neighborhood effects”: Social processes and new directions in research. *Annu Rev Sociol*. 2002;28:443-478. doi:DOI

10.1146/annurev.soc.28.110601.141114.

10. Ross NA, Tremblay S, Graham K. Neighbourhood influences on health in Montreal, Canada. *Soc Sci Med*. 2004;59(7):1485-1494. doi:10.1016/j.socscimed.2004.01.016.

11. Diez Roux A V. Investigating neighborhood and area effects on health. *Am J Public Health*. 2001;91(11):1783-1789. doi:10.2105/AJPH.91.11.1783.

12. Ford JL, Browning CR. Neighborhoods and infectious disease risk: Acquisition of chlamydia during the transition to young adulthood. *J Urban Heal*. 2014;91(1):136-150. doi:10.1007/s11524-013-9792-0.

13. Sales JM, Smearman EL, Swartzendruber A, Brown JL, Brody G, Diclemente RJ. Socioeconomic-related risk and sexually transmitted infection among African-American adolescent females. *J Adolesc Heal*. 2014;55(5):698-704. doi:10.1016/j.jadohealth.2014.05.005.

14. Monteiro EF, Lacey CJN, Merrick D. The interrelation of demographic and geospatial risk factors between four common sexually transmitted diseases. *Sex Transm Infect*. 2005;81(1):41-46. doi:10.1136/sti.2004.009431.

15. Biello KB, Pettigrew MM, Niccolai LM. Multiple chlamydia infection among young women: comparing the role of individual- and neighbourhood-level measures of socioeconomic status. *Sex Transm Infect*. 2011;87(7):560-562. doi:10.1136/sextrans-2011-050185.

16. Carpiano RM. Toward a neighborhood resource-based theory of social capital for health: Can Bourdieu and sociology help? *Soc Sci Med*. 2006;62(1):165-175. doi:10.1016/j.socscimed.2005.05.020.

17. Jennings JM, Hensel DJ, Tanner AE, Reilly ML, Ellen JM. Are social organizational factors independently associated with a current bacterial sexually transmitted infection among urban adolescents and young adults? *Soc Sci Med*. 2014;118:52-60. doi:10.1016/j.socscimed.2014.07.062.

18. Public Health Ontario. Overview of the Ontario Marginalization Index. https://www.publichealthontario.ca/en/LearningAndDevelopment/Events/Pages/Overview-of-the-Ontario-Marginalization-Index-.aspx. Published 2017.

19. Public Health Ontario. *2011 Ontario Marginalization Index: Technical Document*.; 2017. https://www.publichealthontario.ca/en/DataAndAnalytics/Documents/Technical_Document_2011_ON-Marg.pdf.

20. Matheson FI, Dunn JR, Smith KLW, Moineddin R, Glazier RH. Development of the Canadian Marginalization index: A new tool for the study of inequality. *Can J Public Heal*. 2012;103(SUPPL.2).

21. St. Michaels Hospital. *Ontario Marginalization Index User Guide Version 1.0*. http://www.torontohealthprofiles.ca/onmarg/userguide_data/ON-Marg_user_guide_1.0_FINAL_MAY2012.pdf.

22. Cummings LAM, Clarke A, Sochett E, et al. Social Determinants of Health Are Associated with Markers of Renal Injury in Adolescents with Type 1 Diabetes. *J Pediatr*. 2018;198:247-253.e1. doi:10.1016/J.JPEDS.2018.03.030.

23. Inman M, Daneman D, Curtis J, et al. Social Determinants of Health Are Associated with Modifiable Risk Factors for Cardiovascular Disease and Vascular Function in Pediatric Type 1 Diabetes. *J Pediatr*. 2016;177:167-172. doi:10.1016/j.jpeds.2016.06.049.

24. Lachaud J, Donnelly P, Henry D, et al. Characterising violent deaths of undetermined intent: a population-based study, 1999–2012. *Inj Prev*. 2017:injuryprev-2017-042376. doi:10.1136/injuryprev-2017-042376.

25. Silverman JD, Hutchison MG, Cusimano MD. Association between neighbourhood marginalization and pedestrian and cyclist collisions in Toronto intersections. *Can J Public Heal*. 2013;104(5).

26. Buick JE, Ray JG, Kiss A, Morrison LJ. The association between neighborhood effects and out-of-hospital cardiac arrest outcomes. *Resuscitation*. 2016;103:14-19. doi:10.1016/j.resuscitation.2016.03.008.

27. KFL&A Public Health. Population by Age and Sex. https://www.kflaph.ca/en/research-and-reports/population-by-age-and-sex.aspx. Published 2013.

28. KFL&A Public Health. Sexual Health Clinics. https://www.kflaph.ca/en/clinics-and-classes/Sexual-Health-Clinics.aspx. Published 2016.

29. Simcoe Muskoka. Integrated Public Health Information System (iPHIS). http://www.simcoemuskokahealthstats.org/resources/data-sources/iphis.

30. esri. Mapping Without Limits. https://www.arcgis.com/features/index.html. Published 2017.

31. Rietmeijer CA, Van Bemmelen R, Judson FN, Douglas JM. Incidence and repeat infection rates of Chlamydia trachomatis among male and female patients in an STD clinic: implications for screening and rescreening. *Sex Transm Dis*. 2002;29(2):65-72. http://www.ncbi.nlm.nih.gov/pubmed/11818890.

32. Burns DCM, Darougar S, Thin RN, Lothian L, Nicol ACS. Isolation of Chlamydia from

women attending a clinic for sexually transmitted disease. *Sex Transm Infect*. 1975;51(5):314-318. doi:10.1136/sti.51.5.314.

33. Navarro C, Jolly A, Nair R, Chen Y. Risk factors for genital chlamydial infection. *Can J Infect Dis*. 2002;13(3):195-207. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2094865&tool=pmcentrez&rendertype=abstract.

34. Warner L, Stone KM, Macaluso M, Buehler JW, Austin HD. Condom use and risk of gonorrhea and chlamydia: A systematic review of design and measurement factors assessed in epidemiologic studies. *Sex Transm Dis*. 2006;33(1):36-51. doi:10.1097/01.olq.0000187908.42622.fd.

35. Crichton J, Hickman M, Campbell R, Batista-Ferrer H, Macleod J. Socioeconomic factors and other sources of variation in the prevalence of genital chlamydia infections: A systematic review and meta-analysis. *BMC Public Health*. 2015;15(1). doi:10.1186/s12889-015-2069-7.

Tables and Figures

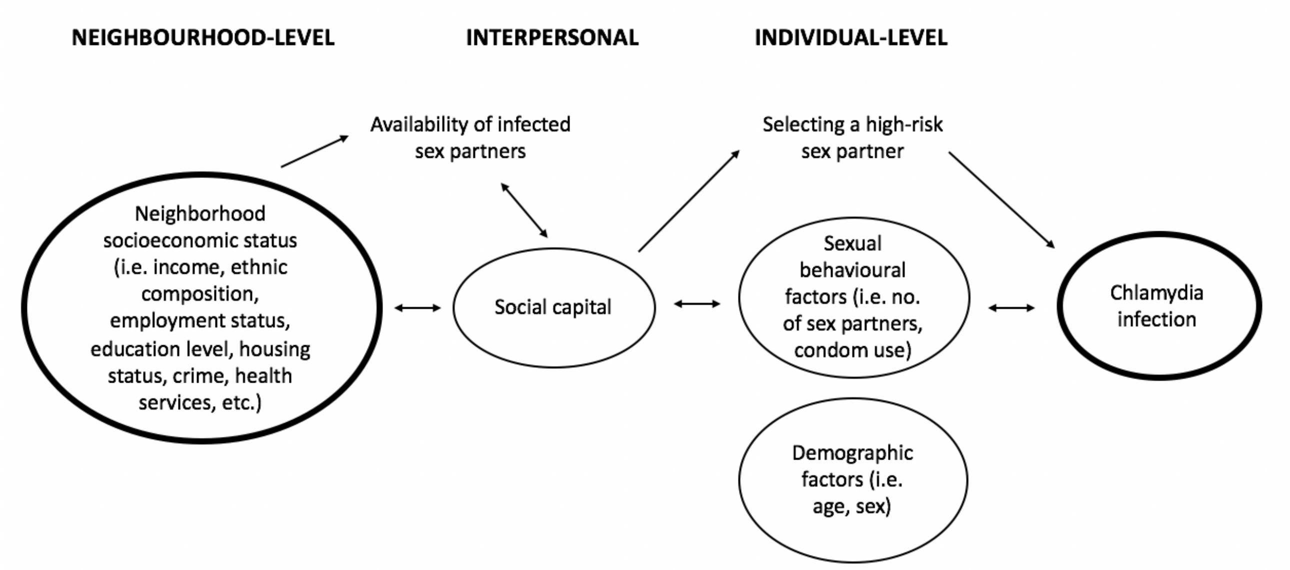

Figure 3.1. Conceptual framework explaining the interpersonal and individual-level factors which relate neighbourhood socioeconomic status (SES) to chlamydia infection.

