CADHAM
PROVINCIAL
LABORATORY

SUMMARY REPORT on Laboratory Detection Trends for *Chlamydia trachomatis* and *Neisseria gonorrhoeae*

2000 to 2016

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Manitoba

LABORATORY DETECTION TRENDS FOR *CHLAMYDIA TRACHOMATIS* AND *NEISSERIA GONORRHOEAE* AT CADHAM PROVINCIAL LABORATORY, 2000 - 2016

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EXECUTIVE SUMMARY

- This report is based on 17 years (2000 to 2016) of diagnostic testing for *Chlamydia trachomatis* (CT) and *Neisseria gonorrhoeae* (NG) at Cadham Provincial Laboratory (CPL). Analysis of overall testing patterns, inclusive of both negative and positive results, as well as patterns associated with positive results are presented.
- Numerous technological changes have taken place at CPL over the study period that have impacted CTNG detection. Given these changes, case counts can be affected even in situations of stable incidence. To demonstrate the effects of these changes and to provide a better representation of transmission trends over time, the likelihood of identifying CT and NG infections in men and women was analyzed. After adjusting for test volume and technological changes, the likelihood of identifying a CT infection in both women and men has consistently decreased over time. Downward inflection points correlate with initiation of new public health programs (e.g. implementation of male screening with urine specimens; implementation of new, more sensitive test platforms). These correlations suggest that public health programs and practice can impact CT incidence and prevalence. While technological changes have also affected NG detection trends, the likelihood of identifying an NG infection fluctuates over time to a greater extent than CT. While public health programs may impact NG transmission, other independent factors, such as the transmission potential and virulence of individual strains, likely also affect NG incidence.
- For women aged 14 to 19, most regional health authorities (RHAs) test approximately 10 to 15% of their population. The exception is Northern RHA (NRHA) where approximately 30% of 14 to 19 year olds are tested annually. For women aged 20 to 24 and 25 to 29, the proportion of the population screened is greater, with most RHAs annually testing approximately 30% of their respective populations; the exception is again NRHA where the percent of 20 to 29 year olds tested reaches 50%. The population percentages tested over time for women are relatively stable, with no clear upward or downward trend.
- For all male age groups across all RHAs, a smaller percentage of the population is tested relative to women. In the most recent year examined (2016), for 14 to 19 year olds most RHAs test between 2 – 4% of their respective male populations. This number increases for older age groups (the percentage of the 20 to 24 and 25 to 29 year old population being tested ranges from 5-10%). As above, the exception is NRHA where values range from 10-20%. Unlike women, there has been a steady increase over time in the percent of the male population being tested in all RHAs.
- Shifts in specimen source have occurred over time. For women in 2000, urines made up 0.25% of specimens received; this value has increased to 46.1% in 2016. Most of this shift has occurred in the last eight years. Similarly, for men in 2000, urines made up 7.8% of specimens; this value has increased to 98.1% in 2016. The shift towards urines for males is coincident with the implementation of male screening in 2004; for females it coincided in time with implementation of the Aptima NAAT assay.
- The majority of testing each year represents repeat tests (any test for a given person at any point after their first known CTNG test). For the most recent years in the study period, approximately 20% of specimens received each year are from individuals being tested for CTNG for the first time; the remaining 80% of specimens represent repeat testing. The amount of repeat testing has been steadily increasing over time.
- For women, aged 14-19, 20-24 and >39, there has been a decline in the number of women newly accessing testing over the past nine years. Conversely, the number of women newly accessing testing between the ages of 25 to 39 has been relatively stable or has increased slightly over time. For all male age groups, the number of individuals newly accessing testing each year has consistently increased over time. While some regional variation exists, these trends tend to occur across RHAs. The opposite trend for women and men with respect to those newly accessing testing each year has led to a female to male testing ratio that approaches or exceeds equality (i.e. in some RHAs more males than females are now newly accessing testing).

- For the study period as a whole, the average number of tests per individual for females across the five RHAs ranges from 3.33 (Southern RHA [SRHA]) to 6.65 (NRHA). Respective numbers for males range from 1.94 (SRHA) to 2.98 (NRHA). The average number of CT infections mimics the average number of tests with the lowest average number of CT infections per person for women and men occurring in SRHA (1.46 and 1.3, respectively) and the highest values in NRHA (2.11 and 1.62). The average number of NG infections per person does not exactly correspond with the average number of tests. The lowest average number of NG infections per person for women and men are in Prairie Mountain RHA (1.20 and 1.24, respectively). The highest values for women are in NRHA (1.43) and for men in Interlake Eastern RHA (1.39).
- Trends related to the number of primary (the first recorded positive result for a given person) and repeat (any positive result recorded for a given person after their primary positive) CT and NG infections identified annually were examined. The number of primary and repeat infections identified each year for CT tended to mimic trends related to the annual amount of primary and repeat testing. This trend was especially apparent for women. Conversely, the number of primary and repeat NG infections tended to fluctuate from year to year with no clear overall trend nor any clear association with testing volume.
- Infection rates and incidence rates were compared. Infection rates reflect the number of cases detected per thousand population and is the rate measure typically used by surveillance units. Incidence rates reflect the number of incident infections per 100 person-years of follow-up and can only be calculated when information on all tests, both negative and positive, are available. The highest and lowest infection rates are in NRHA and SRHA, respectively; infection rates differed by more than 10-fold between these two RHAs. Conversely, incidence rates for these respective RHAs differed by less than two-fold. The underlying difference relates to incidence rates incorporating information on the overall number of people tested and the extent to which they remain negative over time.
- Current provincial guidelines for both CT and NG recommend repeat testing six months after an initial positive result. Adherence to this guideline as well as temporal trends related to follow-up test positivity were examined. The majority of CT or NG positive individuals, especially men, do not re-test within the recommended timeframe. The recommended window of six months for a follow-up test may also be excessively long as a positive test is common past month two of follow-up.
- The time period covered by the data used in this report was coincident with the most recent syphilis (SY) outbreak, therefore a relational analysis between CT, NG and SY was undertaken. All individuals with a new laboratory diagnosis of SY between the years 2014 to 2016 were linked to their CT and NG testing records. Prior to a diagnosis of SY, CT and NG test positivity for these individuals was high across all study years, but dropped substantially after a diagnosis of SY. These results suggested the long-term existence of a network of individuals who exhibited high-risk behaviours for most/all of the time they have been sexually active. The drop in CT and NG positivity after a diagnosis of SY provides evidence of behaviour change and the potential importance of public health interaction with individuals at high risk of infection.

BACKGROUND

This report analyses 17 years (2000 to 2016) of diagnostic testing data carried out at Cadham Provincial Laboratory (CPL) for the two most common bacterial sexually transmitted infections, *Chlamydia trachomatis* (CT) and *Neisseria gonorrhoeae* (NG). The analysis makes use of all test results, both negative and positive and, as such, reveals testing patterns that are not readily apparent to public health practitioners outside of CPL. The report objective and specific analyses are summarized below:

OBJECTIVE

- Describe temporal trends related to CT and NG testing and detection at CPL for the 17 year period from 2000 to2016.

ANALYSES PERFORMED

1. Likelihood of identifying a CT or NG infection
    - 1.1. Likelihood of identifying a CT infection in females
    - 1.2. Likelihood of identifying a CT infection in males
    - 1.3. Likelihood of identifying a NG infection in females
    - 1.4. Likelihood of identifying a NG infection in males
    - 1.5. Likelihood of identifying a CT or NG infection over time – overall data interpretation
2. Testing patterns
    - 2.1. Proportion of the Manitoba population tested
    - 2.2. Specimen type frequency distribution
    - 2.3. Specimen *vs*. patient testing
        - 2.3.1. Number of newly tested individuals by year
        - 2.3.2. Repeat testing
3. Diagnostic tests and CTNG detection
    - 3.1. Mean number of tests and infections
    - 3.2. Primary and repeat infections
        - 3.2.1. CT primary and repeat infections
        - 3.2.2. NG primary and repeat infections
4. CT infection and incidence Rates
5. Index and follow-up testing of population cohorts
6. Relationship between chlamydia, gonorrhea and syphilis infection
7. Urines as a diagnostic specimen

METHODS

Testing records corresponding to nucleic acid probe (NAP) and nucleic acid amplified tests (NAAT) were extracted from the CPL mainframe and LIMS data repositories (i.e. test records for NG culture or CT Microtrak testing were not included). The specific test platforms and points in time when testing methods changed are detailed in Appendix 1. Briefly, NAP testing corresponds to the GenProbe PACE 2 Combo test for CT and NG, while NAAT testing was carried out either with the GenProbe AMP CT test (CT detection only; 1998 to 2004), the Becton Dickinson ProbeTec assay (CT and NG detection; 2004 to 2007) or the GenProbe/Hologic Aptima Combo 2 test (CT and NG detection; 2007 to present). All NAAT assays were coded as "NAAT" and were not differentiated for analytic purposes. Data was cleaned and coded in a consistent manner allowing LIMS data to be appended to mainframe data.

Observations with missing demographic or geographic data were removed, as were out-of-province addresses. Some additional data cleaning, described in more detail in Appendix 2, eliminated minor specimen types or gender designations that were too few in number for meaningful analysis. Data cleaning removed 3.7% of the testing records (starting number of records - 1,573,957; final number of observations - 1,516,368).

The primary dataset created represents each diagnostic test (1,516,368 observations). Individuals who test two or more times appear multiple times in this dataset. Data in this file was cleaned such that it contains no missing data for the following variables:

1) Requisition
2) Personal Health Information Number (PHIN)
3) Age
4) Gender
5) RHA
6) Received date
7) Specimen source
8) Test type

Appendix 3 provides an overview of all data pertaining to the specimen-level dataset, stratified by RHA. Subsequent to completion of the specimen-level database, secondary datasets were created that reflected individual people rather than tests. As necessary, manipulation of the specimen-level data reduced data to person-specific variables (e.g. number of diagnostic tests per person for the study period, number of CT infections per person for the study period).

When creating age categories in the above datasets, the youngest age group of 14-19 spanned six years, as opposed to the more common five or ten year period. The youngest age of 14 corresponds to the age of sexual consent in Manitoba (for partners less than five years older). Although it falls outside the usual age range of 15-19, for simplicity it was grouped with 15-19 year olds to create a 14-19 year age group.

All data cleaning and statistical analysis was performed with Stata version 11.

RESULTS

1. Likelihood of identifying a CT or NG infection - overview

Wylie and Van Caeseele[1] determined the likelihood of identifying a positive CT or NG result over time (2000 to 2012) after controlling for test type and specimen type and two patient characteristics (age and RHA of residence). Over the past 10 to 15 years, at a global level, there has been an increase in the number of CT and NG cases detected. The analysis was undertaken to better understand whether this trend was related to a true increase in prevalence/incidence or whether it was largely technological in nature (i.e. improved test sensitivity). The results indicated a near continual decline in the likelihood of detecting a positive CT result, contrasting markedly with conclusions derived from examination of absolute case numbers.

Here that analysis is repeated to extend the study period and also show RHA-specific results. Details of the analytic approach can be found in the publication cited above. Briefly, CT or NG infection status is used as an outcome variable. Initially, logistic regression, using year of test as the sole predictor variable, generates unadjusted odds ratios (UOR) where these UOR mimic test positivity (the earliest year in the study period – 2000 – was used as the reference year). Test positivity was not incorporated into the figures in this report, but examples of the manner in which test positivity mimics UORs can be seen in Wylie and Van Caeseele[1]. The unadjusted model is then refined by incorporating additional control variables. The variables of most interest include test type and specimen type, however age and, when appropriate, RHA are also used as control variables. These regression models generate adjusted odds ratios (AOR) that reflect the likelihood of identifying an infection after controlling for changing diagnostic assays and shifts in swab *vs*. urine specimens over time. Although the focus will be on AOR trends by year (as above using the year 2000 as the reference year), the AOR for control variables are also discussed, as they are relevant to some of the changing patterns in CT and NG diagnostics observed over time. Following the provincial analysis, the process is repeated for each RHA, as individual RHAs do not necessarily follow the overall provincial pattern.

The figures embedded within each section provide a pictorial representation of unadjusted and adjusted ORs over time. The logistic regression output used to generate the figures, plus the data for individual control variables are attached as appendices 4A to 7F.

1.1. Likelihood of identifying a CT infection in females

Figure 1.1A shows the UORs for females for the province as a whole. The most evident trend is the increase in UOR between 2007 and 2009. This change is associated with the increased sensitivity of the Aptima Combo 2 assay, leading to an increase in the number of positive tests identified post-implementation (i.e. the increase in OR reflects the increased likelihood of identifying a positive result).