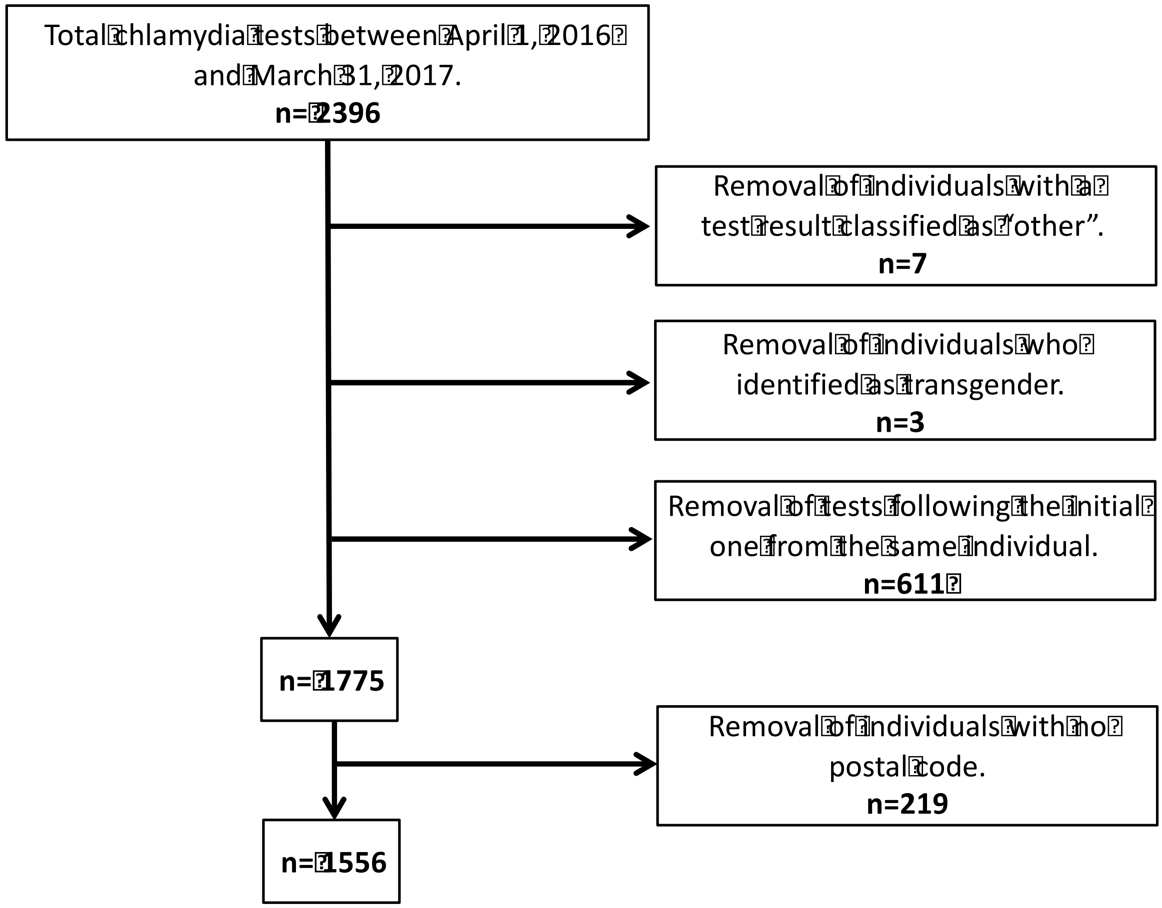

Figure 3.2. Flow diagram of the data creation set for this study. A total of 1775 participants were included in the descriptive and analytic portion and 1556 participants were included in the geographic information system (GIS) portion of this study.

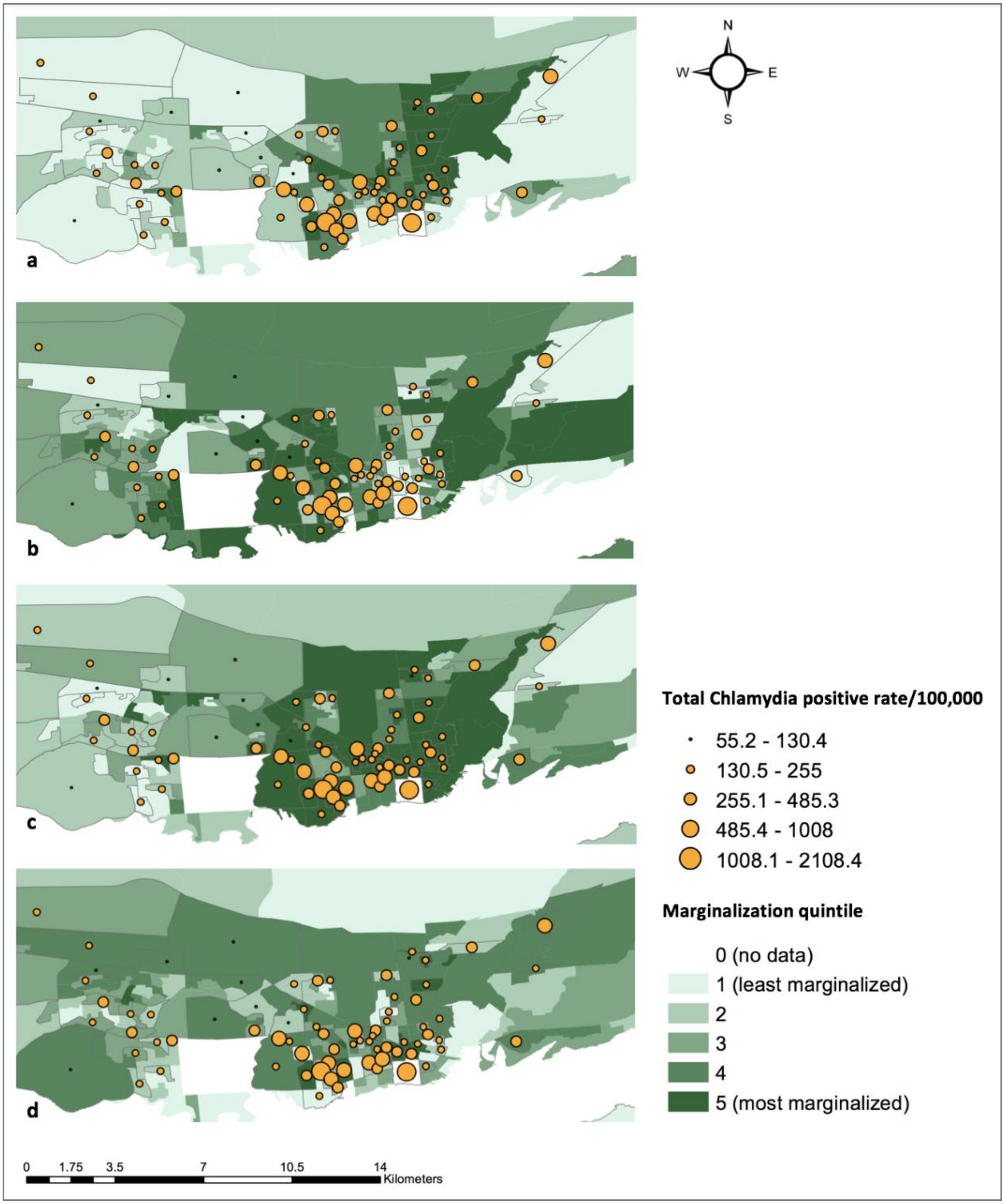

Figure 3.3. Total chlamydia positive rates from KFL&A Public Health's sexual health clinic (April 1, 2016 to March 31, 2017) plotted against a) material deprivation, b) dependency, c) residential instability and d) ethnic concentration from the Ontario-Marginalization (ON-Marg) Index.