Figure 1.1A also shows AORs after controlling for test type, specimen type, patient age and RHA (the AOR, 95% CI and *p* values for the variables associated with this data are found in Appendix 4A). With respect to the variables used as control variables, the AOR for test type is 1.82. The significant, positive AOR for this variable is expected and reflects the superiority of NAAT over NAP for detecting a positive CT result. Also expected is the decreasing AOR associated with age when 14-19 year olds are used as the reference group, as this age group for females is the most likely to be associated with an infection.

The AOR for urine specimens relative to cervical swabs is also significant with a value of 1.28. This result indicates that a urine specimen has a greater likelihood of being associated with a positive CT result in women. This result is not necessarily expected, and may indicate that a urine specimen is a superior diagnostic specimen for women compared to a swab and/or that the availability of urine testing has

[1] Wylie, J.L. and P. Van Caeseele. 2015. Interpreting *Chlamydia trachomatis* and *Neisseria gonorrhoeae* laboratory surveillance data: Manitoba, Canada, 2000-2012. Sex. Transm. Infect. 92:1):55-7.

encouraged testing of a different, higher risk, population of women (discussed further below in section 2.2 and section 7).

When used as a control variable for the provincial analysis, individual RHAs are associated with different likelihoods of being associated with CT detection in women. Using ILE as a reference, NRHA has the highest likelihood of being associated with a CT infection (AOR of 1.82), while each of PMH, SRHA, and WRHA are similar to each other and less likely than ILE to be associated with CT detections in women (AOR of 0.88, 0.70, and 0.90, respectively).

After controlling for each of the above variables, the AOR corresponding to each respective year of the study period changes notably after 2006. Unlike the increase associated with the yearly UOR, the AOR begins to trend downward in 2004, shows another downward inflection from 2007 to 2010 and continues to gradually decrease from 2010 to 2016. The likelihood of identifying a CT infection in females therefore appears to have first declined at the point in time when male screening with urine specimens was introduced and then declines again subsequent to the introduction of the Aptima Combo 2 test. This result suggests that both of these public health initiatives may have contributed to a decrease in the likelihood of identifying an infection in women in the province.

The same analysis described above was repeated for each individual RHA. UORs for each RHA over time are shown in figure 1.1B, while figure 1.1C shows AOR after adjusting for test type, specimen source and age. Data for these figures is found in appendices 4B to 4F. Note that because a small proportion of specimens in PMH were sent to Westman laboratories, only data from 2006 onward was analyzed for this RHA in sections 1.1 to 1.4 to avoid any confounding that may occur by the absence of data for specimens not tested at CPL.

The UOR and AOR for each RHA generally reflects provincial patterns. UOR for all RHAs show the expected increase after implementation of Aptima Combo 2. After adjustment, all RHAs show a downward trend in the likelihood of identifying a CT infection in females after the years 2003 or 2004 (as noted above, the approximate point in time when male screening with urine specimens was implemented in Manitoba). The WRHA showed a continual downward trend in the likelihood of identifying a CT infection until 2013; after that year the AOR of identifying a CT infection began to trend upwards. NRHA and PMH also show a continual downward trend, however, after 2013 the AOR continues to decline and appears to decrease to a greater extent than in previous years. While SRHA and ILE also show a general downward trend, the AOR are not significantly different compared to the reference year of 2000 (the only exception is the year 2016 for SRHA, with a *p* value of 0.047). This pattern would be partially associated with the smaller sample sizes associated with these two RHAs, but does suggest that the change in likelihood of identifying a CT positive in these RHAs has been less marked than that seen in NRHA, PMH or WRHA.

***Figure 1.1A: Unadjusted and adjusted odds ratios showing the likelihood of detecting a positive CT result in females over time in Manitoba**. Odds ratios adjusted for age, specimen source, test type and RHA. Odds ratios graphed on a logarithmic scale; lower and upper limits set at 0.6 and 1.7, respectively. The horizontal bar above the date labels represents an OR of 1.0.*

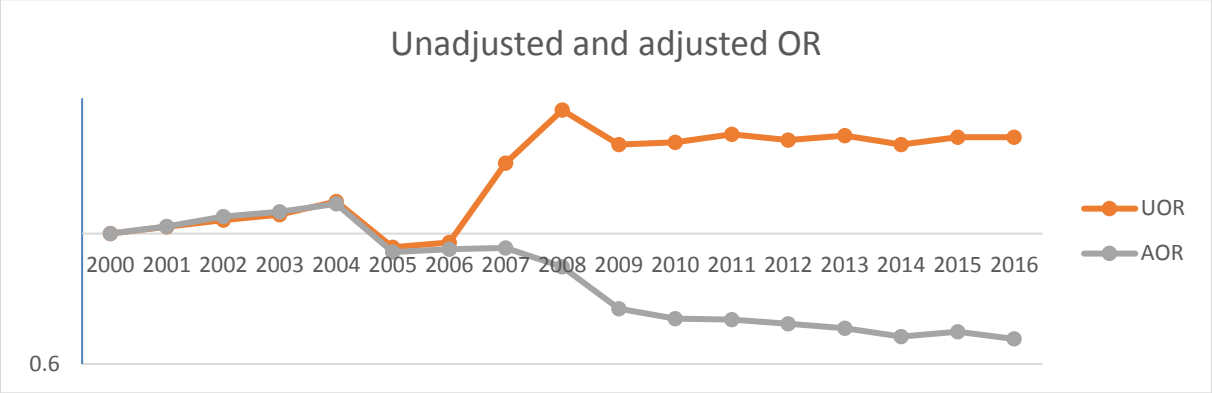


***Figure 1.1A: Unadjusted odds ratios showing the likelihood of detecting a positive CT result in females in each RHA in Manitoba**. Odds ratios graphed on a logarithmic scale; lower and upper limits set at 0.9 and 2.0, respectively. The horizontal bar above the date labels represents an OR of 1.0.*

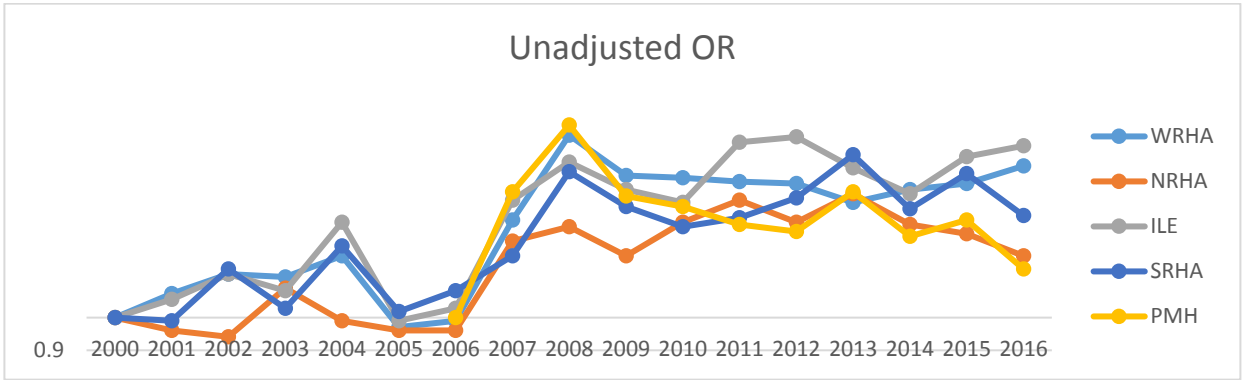
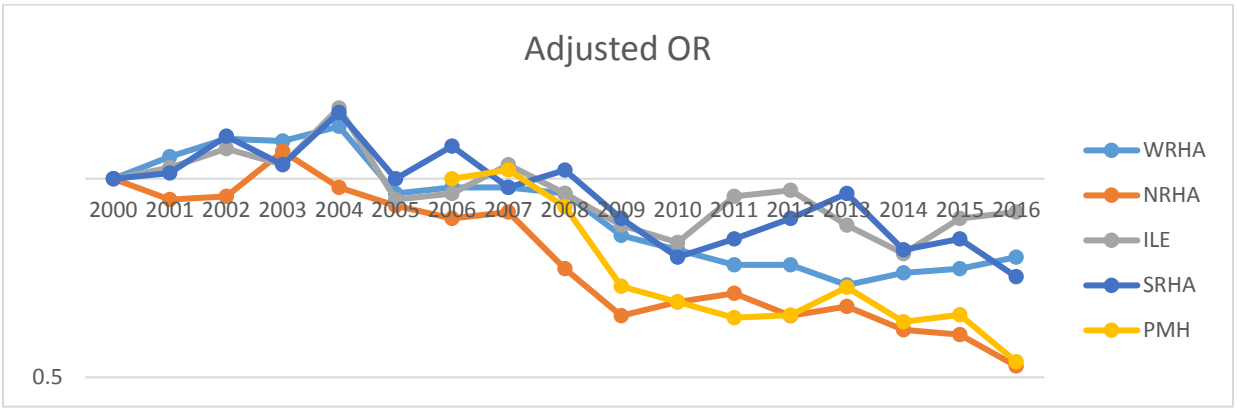


***Figure 1.1B: Adjusted odds ratios showing the likelihood of detecting a positive CT result in females in each RHA in Manitoba**. Odds ratios are adjusted for age, specimen source and test type. Odds ratios graphed on a logarithmic scale; lower and upper limits set at 0.5 and 1.3, respectively. The horizontal bar above the date labels represents an OR of 1.0.*



1.2. Likelihood of identifying a CT infection in males

This analysis replicates that performed above, but uses testing data from males. Figure 1.2A shows the UORs for males for the province as a whole. The clear increase in UOR seen for females between 2007 and 2009 is less evident for males. Unlike females much of the testing carried out for males prior to implementation of Aptima Combo 2 has always been conducted with a NAAT assay (AMP-CT and ProbeTec). Therefore, the implementation of Aptima did not have the same pronounced effect on CT detection in males. The increase that is seen could either be related to a higher sensitivity of the Aptima Combo 2 assay relative to AMP-CT or ProbeTec or the increased case finding for females may have resulted in a coincident increase in male case finding as a result of additional contact tracing efforts.

Figure 1.2A show AORs for the province after controlling for test type, specimen type, patient age and RHA (the corresponding data for AOR, 95% CI and *p* values for all predictor variables are found in Appendix 5A). With respect to control variables, for test type, the AOR for NAAT testing is significant and positive (AOR of 2.31). Although the majority of male testing since 2000 has been done with a NAAT, during the study period some urethral swabs were tested with a NAP. As per females, the AOR indicates the superiority of NAAT relative to NAP testing. For age, the same pattern seen for females occurs for males. Tests associated with males aged 14-19 year olds are the most likely to be associated with a CT detection for the province as a whole. The AOR for urine specimens relative to urethral swabs is also significant, but unlike females, is below 1.0 (AOR of 0.68). This result indicates that a urine specimen has a lesser likelihood of being associated with a positive CT result in men, relative to urethral swabs. This result is not necessarily expected, and may indicate that a urine specimen is an inferior diagnostic specimen for men compared to a swab and/or that the availability of urine testing encourages testing by a different, lower risk, population of men (addressed further in section 2.2 and section 7). Finally, the AOR for individual RHAs follows the same pattern as for females. The highest likelihood of identifying a CT infection in males is associated with NRHA using ILE as a reference. Each of PMH, SRHA, and WRHA are associated with a lower likelihood of identifying a CT infection relative to ILE.

AOR for each respective year of the study is very similar to that seen for females with notable downward deflections in 2004 and 2008, generally corresponding to the introduction of male screening with urine specimens (2004) and introduction of the Aptima Combo 2 test (2007).

The analysis was repeated for each individual RHA. Unadjusted and adjusted ORs by year are shown in figures 1.2B and 1.2C. Corresponding data is found in appendices 5B to 5F. At the RHA level, AOR by year showed two broad patterns. While all RHAs generally show a downward trend in the likelihood of identifying a CT infection in males, this trend is less evident for PMH and SRHA compared to WRHA, NRHA and ILE. With only occasional exceptions, the likelihood of identifying a CT infection in males in SRHA and PMH is not significantly different than their respective reference years (2000 for SRHA and, as noted above, 2006 for PMH). This is not solely related to sample size as the sample size of 20,991 (2,717 CT positive) for ILE is smaller than the sample size of 22,619 (2,891 positive) for PMH. This pattern also does not exactly match that seen for females above, where SRHA and ILE were the RHAs with the least change in the likelihood of detecting a CT infection.