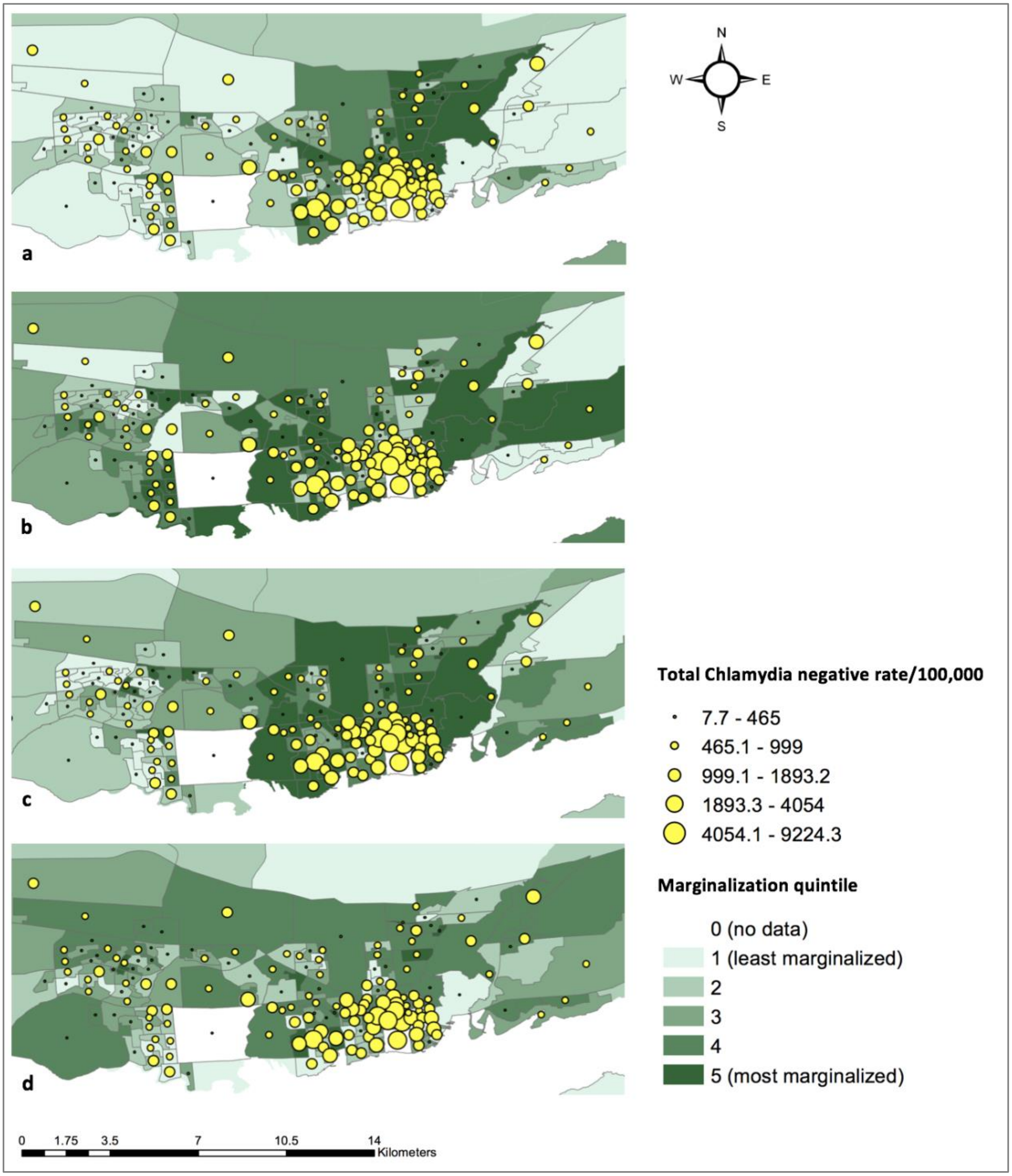

Figure 3.4. Total chlamydia negative rates from KFL&A Public Health's sexual health clinic (April 1, 2016 to March 31, 2017) plotted against a) material deprivation, b) dependency, c) residential instability and d) ethnic concentration from the Ontario-Marginalization (ON-Marg) Index.

Table 3.1. Demographic and risk factor characteristics for those who tested positive and negative for chlamydia at KFL&A Public Health's sexual health clinic between April 1, 2016 and March 31, 2017.

Characteristic		Chlamydia Positive n=208		Chlamydia Negative n=1567		Total n=1775	
Sex							
	Male	89	42.8	779	49.7	868	48.9
	Female	119	57.2	788	50.3	907	51.1
Age (years)							
	>40	10	4.8	163	10.4	173	9.8
	30-40	18	8.7	226	14.4	244	13.8
	26-29	36	17.3	301	19.2	337	19.0
	20-25	90	43.3	623	39.8	713	40.2
	<20	54	26.0	254	16.2	308	17.4
Student							
	Yes	78	37.5	640	40.8	718	40.5
	No	100	48.1	834	53.2	934	52.6
	Missing	30	14.4	93	5.9	123	6.9
Sexual orientation							
	Heterosexual	187	89.9	1283	81.9	1470	82.8
	Bisexual	8	3.9	88	5.6	96	5.4
	Homosexual	4	1.9	148	9.4	152	8.6
	Missing	9	4.3	48	3.1	57	3.2
Condom use							
	Always	22	10.6	284	18.1	306	17.2
	Usually	63	30.3	490	31.3	553	31.2
	Sometimes	57	27.4	343	21.9	400	22.5
	Rarely	23	11.1	126	8.0	149	8.4
	Never	29	13.9	244	15.6	273	15.4
	Missing	14	6.7	80	5.1	94	5.3
No. of sex partners, last 2 months							
	0	4	1.9	131	8.4	135	7.6
	1	112	53.9	716	45.7	828	46.7
	2	42	20.2	342	21.8	384	21.6
	≥3	39	18.8	297	19.0	336	18.9
	Missing	11	5.3	81	5.2	92	5.2
Tobacco use[a]							
	Yes	59	28.4	366	23.4	425	23.9
	No	66	31.7	826	52.7	892	50.3
	Not asked	34	16.4	118	7.5	152	8.6
	Missing	49	23.6	257	23.6	306	17.2
Excessive alcohol use[b]							
	Yes	22	10.6	195	12.4	217	12.2
	No	72	34.6	754	48.1	826	46.5
	Not asked	41	19.7	143	9.1	184	10.4
	Missing	73	35.1	475	30.3	548	30.9
STI Symptoms							
	No	117	56.3	858	54.8	975	54.9
	Yes	91	43.8	709	45.3	800	45.1
STI Contact							
	No	109	52.4	1361	86.9	1470	82.8
	Yes	99	47.6	206	13.2	305	17.2
Material deprivation							

	1 (least deprived)	40	19.2	336	21.4	376	21.2
	2	27	13.0	238	15.2	265	14.9
	3	35	16.8	234	14.9	269	15.2
	4	32	15.4	315	20.1	347	19.6
	5 (most deprived)	38	18.3	261	16.7	299	16.9
	Missing	36	17.3	183	11.7	219	12.3
Dependency							
	1 (least dependent)	24	11.5	297	19.0	321	18.1
	2	37	17.8	264	16.9	301	17.0
	3	56	26.9	334	21.3	390	22.0
	4	21	10.1	267	17.0	288	16.2
	5 (most dependent)	34	16.4	222	14.2	256	14.4
	Missing	36	17.3	183	11.7	219	12.3
Residential instability							
	1 (least instable)	15	7.2	137	8.7	152	8.6
	2	28	13.5	206	13.2	234	13.2
	3	24	11.5	215	13.7	239	13.5
	4	39	18.8	226	14.4	265	14.9
	5 (most instable)	66	31.7	600	38.3	666	37.5
	Missing	36	17.3	183	11.7	219	12.3
Ethnic concentration							
	1 (least ethnically concentrated)	23	11.1	191	12.2	214	12.1
	2	36	17.3	263	16.8	299	16.9
	3	47	22.6	316	20.2	363	20.5
	4	49	23.6	397	25.3	446	25.1
	5 (most ethnically concentrated)	17	8.2	217	13.9	234	13.2
	Missing	36	17.3	183	11.7	219	12.3

[a] Use of tobacco in the past 6 months.

[b] Drink more than 10 drinks a week or more than 2 drinks a day at most (female); drink more than 15 drinks a week or more than 3 drinks a day at most (male).

Table 3.2. Multivariate analysis of individual-level risk factors for chlamydia among those who presented at KFL&A Public Health's sexual health clinic between April 1, 2016 and March 31, 2017.

Risk factor		**Crude OR[a] (95% CI[b])** n=1775	**Adjusted OR (95% CI)[c]** n=1775
Age (years)			
	>40	Ref[d]	Ref
	30-40	1.30 (0.58-2.89)	1.08 (0.46-2.51)
	26-29	1.95 (0.94-4.03)	1.75 (0.82-3.77)
	20-25	2.35 (1.20-4.63)*	2.59 (1.25-5.37)*
	<20	3.47 (1.72-7.00)*	4.84 (2.18-10.74)*
Sex			
	Male	Ref	Ref
	Female	1.32 (0.99-1.78)	1.19 (0.85-1.67)
Student			
	No	Ref	Ref
	Yes	1.02 (0.74-1.39)	0.74 (0.50-1.09)
	Missing	2.69 (1.70-4.27)*	1.31 (0.78-2.22)
No. of sex partners, last 2 months			
	0	Ref	Ref
	1	5.12 (1.86-14.13)*	3.67 (1.30-10.42)*
	2	4.02 (1.41-11.44)*	3.11 (1.06-9.10)*
	≥3	4.30 (1.51-12.28)*	2.72 (0.92-8.03)
	Missing	4.45 (1.37-14.44)*	2.84 (0.78-10.30)
Condom use			
	Always	Ref	Ref
	Usually	1.66 (1.00-2.76)	1.66 (0.97-2.84)
	Sometimes	2.15 (1.28-3.60)*	2.05 (1.18-3.55)*
	Rarely	2.36 (1.27-4.39)*	2.09 (1.07-4.09)*
	Never	1.53 (0.86-2.74)	1.60 (0.85-2.99)
	Missing	2.26 (1.11-4.62)*	3.11 (1.29-7.51)*
STI Symptoms			
	No	Ref	Ref
	Yes	0.94 (0.70-1.26)	1.32 (0.95-1.83)
STI Contact			
	No	Ref	Ref
	Yes	6.00 (4.41-8.18)*	6.16 (4.35-8.74)*

* Significant at the $p<0.05$ level.
[a] OR = odds ratio.
[b] CI = confidence interval.
[c] Adjusted for one another.
[d] Ref = reference value (1).

Table 3.3. Multivariate analysis of area-level risk factors (four indices of the Ontario Marginalization (ON-Marg) Index) for chlamydia among those who presented at KFL&A Public Health's sexual health clinic between April 1, 2016 and March 31, 2017.