Figure 1.2A: Unadjusted and adjusted odds ratios showing the likelihood of detecting a positive CT result in males in Manitoba over time. *Odds ratios are adjusted for age, specimen source, test type and RHA. Odds ratios are graphed on a logarithmic scale; lower and upper limits set at 0.5 and 1.25, respectively.*

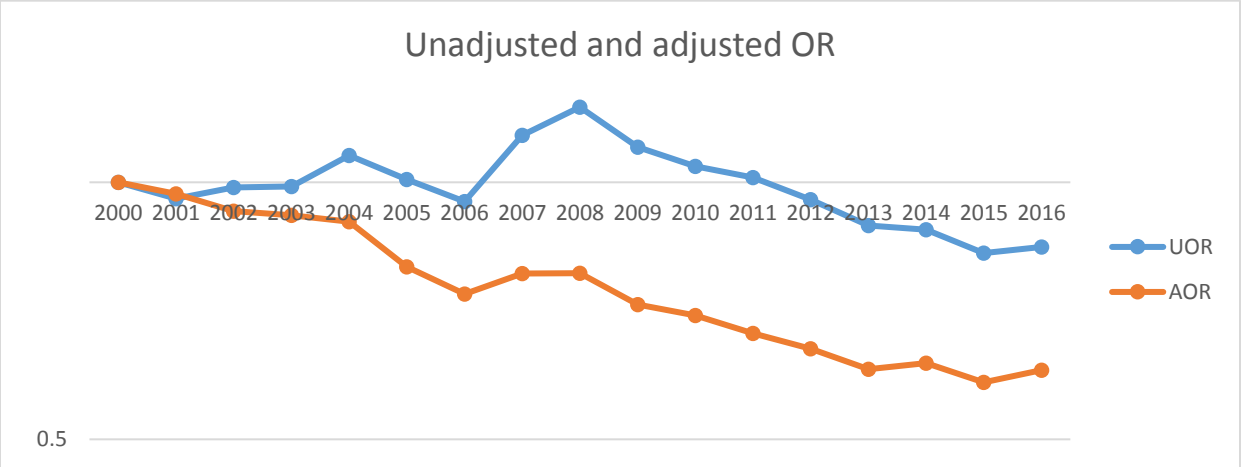


Figure 1.2B: Unadjusted odds ratios showing the likelihood of detecting a positive CT result in males in each of the five RHAs in Manitoba*. Odds ratios graphed on a logarithmic scale; lower and upper limits set at 0.7 and 1.65, respectively.*

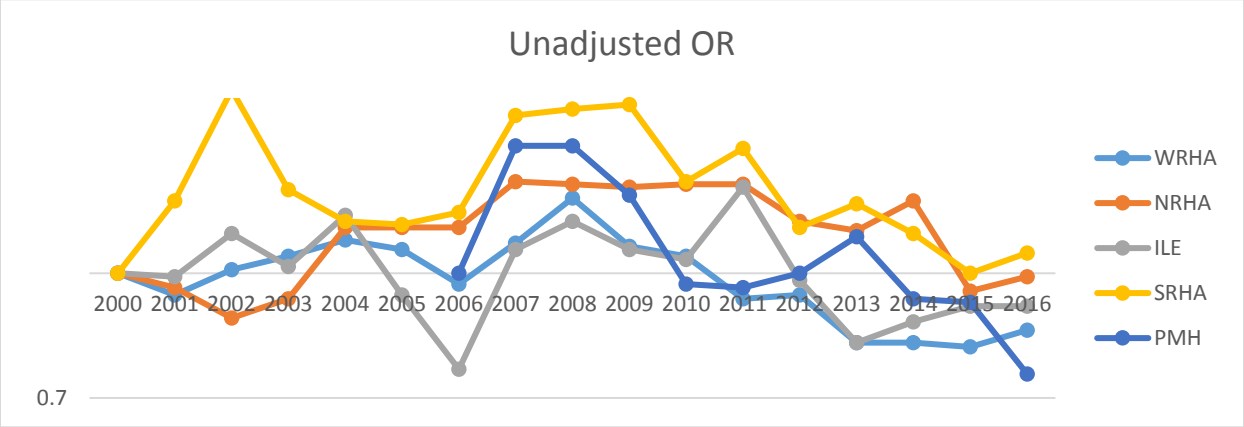
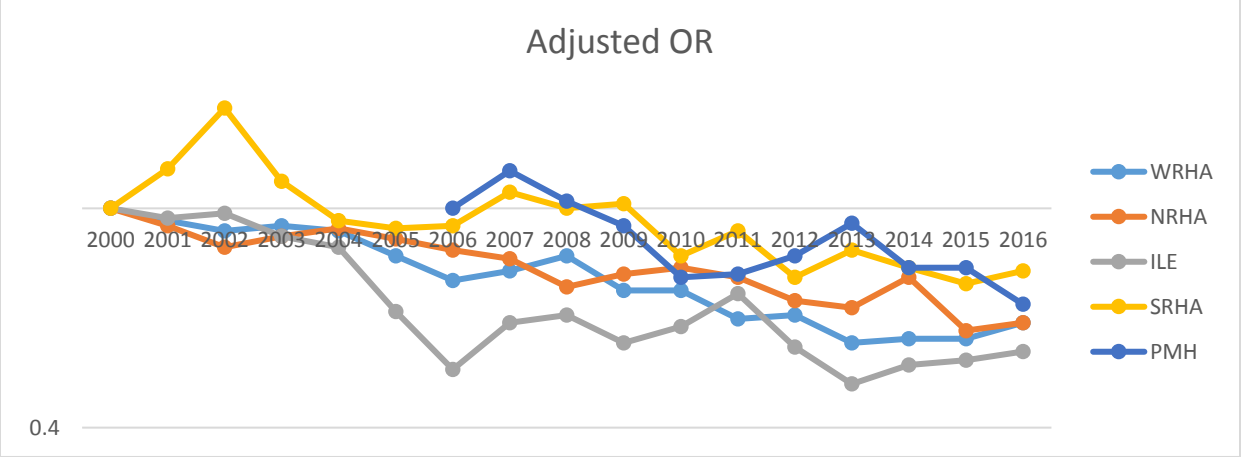


Figure 1.2C: Adjusted odds ratios showing the likelihood of detecting a positive CT result in males in each of the five RHAs in Manitoba*. Odds ratios are adjusted for age, specimen source and test type. Odds ratios are graphed on a logarithmic scale; lower and upper limits set at 0.4 and 1.6, respectively.*



1.3. Likelihood of identifying an NG infection in females

Analogous to the CT analysis described in sections 1.1 and 1.2 above, trends related to the likelihood of identifying an NG infection were analyzed. Figure 1.3A shows UOR and AOR associated with identifying an NG infection for the province as a whole. Corresponding data is found in Appendix 6A. As above, AOR reflect incorporation of test type, specimen source, age and RHA as control variables.

UOR by year show a cyclical pattern with peaks in 2006, 2012 and 2016. The latter increase corresponds to the recent increase in NG detections that has been observed in some RHAs. UOR and AOR are similar up to 2006 at which point, AOR diverges from UOR with a marked downward shift in the AOR temporal trend line. This shift is related to results obtained for two of the control variables. Both NAAT test type and urine as a specimen source are associated with a significant AOR above 1.0 (1.75 for NAAT as a test type and 1.47 for urine as a specimen type). The results for NAAT vs NAP testing were not expected as the Aptima Combo 2 test had been promoted as a more sensitive test for CT detection, but was not promoted in this way for NG by the manufacturer. Similarly, the greater likelihood of identifying an NG infection with a urine specimen was not expected. This result could be associated with similar hypotheses proposed for CT detection in women – either a urine specimen is a superior specimen for NG detection in women or the availability of urine testing has promoted testing of and access to a higher risk population of women. Adjustment for these two control variables therefore results in a downward shift in the overall likelihood of identifying an NG infection over time for females.

After adjustment, the sharp increase in detection in 2016 is still evident, however, unlike the UOR, the AOR for NG detection in 2016 is less than the AOR seen in 2006. This result indicates that while the 2016 increase is still evident after adjustment, the high number of infections currently being identified may partially be related to technological changes that have improved our ability to detect infections. However, regardless of whether the likelihood of identifying NG is more or less than in 2006, the rapidity of the change (i.e. the extent of the change in AOR from 2015 to 2016) is unusual and unlike any other change seen in the preceding years.

When analyzed on an RHA-by-RHA basis, the regional patterns largely reflect the overall provincial pattern (figures 1.3B and 1.3C**;** data in appendices 6B to 6F). Similar to CT, the highest likelihood of identifying an NG infection occurs either in the 14-19 year age group (WRHA, ILE, PMH, NRHA) or is not significantly different from the AOR for the 20-24 year age group (SRHA). There is a difference seen between RHAs related to the 2016 increase in AOR. While the increase is evident in the WRHA, ILE, and SRHA, in 2016, the end point for this study period, PMH and NRHA had not yet shown an increased AOR for NG detection in women.

Figure 1.3A: Unadjusted and adjusted odds ratios showing the likelihood of detecting a positive GC result in females in Manitoba*. Odds ratios are adjusted for age, specimen source, test type and RHA. Odds ratios are graphed on a logarithmic scale; lower and upper limits set at 0.4 and 1.9, respectively.*

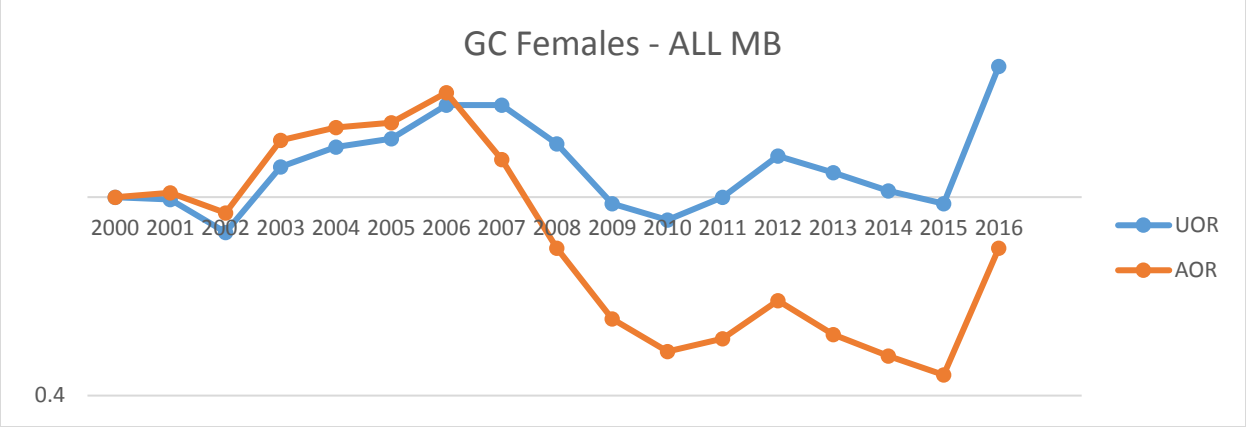


Figure 1.3B: Unadjusted odds ratios showing the likelihood of detecting a positive GC result in females in each RHA in Manitoba*. Odds ratios graphed on a logarithmic scale; lower and upper limits set at 0.4 and 6.0, respectively.*