ON-Marg index		**Crude OR[a] (95% CI[b])** n=1775	**Adjusted OR (95% CI)[c]** n= 1775
Material deprivation			
	1 (least deprived)	Ref[d]	Ref
	2	0.95 (0.57-1.60)	0.91 (0.53-1.59)
	3	1.26 (0.78-2.04)	1.27 (0.76-2.14)
	4	0.85 (0.52-1.39)	0.87 (0.51-1.46)
	5 (most deprived)	1.22 (0.76-1.96)	1.21 (0.73-2.01)
	Missing	1.65 (1.02-2.68)*	1.33 (0.78-2.26)
Dependency			
	1 (least dependent)	Ref	Ref
	2	1.73 (1.01-2.98)*	1.48 (0.83-2.63)
	3	2.08 (1.26-3.43)*	1.95 (1.14-3.33)*
	4	0.97 (0.53-1.79)	0.86 (0.45-1.64)
	5 (most dependent)	1.90 (1.09-3.29)*	1.90 (1.05-3.43)*
	Missing	2.43 (1.41-4.21)*	1.82 (1.00-3.29)
Residential Instability			
	1 (least instable)	Ref	Ref
	2	1.24 (0.64-2.41)	1.30 (0.64-2.66)
	3	1.02 (0.52-2.01)	1.20 (0.58-2.49)
	4	1.58 (0.84-2.97)	1.76 (0.89-3.47)
	5 (most instable)	1.01 (0.56-1.81)	1.27 (0.67-2.39)
	Missing	1.80 (0.95-3.41)	1.67 (0.83-3.37)
Ethnic Concentration			
	1 (least ethnically concentrated)	Ref	Ref
	2	1.14 (0.65-1.98)	1.31 (0.72-2.39)
	3	1.24 (0.73-2.10)	1.35 (0.76-2.41)
	4	1.03 (0.61-1.73)	1.21 (0.68-2.13)
	5 (most ethnically concentrated)	0.65 (0.34-1.25)	0.77 (0.38-1.56)
	Missing	1.63 (0.93-2.86)	1.47 (0.79-2.72)

* Significant at the p<0.05 level.
[a] OR = odds ratio.
[b] CI = confidence interval.
[c] Adjusted for age, sex, partners in the last 2 months, condom use, STI contact, STI symptoms and student status.
[d] Ref = reference value (1).

Chapter 4

Discussion

4.1 Study Summary

This study examined the effects of area- and individual-level risk factors and chlamydia infection within an STI Clinic sample in Kingston, Ontario. The purpose of this study was to identify the independent individual-level risk factors for chlamydia infection, and to determine whether low neighbourhood SES, as described by the ON-Marg Index, is associated with increased chlamydia rates. The findings of this study provide new information about chlamydia infection on a geographic scale and in the context of the ON-Marg Index given there is a lack of literature examining the relationship between area- and individual-level risk factors on STI acquisition, and there have been no studies that have used the ON-Marg Index as an area-level indicator for chlamydia infection. Additionally, studies such as this one add to the body of literature to inform public health agencies on where to deliver targeted neighbourhood-level interventions for STI prevention.

This chapter will summarize the major findings, compare the findings with the literature, review strengths and limitations, and discuss future research and public health implications.

4.2 Summary of Major Findings

This study assessed various individual-level risk factors which were collected during the STI Clinic visit. After building a parsimonious model, it was found that young age, number of sexual partners in the last 2 months, condom use, and STI contact were the strongest predictors for chlamydia infection. These risk factors have been previously identified as being strong predictors for infection in the literature. Sex, student status, and STI symptoms were not associated with chlamydia infection, contrary to what was hypothesized. These three variables are not as commonly studied in the literature for various reasons, as described in Chapter 3.

More recently, it has been found that area-level risk factors, such neighbourhood SES, can have a powerful influence on the health of an individual. In this study, the ON-Marg Index was used as an area-level measure for neighbourhood SES to examine its association with chlamydia infection in an STI Clinic population. Apart from the ethnic concentration index, there was a trend suggesting an association between the highest levels of marginalization for residential instability, material deprivation, dependency and increased odds of chlamydia infection compared to the lowest levels of marginalization. This association was only statistically significant for the dependency ON-Marg Index, and no clear dose-response was observed with increasing marginalization in any of the indices.

4.3 Comparison of Findings with Literature

As discussed, the results of this study do not show that neighbourhood-level marginalization, or SES, as measured by the ON-Marg Index, is a significant predictor for chlamydia infection in this Clinic population. To our knowledge, no other published studies have looked at the ON-Marg Index as an indicator for neighbourhood-level SES with any STI, including chlamydia. Although, there have been some studies which have used different measures of neighbourhood SES to measure associations with chlamydia infection.

One American study looked at neighbourhoods and acquisition of chlamydia during the transition to young adulthood [1]. The authors used census tract of residence to define the individuals' neighbourhood, and looked at three indicators of neighbourhood social context – racial and ethnic concentration, concentrated poverty, and residential instability. Similar to the ON-Marg Index, each of these indicators were defined by various neighbourhood aspects. For example, residential instability was measured as the mean of two standardized items: proportion of households living in the census tract for 5 years or more and proportion of owner occupied homes. The authors studied various sexual risk behaviours and depression measures as mediators between neighbourhood context and acquisition of chlamydia, similar to the current study. Sexual risk behaviours included age at first vaginal intercourse, STI in the prior year, multiple STI partners in the prior year, condom used at last sex, binge drinking, and drug use. The authors conducted several models, and only found a positive association between exposure to neighborhood poverty during adolescence and the likelihood of a positive urine test for chlamydia during young adulthood. No significant relationships were found for residential instability or racial/ethnic concentration as the exposure. Although this study looks at young adults solely (18 to 27 years) and does not focus on an STI clinic population, the results mirror the findings of the current study, where residential instability and ethnic concentration as measures of neighbourhood SES were also not significant predictors for chlamydia infection. Therefore, there is some evidence that a measure of neighbourhood SES (poverty) is associated with chlamydia acquisition. Similarly, in the current study, it was found that dependency could be a predictor for chlamydia infection.

Another similar study conducted in the United Kingdom measured the interrelation of demographic and geospatial risk factors between four common STIs, including chlamydia, in an STI clinic population [2]. This study used a similar method to the ON-Marg Index to measure SES - the Superprofile (SP) classification. Using 72 census variables, areas were scored on a decreasing scale in order of affluence from 1 to 10 for the SES indicator. After controlling for sex, age, and ethnic group, SES was positively associated with chlamydia infection, but mostly for the SP classification 8, which is predominant in the more deprived central and urban areas of Leeds. Although this study found significant results, it is important to note that the SP classification is one large measure of SES, whereas the ON-Marg Index measures four different indices of SES. Additionally, this study only controlled for three factors (sex, age, and ethnic group), and none of them were related to sexual behaviour.

Interestingly, an American study examined whether neighbourhood SES provides a useful measure in comparison with individual-level SES with respect to the burden of multiple chlamydia diagnoses [3]. This study used a cohort of women diagnosed with chlamydia at family planning clinics, and controlled for various individual-level risk factors such as race, age, age at first intercourse, lifetime number of sex partners, number of sex partners in the last 3 months, and condom use in the past 30 days. Individual-level SES measures included education level and employment, meanwhile neighbourhood SES was defined as per cent of people with income below the poverty line in each census tract, and was obtained from the US Census Bureau. In adjusted models, neither education nor employment was significantly associated with multiple chlamydia diagnoses, whereas neighbourhood-level poverty maintained its significant association. This study is unique as it compares both individual and neighbourhood-level SES for chlamydia infection. It was shown that neighborhood-level poverty may provide a better measure of SES than individual-level variables as a predictor of multiple chlamydia diagnoses in young women. Additionally, this study demonstrated that neighbourhood-level measures may be useful when valid measures of individual-level SES are unavailable.

The main novel observation from this thesis was that the ON-Marg Dependency index was significantly associated with chlamydia infection. In general, it appears that studies similar to this project have also observed associations between some markers of neighbourhood-level SES and chlamydia infection, but not all markers.

It is important to understand the potential mechanisms of a neighbourhood which could impact STI acquisition in an individual. For example, individuals who live in impoverished neighbourhoods may be more likely to get in contact with a high risk sexual partner. Additionally, these individuals are most likely less educated, and may not be aware of the impacts of high risk sexual behaviours, such as not using a condom or having multiple sexual partners [1]. Additionally, another interesting explanation is that chronic stress associated with living in adverse neighbourhood contexts may impair the immune system function and therefore increase vulnerability to STI acquisition [1,4]. Future studies should incorporate neighbourhood-level factors to study the effects on chlamydia and other STIs, as it may be more meaningful to target marginalized neighbourhoods, as opposed to individuals, for interventions and services.

It is also important to contrast these proposed mechanisms of neighbourhood SES with individual-level SES. To date, limited studies assess the relationship between neighbourhood SES and chlamydia infection; most studies have focused on individual-level SES. That said, many studies have described the role of social, political, economic, legal, and environmental forces that interact with individual and behavioural risk factors for adverse health outcomes [5,6]. One study determined the associations of geosocial and psychosocial factors with having a prevalent STI, recent STI diagnosis, and sexual risk behaviours [7]. This study found that contextual conditions, such as low income and housing insecurity, which are often present before sexual debut, may enhance STI risk by increasing sexual risk behaviours and likelihood of exposure. It is clear that neighbourhood and individual-level risk factors interact with one another to increase the likelihood that an individual will become infected with an STI. Therefore, upstream neighbourhood-level conditions such as housing and safety also contribute to STI burden, which is why it is important to not only target interventions at the individual-level (such as providing condoms), but to also target interventions to impoverished geographical regions (such as delivering sexual health education to neighbourhoods with lower SES).

4.4 Strengths and Limitations

4.4.1 Internal Validity

4.4.1.1 Selection bias

This study used data from all individuals who attended KFL&A Public Heath's sexual health clinic during the study period. Individuals did not volunteer to participate in this study and therefore, there is no risk of volunteer bias, a form of selection bias. Nevertheless, the population that attends the KFL&A Public Health sexual health clinic are more likely to represent a sexually active young adult population, and therefore, rates of chlamydia infection observed in this population are likely to be an over-estimate of the chlamydia rate in the general Canadian population, which includes children and senior citizens, who are at low risk for chlamydia infection, in the denominator.

4.4.1.2 Information bias

4.4.1.2.1 Exposure assessment

Exposures in this study included all individual-level risk factors available from the Clinic questionnaire (Appendix F; Figure F.1) and the ON-Marg indices for the area-level risk factors. All questionnaire data (individual-level risk factors) in this study are self-reported, and individuals may inaccurately report or be untruthful about certain aspects of their sexual history. It is known that individuals might over- or under-report their number of partners for social desirability. While men typically over-report their number of sexual partners, women more often under-report [8]. This cannot be determined with certainty in this study. Additionally, condom use is a very difficult variable to measure, as individuals tend to inaccurately recall condom use and may have trouble differentiating between the various responses, such as "rarely", "sometimes" and "usually" using condoms.

In this study, nurses conducted face-to-face, standardized interviews with each participant. However, interview-based questionnaires can be problematic, especially when based on sensitive topics such as sexual history. When compared to other questionnaire-based methods, such as computer-assisted survey instruments (where respondents answer questions directly on a computer) or self-administered questionnaires, the literature suggests that questionnaire delivery modes affect self-reported sexual behaviours, and that use of computer-assisted survey instruments can significantly reduce reporting bias [9]. Other studies have also found that computer-assisted survey instruments improve quality of data and increase respondents' willingness to report sensitive behaviours, possibly due to an increased sense of privacy [10,11]. Another study assessed the validity of female adolescent sexual behaviour data collected in Tanzania using five methods and found that self-reported sexual behaviour data and face-to-face interviews were inconsistent, but the additional use of in-depth interviews was useful in identifying risk factors [12].

In summary, it is possible that the face-to-face interview method used in the STI Clinic for this study may have contributed to individuals feeling uncomfortable answering certain questions to the nurse, which could have led to either missing or misclassified data. Although there is a risk for information bias, it is not expected to differ based on chlamydia status, as individuals did not know their test result at the time the information was collected and recorded. This non-differential misclassification of the exposure may explain, at least in part, the ORs tending towards the null. That said, an individual may have suspected that they had an infection, especially if they presented at the Clinic after learning they were an STI contact. In this case, if those that correctly suspected a chlamydia infection systematically under or over-reported their sexual history, this could have introduced differential misclassification and the ORs would be under or over-estimated, respectively.

Lastly, it is important to not misinterpret the meaning of the ON-Marg Index. Although the ON-Marg Index is a measure of SES, it is not a measure of individual SES, but rather an average for those living within a geographic area. This interpretation could result in an ecological fallacy. Therefore, the ON-Marg Index must be interpreted as neighbourhood SES, or the effect of living in a given geographic area, rather than the SES of an individual. Additionally, the ON-Marg Index has yet to be validated against other measures of neighbourhood SES or deprivation indices. Future studies may benefit from contrasting the use of the ON-Marg Index compared to other measures of neighbourhood SES for different health outcomes.

It is also important to understand the implications of assigning students to a DA in which they did not contribute to the ON-Marg Index for. For example, if a student attends a University or college in Kingston during the school year (September to April) but has a permanent home address in another city, their responses to the census survey contributed to the ON-Marg Index in a DA that reflects their permanent home address, and not that of their University (or Kingston) address. This is a limitation of the study, and would impact the 40% of respondents who were identified as students.

A stratified analysis on student-status for the area-level risk factors model was conducted, in order to observe if results differed based on student-status (see Appendix H; Table H.1). Different independent-risk factors made it into the final parsimonious model as confounders for each group. For residential instability, increased marginalization (quintiles 3-5 vs 1) was significantly associated with an increase in chlamydia prevalence. There were no clear associations with residential instability and chlamydia prevalence in the student population. When students and non-students were analyzed together (Table 3.3), no statistically significant effects were observed for residential instability. For ethnic concentration, there were significant associations between marginalization and chlamydia prevalence in the student strata, but with an inverse dose response for quintiles 2-5. There was no, significant association between ethnic marginalization and chlamydia prevalence in the non-student strata. Similarly, when analyzed as a whole, no statistically significant effects were observed for ethnic concentration.

In conclusion, a stratified analysis by student status for the area-level risk factors shows that the effects of neighbourhood SES on chlamydia infection differs for students and non-students in this sample. This may in part be due to the misclassification that arises with assigning students to a DA in which they did not contribute census data to. Although, it is important to note that by stratifying this analysis by student status, power to detect associations between the indices of the ON-Marg Index and chlamydia infection is lost, as the sample size decreases. Additionally, 7% of the Clinic sample was not accounted for in this stratified analysis, as student status was missing for these individuals.

Finally, it is of importance to mention that the ON-Marg Index used in this study was the 2006 version. The study sample consisted of individuals who attended the Clinic from 2016-2017. Individuals who completed the census questionnaire and contributed to the ON-Marg Index in 2006 may be different than the individuals who attended the STI Clinic 10 years later.

4.4.1.2.2 Outcome assessment

The outcome of interest of this study was a chlamydia test result, as recorded in the EMR database of the Clinic. A strength of this study is that this outcome assessment is an objective measure, which is obtained from bodily samples, meaning it is expected to be very accurate. Minimal problems are expected to arise with misclassification of the outcome, as the sensitivity and specificity of the NAAT tests are typically very high [13]. Although 86% of the Clinic population was tested for chlamydia using the NAAT, the other 14% were tested for chlamydia via culture. The sensitivity of a culture-based test is not as high as the NAAT (60-80% for culture versus 96-100% for NAAT), as it may be impaired by poor specimen collection, storage and transport, toxic substances in clinical specimens, and overgrowth of cell cultures by commensal microbes [14]. Therefore, some individuals in this study may have been incorrectly classified as having a negative test result. That said, individuals who continue to experience STI symptoms will often return to the Clinic for re-testing during the study period and be later correctly classified as having a positive test result. Because this study only looked at the first test result for each individual, the small percentage of participants who incorrectly tested negative and then returned to the clinic for a re-rest and then tested positive at a later date would be misclassified as having a negative chlamydia test.

4.4.1.3 Confounding

All analytic components of this study controlled for several potential confounders which were determined from past literature, were available in the questionnaire, and were associated with the outcome in bivariate analysis at a $p<0.20$ level. Two *a priori* confounders were measured in this study – age and sex. Age was a strong and significant predictor for chlamydia infection in this Clinic sample, and as age increased, the odds of chlamydia increased. However, sex was not a significant predictor for infection.

It is also possible that there are other confounders which were not considered in this study. Although the Clinic questionnaire considered most risk factors, it is possible that variables such as marital/boyfriend or girlfriend status, ethnicity, mental and physical health, age at sexual debut, and other risk factors could have been important confounders in the multivariate models of this study. Since this study was limited to the variables included in the questionnaire, there was no way to explore these other variables of interest.

4.4.1.4 Study Power

A priori power calculations (Appendix I) revealed that there was reasonable power (>80%) to detect an association between the least frequent exposure in this study (there was no single exposure of interest) that was in the literature (number of partners in the last two months) and chlamydia infection. The analysis strategy employed the use of a backward deletion procedure to generate the most parsimonious model of risk factors associated with chlamydia infection. Because of the large sample size and a high proportion of individuals who tested positive for chlamydia in the Clinic, this study had high power to detect a significant effect if present.

4.4.2 External Validity

The population for this study includes only individuals who attended KFL&A Public Health's sexual health clinic during the period of study. Therefore, it is important to take caution with the generalizability of these results, knowing that it can only be potentially generalized to other STI clinic populations in Ontario, specifically cities with similar demographics and distributions of the ON-Marg indices to the KFL&A region. Future studies using the ON-Marg Index may choose to include a wider sample which may include all individuals in a certain region, rather than to focus on an STI clinic. Doing so may result in significant associations between the indices of the ON-Marg Index and chlamydia infection.

4.4.3 Additional Strengths and Limitations

4.4.3.1 Missing Data

Although the Clinic questionnaire used in this study was delivered by nurses, there is still some missing data for most of the variables. Some nurses may not have been as diligent while filling out the questionnaire, or some individuals may have refused to answer certain questions. As seen in Table 3.1, most missing data is from the tobacco and excessive alcohol use questions, with 26% of Clinic participants having missing data for the tobacco question and 41% having missing data for the excessive alcohol use question. This small sample size could have contributed to the tobacco and alcohol variables not making it into the final parsimonious individual-level risk factor model in Table 3.2. Additionally, just over 12% of individuals did not provide a postal code, and therefore marginalization data for these individuals was not captured in the area-level model in Table 3.3. Perhaps alternative forms of data collection such as computer-assisted questionnaires would help minimize missing data.