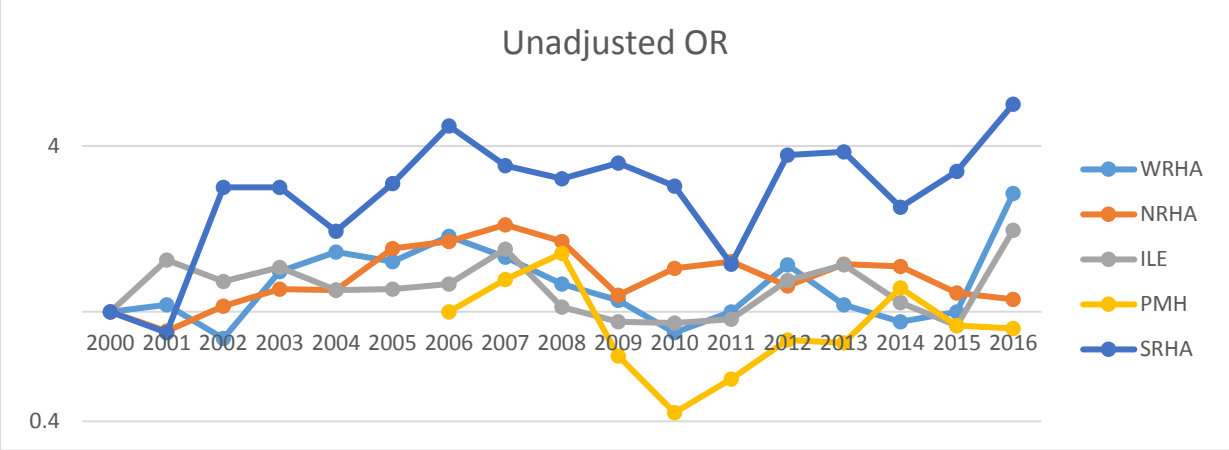
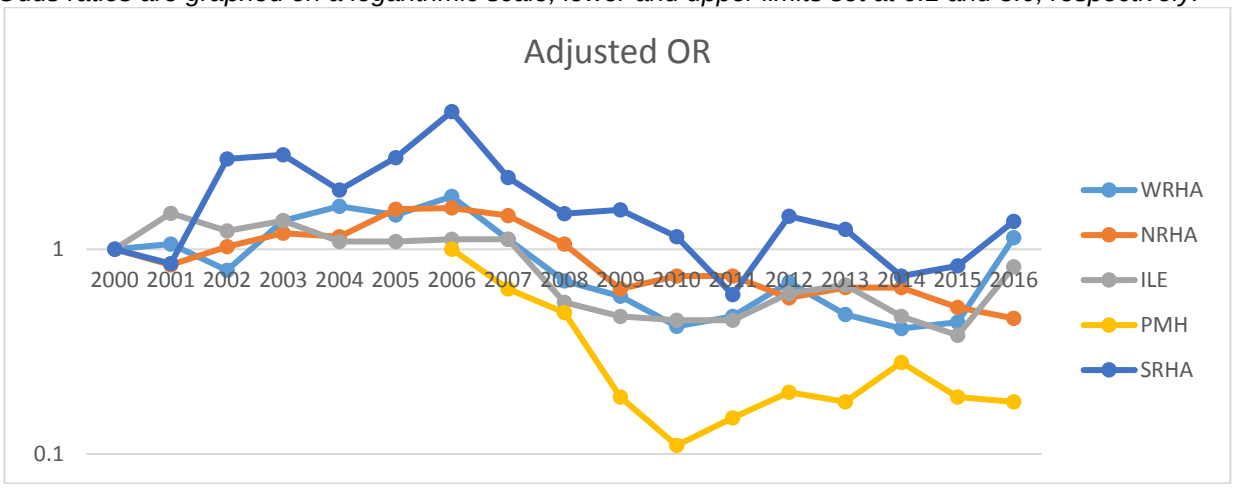


Figure 1.3C: Adjusted odds ratios showing the likelihood of detecting a positive GC result in females in each RHA in Manitoba. *Odds ratios are adjusted for age, specimen source and test type. Odds ratios are graphed on a logarithmic scale; lower and upper limits set at 0.1 and 5.0, respectively.*



1.4. Likelihood of identifying an NG infection in males

The analysis for females with respect to the likelihood of identifying an NG positive result was repeated for males. For the provincial data as a whole, the overall shape of the line for both UOR and AOR was very similar to that seen for females, with peaks in 2006, 2012/13 and 2016 (figure 1.4A; data in appendix 7A). The notable exception is that the line describing trends for AOR adjusted upwards such that it was above the line for UOR (the opposite occurred for females). The main driver of this difference is the clear difference in AOR for urine specimens in females vs. males. For females, as noted above, the AOR for a urine specimen is 1.47 while it is 0.52 for males. This may indicate that male urines relative to swabs have a lower sensitivity when tested by Aptima. Conversely, the availability of urine testing may have encouraged increased screening of males, many of whom may be at low risk of infection (and hence urines from these individuals would be less likely to be associated with a positive result). Urine-based screening of males would contrast with the historical focus of male testing being part of contact tracing efforts where the likelihood of encountering infected males would be high. These alternate hypotheses are discussed further in subsequent sections.

When analyzed on an RHA-by-RHA basis, the regional patterns largely reflect the overall provincial pattern with each RHA experiencing approximately the same peaks in 2006 and 2012/13 (figure 1.4B and 1.4C; data in appendices 7B to 7F). The highest likelihood of identifying an NG infection either occurs in the 14-19 year age group (WRHA) or is not significantly different from the AOR for the 20-24 year age group (ILE, PMH, NRHA, SRHA). Unlike the trend for females, all five RHAs have experienced an increase in the likelihood of detecting an NG infection in males in 2016.

***Figure 1.4A: Unadjusted and adjusted odds ratios showing the likelihood of detecting a positive GC result in males in Manitoba**. Odds ratios are adjusted for age, specimen source, test type and RHA. Odds ratios are graphed on a logarithmic scale; lower and upper limits set at 0.35 and 1.25, respectively.*

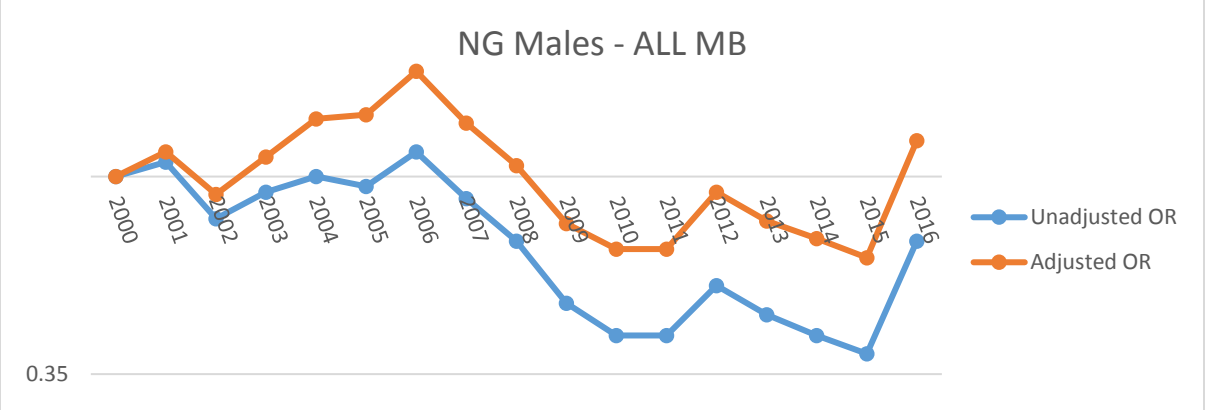


***Figure 1.4B: Unadjusted odds ratios showing the likelihood of detecting a positive GC result in males in each RHA in Manitoba**. Odds ratios graphed on a logarithmic scale; lower and upper limits set at 0.2 and 3.0, respectively.*