Implications of missing data and smaller categories for certain variables may have led to the wide confidence intervals and lack of significant findings. It is possible that if the categories had larger sample sizes, this study would have had more power to detect some associations.

4.4.3.2 Novelty

Although studies in the past have measured the association between low individual and neighbourhood SES and chlamydia infection, no studies to date have used the ON-Marg Index as a measure of neighbourhood SES for any STI, including chlamydia infection. This study adds to the significance of using the ON-Marg Index as a measure of neighbourhood SES for health outcomes in epidemiological research. There are currently a limited number of studies which have used the ON-Marg Index to measure health outcomes, and no studies have used the tool for sexual health research. Although the findings of this study were not all statistically significant, it will be the first of its kind and will hopefully initiate further research.

Additionally, studies have not plotted test positive and negative individuals from an STI clinic on a GIS. The findings of this study add to the growing body of literature regarding the multiple area- and individual-level risk factors for chlamydia infection, specifically in an STI clinic population.

4.5 Future Research and Public Health Implications

Many studies have shown that individual- and area-level risk factors both impact the risk of being infected with chlamydia. It may be possible that although neighbourhood SES has been proven to be a risk factor for chlamydia infection in the past, neighbourhood SES as measured by the ON-Marg Index, in this limited STI Clinic population, may not be. Future research should focus on examining this relationship using different populations, to confirm and strengthen the results of the current study.

This research has direct implications to public health agencies and STI clinics in Canada. Traditional STI prevention strategies have focused on student populations, specifically universities and colleges. This study has suggested that those who are more likely to be infected may be individuals who are less educated, may not have a permanent home address, and may come from more marginalized regions. The results of this study add some knowledge to the existing literature, suggesting that neighbourhood-level population health intervention strategies should focus prevention efforts in regions which may be more marginalized, to educate individuals and to reduce the risk of chlamydia acquisition.

Additionally, since STI contact was the strongest and most significant predictor of chlamydia infection, STI clinics such as the KFL&A Public Health sexual health clinic should continue to put efforts into correctly tracking sexual contacts of those who tested positive for chlamydia. Although most STI clinics currently ask that if an individual tests positive for chlamydia, they should advise recent sexual partners to get tested, many clinics do not have the capacity to call all previous partners of each infected individual. This study suggests that more resources should go into ensuring continued intensive contact tracing for infected individuals. Additionally, social network analysis programs should be considered to further identify sexual contacts.

4.6 Conclusion

In conclusion, this study confirms that several individual-level risk factors, such as age, number of recent sexual partners, STI contact, and condom use, are important predictors for chlamydia infection in an STI clinic. There is also a trend suggesting an association between high marginalization, as defined by the indices of the ON-Marg Index, and chlamydia infection.

The knowledge that has come from this study is novel and will add to the literature to better target neighbourhood-level prevention interventions in specific geographic regions, as prevention strategies are facilitated by understanding the transmission dynamics of the STI.

4.7 References

1. Ford JL, Browning CR. Neighborhoods and infectious disease risk: Acquisition of chlamydia during the transition to young adulthood. *J Urban Heal*. 2014;91(1):136-150. doi:10.1007/s11524-013-9792-0.
2. Monteiro EF, Lacey CJN, Merrick D. The interrelation of demographic and geospatial risk factors between four common sexually transmitted diseases. *Sex Transm Infect*. 2005;81(1):41-46. doi:10.1136/sti.2004.009431.
3. Biello KB, Pettigrew MM, Niccolai LM. Multiple chlamydia infection among young women: Comparing the role of individual- and neighbourhood-level measures of socioeconomic status. *Sex Transm Infect*. 2011;87(7):560-562. doi:10.1136/sextrans-2011-050185.
4. Aiello AE, Simanek AM, Galea S. Population levels of psychological stress, herpesvirus reactivation and HIV. *AIDS Behav*. 2010;14(2):308-317. doi:10.1007/s10461-008-9358-4.
5. Poundstone KE, Strathdee S a, Celentano DD. The social epidemiology of human immunodeficiency virus/acquired immunodeficiency syndrome. *Epidemiol Rev*. 2004;26:22-35. doi:10.1093/epirev/mxh005.
6. Link BG, Phelan J. Social Conditions As Fundamental Causes of Disease Social Conditions as Fundamental Causes of Disease*. *Source J Heal Soc Behav J Heal Soc Behav*. 1995:80-9480. doi:10.2307/2626958.
7. Buffardi AL, Thomas KK, Holmes KK, Manhart LE. Moving upstream: Ecosocial and psychosocial correlates of sexually transmitted infections among young adults in the United States. *Am J Public Health*. 2008;98(6):1128-1136.

doi:10.2105/AJPH.2007.120451.

8. Anderson JE, Dahlberg LL. High-risk sexual behavior in the general population. Results from a national survey, 1988-1990. *Sex Transm Dis*. 1992;19(6):320-325.

9. Langhaug LF, Sherr L, Cowan FM. How to improve the validity of sexual behaviour reporting: Systematic review of questionnaire delivery modes in developing countries: Systematic Review. *Trop Med Int Heal*. 2010;15(3):362-381. doi:10.1111/j.1365-3156.2009.02464.x.

10. Weeks MF. Computer-Assisted Survey Information Collection: A Review of CASIC Methods and Their Implications for Survey Operations. *J Off Stat*. 1992;8(4):445-465. http://search.proquest.com/docview/1266814966/abstract?%5Cnhttp://media.proquest.com/media/pq/classic/doc/2858937871/fmt/pi/rep/NONE?hl=&cit%253Aauth=Weeks%252C+Michael+F&cit%253Atitle=Computer-Assisted+Survey+Information+Collection%253A+A+Review+of+CASIC+...&cit%253.

11. Turner CF, Ku L, Rogers SM, Lindberg LD, Pleck JH, Sonenstein FL. Adolescent sexual behavior, drug use, and violence: Increased reporting with computer survey technology. *Science (80-)*. 1998;280(5365):867-873. doi:10.1126/science.280.5365.867.

12. Plummer ML, Ross DA, Wight D, et al. "A bit more truthful": The validity of adolescent sexual behaviour data collected in rural northern Tanzania using five methods. In: *Sexually Transmitted Infections*. Vol 80. ; 2004. doi:10.1136/sti.2004.011924.

13. Gaydos CA, Theodore M, Dalesio N, Wood BJ, Quinn TC. Comparison of three nucleic acid amplification tests for detection of Chlamydia trachomatis in urine specimens. *J Clin Microbiol*. 2004;42(7):3041-3045. doi:10.1128/JCM.42.7.3041-3045.2004.

14. Meyer T. Diagnostic Procedures to Detect Chlamydia trachomatis Infections. *Microorganisms*. 2016;4(3):25. doi:10.3390/microorganisms4030025.

Appendix A

Ethics Letter of Approval

QUEEN'S UNIVERSITY HEALTH SCIENCES & AFFILIATED TEACHING HOSPITALS RESEARCH ETHICS BOARD (HSREB)

HSREB Initial Ethics Clearance

September 20, 2017

Ms. Mara Habash
Department of Public Health Sciences
Queen's University

ROMEO/TRAQ: #6021888
Department Code: EPID-597-17
Study Title: The Association between Area and Individual-Level Risk Factors and Chlamydia Infection in KFL&A's sexual health clinic: application of a GIS system
Co-Investigators: Dr. B. Harvey and Dr. H. Richardson
Review Type: Delegated
Date Ethics Clearance Issued: September 20, 2017
Ethics Clearance Expiry Date:

Dear Ms. Habash,

The Queen's University Health Sciences & Affiliated Teaching Hospitals Research Ethics Board (HSREB) has reviewed the application and granted ethics clearance for the documents listed below. Ethics clearance is granted until the expiration date noted above.

- Thesis Proposal
- KFL&A Questionnaire

Documents Acknowledged:

- CORE Certificate

Amendments: No deviations from, or changes to the protocol should be initiated without prior written clearance of an appropriate amendment from the HSREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

Renewals: Prior to the expiration of your ethics clearance you will be reminded to submit your renewal report through ROMEO. Any lapses in ethical clearance will be documented on the renewal form.

Completion/Termination: The HSREB must be notified of the completion or termination of this study through the completion of a renewal report in ROMEO.

Reporting of Serious Adverse Events: Any unexpected serious adverse event occurring locally must be reported within 2 working days or earlier if required by the study sponsor. All other serious adverse events must be reported within 15 days after becoming aware of the information.

Reporting of Complaints: Any complaints made by participants or persons acting on behalf of participants must be reported to the Research Ethics Board within 7 days of becoming aware of the complaint. Note: All documents supplied to participants must have the contact information for the Research Ethics Board.

Investigators please note that if your trial is registered by the sponsor, you must take responsibility to ensure that the registration information is accurate and complete.

Yours sincerely,

Albert J. Clark.

Chair, Health Sciences Research Ethics Board

The HSREB operates in compliance with, and is constituted in accordance with, the requirements of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2); the International Conference on Harmonisation Good Clinical Practice Consolidated Guideline (ICH GCP); Part C, Division 5 of the Food and Drug Regulations; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations, Canadian General Standards Board, and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. The HSREB is qualified through the CTO REB Qualification Program and is registered with the U.S. Department of Health and Human Services (DHHS) Office for Human Research Protection (OHRP). Federalwide Assurance Number: FWA#:00004184, IRB#:00001173

HSREB members involved in the research project do not participate in the review, discussion or decision.

Appendix B

Neighbourhood Profiles- 2011 Census Key Map

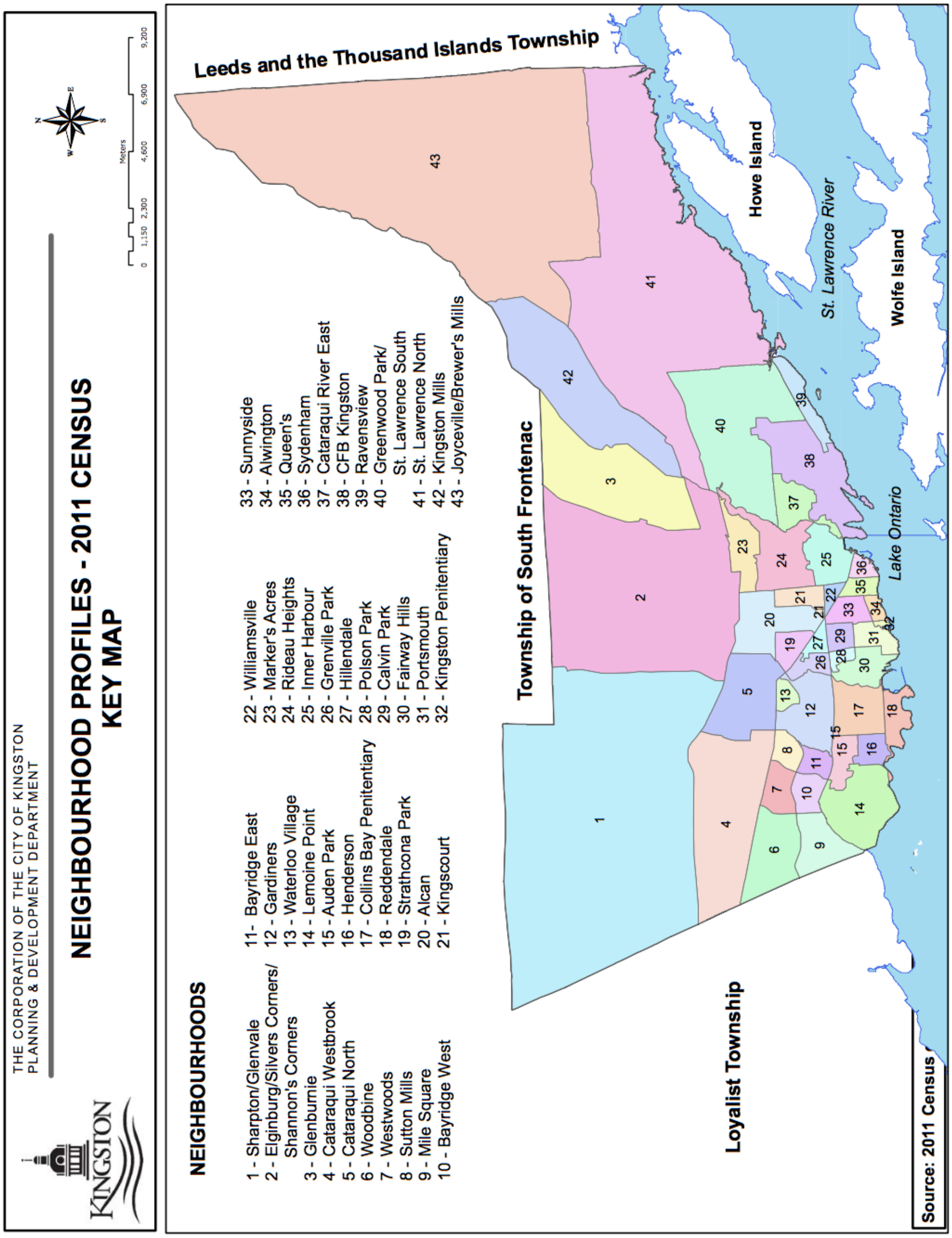

Figure B.1. Neighbourhood profile map for the city of Kingston from the 2011 census, which shows all 43 neighbourhoods. Each neighbourhood has five to seven blocks (DAs).

Appendix C

Dissemination Area Reference Map

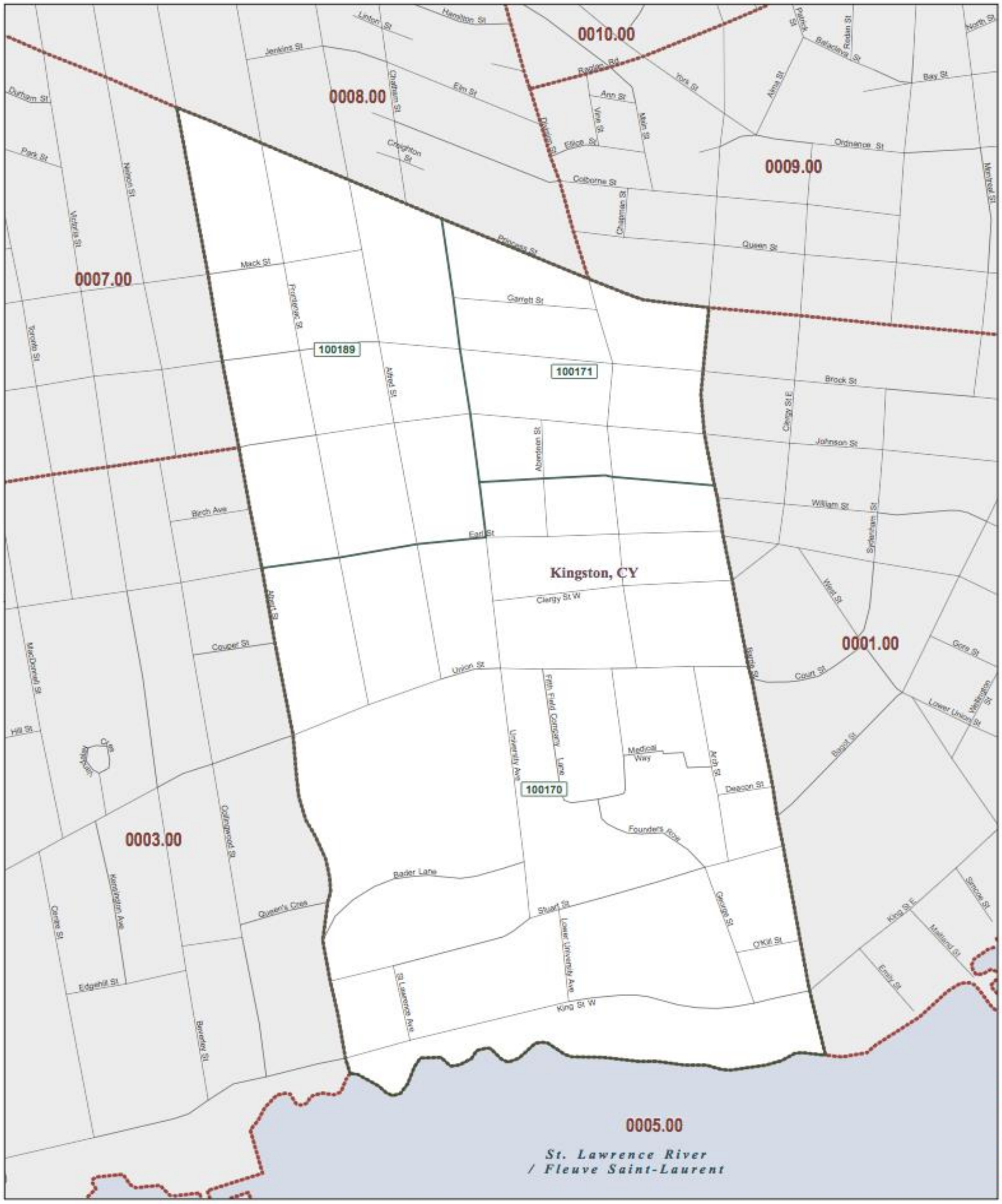

Figure C.1. A reference map showing the three dissemination areas (DA) for the Census tract 0002.00 in Kingston (neighbourhood 35 from Figure 1). Each DA is outlined in a thin green line and labelled in green text with a six-digit code.

Appendix D

Marginalization Indicators

	DIMENSIONS			
	Residential instability	Material deprivation	Dependency	Ethnic concentration*
INDICATORS	Proportion of the population living alone	Proportion of the population aged 20+ without a high-school diploma**	Proportion of the population who are aged 65 and older	Proportion of the population who are recent immigrants (arrived in the 5 years prior to census)
	Proportion of the population who are not youth (aged 16+)***	Proportion of families who are lone parent families	Dependency ratio (total population 0-14 and 65+ /total population 15 to 64)	Proportion of the population who self-identify as a visible minority
	Average number of persons per dwelling***	Proportion of the population receiving government transfer payments	Proportion of the population not participating in labour force (aged 15+)***	
	Proportion of dwellings that are apartment buildings	Proportion of the population aged 15+ who are unemployed		
	Proportion of the population who are single/ divorced/widowed***	Proportion of the population considered low-income****		
	Proportion of dwellings that are not owned***	Proportion of households living in dwellings that are in need of major repair		
	Proportion of the population who moved during the past 5 years			

* Aboriginal indicators did not load on any of the factors.

** For the 2006 index, the indicator is the proportion of the population aged 25+ without a certificate, diploma or degree. This is due to a change in the Statistics Canada definition.

*** Indicators were reverse coded, meaning they were coded opposite of the measure (e.g. % married/common law becomes %single/divorced/separated/widowed).

**** "Low income" is defined as below the low income cutoff (LICO), a Statistics Canada measure that is adjusted for community size, family size and inflation.

Figure D.1. Dimensions of marginalization and their respective indicators for the ON-Marg.

Appendix E

Methods of Chlamydia Tests

Table E.1. Methods of chlamydia tests conducted at the clinic during the study period (April 1, 2016 to March 31, 2017) and results (normal and abnormal). Column and row totals are presented.

Test	Negative	Positive	Total
CT Culture Cervical	1	0	1
CT Culture Rectal	97	6	103
CT Culture Throat	236	0	236
CT Culture Urethral	1	0	1
CT NAAT Cervical	413	35	448
CT NAAT Urine	1423	191	1614
Total	2171	232	2403

Appendix F

Questionnaire at the KFL&A Public Health Sexual Health Clinic

STI Testing		
Presenting concern	Routine screening ▾	
Partners	☐ Male ☐ Female	
Last sexual contact		
Number of Partners	☐ in the past 2 months ☐ lifetime ▾	
Practices	**Protected** **Unprotected** ☐ Oral ☐ Performed ☐ ☐ ☐ Received ☐ ☐ ☐ Vaginal ☐ ☐ ☐ Anal ☐ Top ☐ ☐ ☐ Bottom ☐ ☐ ☐ Other ☐ ☐	
Condom Use	☐ Always ☐ Usually ☐ Sometimes ☐ Rarely ☐ Never	
Symptoms	☐ None apply ☐ Discharge ☐ Urinary symptoms ☐ Pelvic pain ☐ Abnormal bleeding ☐ Skin changes ☐ Other	
Risk Factors	☐ None apply ☐ History STI ☐ STI Contact ☐ Tattoos/piercings (unsterile) ☐ Nasal drug use ☐ Injection drug use ☐ Partner from an endemic area ☐ Other	

Figure F.1. List of risk factor variables collected from clients by staff at the KFL&A Public Health sexual health clinic.

Appendix G

Detailed Demographic and Risk Factor Characteristics

Table G.1. More detailed risk factor characteristics for those who tested positive and negative for chlamydia at KFL&A Public Health's sexual health clinic between April 1, 2016 and March 31, 2017.

Characteristic		**Chlamydia Positive** n=208		**Chlamydia Negative** n=1567		**Total** n=1775	
Presenting concern							
	Contact tracing	94	45.2	135	8.6	229	12.9
	Routine screening	55	26.4	943	60.2	998	56.2
	Symptomatic	48	23.1	446	29.1	494	27.8
	Resubmitting a specimen	0	0.0	4	0.3	4	0.2
	Test of cure	0	0.0	2	0.1	2	0.1
	Post-window follow-up	0	0.0	3	0.2	3	0.2
	Missing	11	5.3	34	2.2	45	2.5
STI Symptoms							
	None	110	52.9	805	51.4	915	51.6
	Discharge	36	17.3	223	14.2	259	14.6
	Urinary symptoms	46	22.1	172	11.0	218	12.3
	Pelvic pain	14	6.7	89	5.7	103	5.8
	Abnormal bleeding	10	4.8	83	5.3	93	5.2
	Skin change	18	8.7	282	18.0	300	16.9
	Other symptoms	14	6.7	150	9.6	164	9.2
STI Risks							
	No risks	76	36.5	797	50.9	873	49.2
	History STI	43	20.7	375	23.9	418	23.6
	STI contact	64	30.8	147	9.4	211	11.9
	Unsterile tattoos/piercings	10	4.8	28	1.8	38	2.1
	Nasal drug use	24	11.5	173	11.0	197	11.1
	Injection drug use	3	1.4	16	1.0	19	1.1
	Partner from an endemic area	6	2.9	64	4.1	70	3.9
	Other	3	1.4	49	3.1	52	2.9

Table G.2. Age and sex demographics for the abnormal cases in iPHIS and for the abnormal/ normal testing population attending the KFL&A Public Health sexual health clinic.

Demographic		**iPHIS Abnormal**		**Clinic Abnormal**		**Clinic Normal**		**Clinic Total**	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total		905	100	208	11.7	1567	88.3	1775	100
Sex									
	Male	375	41.4	119	57.2	788	50.3	907	51.1
	Female	530	58.6	89	42.8	779	49.7	868	48.9
Age (years)									
	10 to 14	4	0.4	1	0.5	4	0.3	5	0.28
	15 to 19	215	23.8	53	25.5	250	16.0	303	17.07
	20 to 24	404	44.6	90	43.3	623	39.8	713	40.17
	25 to 29	147	16.2	36	17.3	301	19.2	337	18.99
	30 to 29	91	10.1	18	8.7	226	14.4	244	13.75
	40 to 59	43	4.8	10	4.8	140	8.9	150	8.45
	60 and over	1	0.1	0	0.0	23	1.5	23	1.30

Appendix H

Stratified Multivariate Analysis of Area-Level Risk Factors by Student Status

Table H.1. Multivariate analysis of area-level risk factors (four indices of the Ontario Marginalization (ON-Marg) Index) for chlamydia among those who presented at KFL&A Public Health's sexual health clinic between April 1, 2016 and March 31, 2017, stratified by student-status.

ON-Marg index		**Adjusted[c] OR[a] (95% CI[b])** **Students** **n=718**	**Adjusted[d] OR (95% CI)** **Non-students** **n=934**
Material deprivation			
	1 (least deprived)	Ref[d]	Ref
	2	1.44 (0.60-3.47)	0.62 (0.29-1.36)
	3	2.00 (0.88-4.53)	0.89 (0.41-1.92)
	4	1.11 (0.50-2.64)	0.81 (0.38-1.75)
	5 (most deprived)	0.78 (0.30-2.02)	1.36 (0.69-2.68)
	Missing	1.92 (0.82-4.52)	1.12 (0.49-2.52)
Dependency			
	1 (least dependent)	Ref	Ref
	2	2.58 (1.00-6.62)	0.97 (0.44-2.14)
	3	3.56 (1.48-8.56)*	0.86 (0.40-1.85)
	4	0.88 (0.27-2.91)	0.57 (0.24-1.35)
	5 (most dependent)	3.42 (1.27-9.17)*	1.39 (0.64-3.02)
	Missing	3.42 (1.30-8.98)*	1.11 (0.46-2.67)
Residential Instability			
	1 (least instable)	Ref	Ref
	2	0.76 (0.26-2.26)	1.81 (0.57-5.81)
	3	0.59 (0.18-1.95)	3.18 (1.06-9.61)*
	4	1.07 (0.41-2.82)	3.32 (1.10-10.1)*
	5 (most instable)	0.54 (0.21-1.38)	3.31 (1.18-9.29)*
	Missing	1.17 (0.42-3.23)	3.24 (1.02-10.3)*
Ethnic Concentration			
	1 (least ethnically concentrated)	Ref	Ref
	2	4.67 (1.20-18.1)*	0.84 (0.38-1.85)
	3	3.91 (1.05-14.6)*	0.79 (0.36-1.73)
	4	2.61 (0.68-10.1)	1.24 (0.62-2.50)
	5 (most ethnically concentrated)	1.18 (0.28-5.05)	1.11 (0.42-2.96)
	Missing	4.27 (1.08-17.0)*	1.18 (0.50-2.79)

* Significant at the $p<0.05$ level.
[a] OR = odds ratio.
[b] CI = confidence interval.
[c] Adjusted for age, sex, condom use and STI contact.
[d] Adjusted for age, sex, partners in the last 2 months, STI contact and STI symptoms.
[d] Ref = reference value (1).

Appendix I

A Priori Power Calculation

Exposure: Number of partners (last 2 months)

8.9% of male STI clinic attendees reported having over 3 partners in the past few months.[1]

RR=1.35
n= 2403
r= 2190/213
 = 10.28
p_0 = 0.074[2]
$p_1 = (p_0 RR)/(1+p_0 + p_0 (RR-1))$
 $= (0.074)(1.35) / (1+0.074 + 0.074 (1.35-1))$
 $= 0.091$
$d^* = p_1 - p_0$
 $= 0.091-0.074$
 $= 0.017$
$p = (p_1+rp_0) / 1+r$
 $= (0.091 + 10.28(0.074)) / 11.28$
 $= 0.076$
$Z_B = ((n(d^*)^2 r)/(r+1)p(1-p))^{0.5} - Z_{a/2}$
 $= ((2403)(0.017)^2(10.28))/ (11.28)(0.076)(1-0.076))^{0.5} - 1.96$
 $= 1.042$
Power= 85.3%

References

1. Rietmeijer CA, Van Bemmelen R, Judson FN, Douglas JM. Incidence and repeat infection rates of Chlamydia trachomatis among male and female patients in an STD clinic: implications for screening and rescreening. *Sex Transm Dis*. 2002;29(2):65-72. http://www.ncbi.nlm.nih.gov/pubmed/11818890.