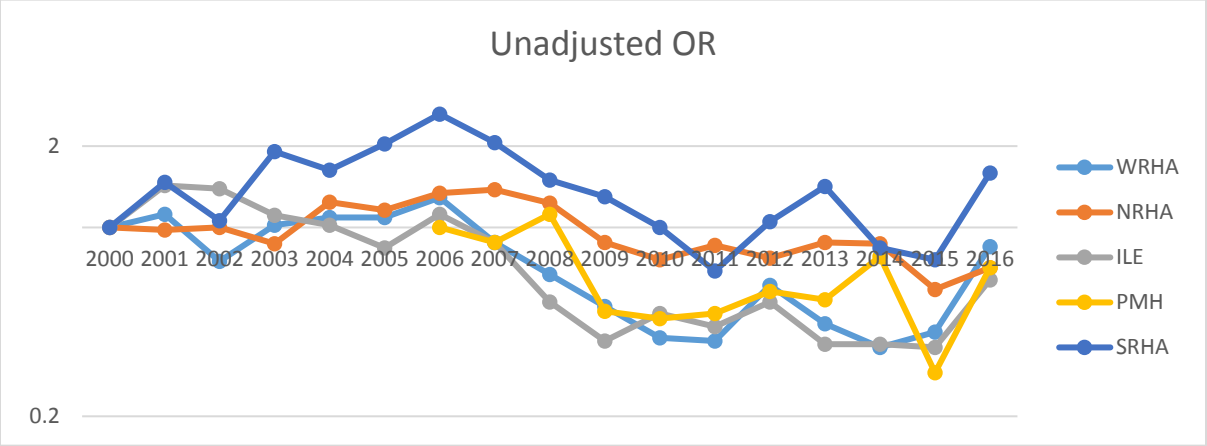
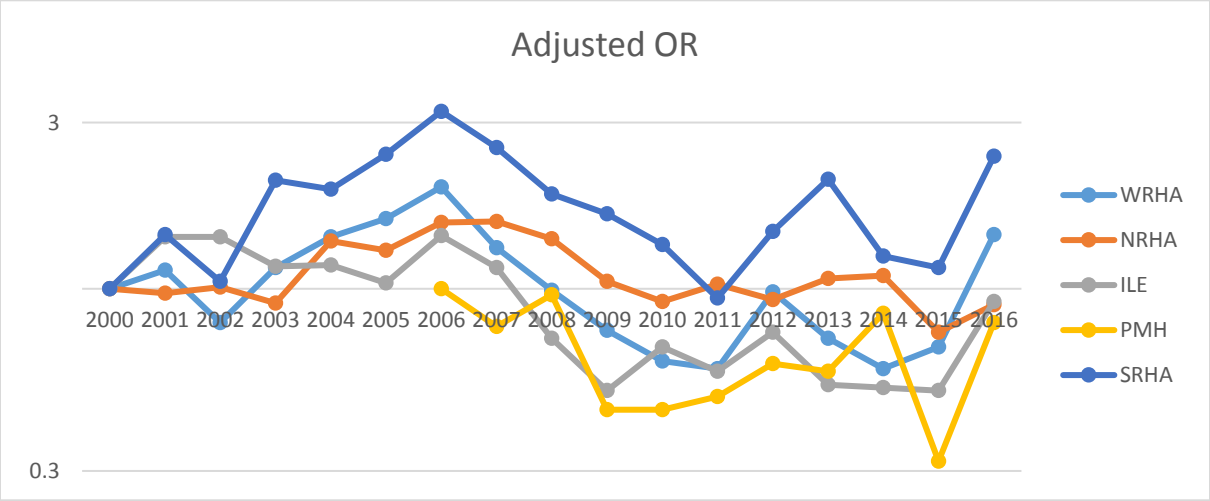


***Figure 1.4C: Adjusted odds ratios showing the likelihood of detecting a positive GC result in males in each RHA in Manitoba**. Odds ratios are adjusted for age, specimen source and test type. Odds ratios are graphed on a logarithmic scale; lower and upper limits set at 0.3 and 3.5, respectively.*



1.5 Likelihood of identifying a CT or NG infection over time – overall data interpretation

With respect to CT, the trend for the adjusted odds of identifying a CT infection over time is in direct contrast to the trend associated with simple case counts. While the former shows a continual decline over time, the latter shows a continual increase. This contrast is important as it potentially alters the perception of CT trends in at-risk populations at a national and international level. Not uncommonly, continual increases in case counts are postulated as a sequential set of hypotheses where increased case counts are hypothesized to be linked to increased population prevalence, which in turn is hypothesized to be linked to a shift towards higher-risk sexual behaviours. If in fact, the increased case counts are largely technological in nature, hypotheses of this type may result in a misdirection of research efforts.

There are two broad underlying determinants for a decreasing likelihood of identifying CT-positive specimens over time: 1) a decline in CT prevalence and incidence at the population level, and/or 2) testing is shifting towards population subgroups that are at lower risk of infection.

These two possibilities are not mutually exclusive and both may play a role. A dual role underlying trends associated with males may be likely, as analyses described further below (section 7) do suggest that the advent of male screening with urine specimens has resulted in lower risk males presenting for testing. This type of effect is still advantageous as the majority of CT infections identified in males are found in this group. For females, a shift towards testing of low-risk population subgroups is likely not a factor. Analyses presented in section 7 suggest that the opposite may be occurring, as the last 10 years of testing appears to coincide with a higher-risk population subgroup of women presenting for testing. As such, the decline in the likelihood of identifying a CT positive in women overall is most appropriately hypothesized as a potential decline in population prevalence.

While a declining CT population prevalence is not intuitively obvious, studies from the United States, Switzerland, and Scotland have all yielded similar results[2]. Two population-based surveys in the United States have also suggested that CT prevalence is stable or dropping[3]. As such, this possibility should be considered when forming any hypotheses related to identifying and understanding CT trends over time.

Notably, trends for NG are in marked contrast to CT. While test type and shifts in specimen type have influenced the likelihood of identifying NG infections over time, the dominant trend is still one of periodic increases and decreases over time. In this sense, while technology and sexual behaviours would play a role, there are clearly additional factors associated with NG transmission. These factors could be related to characteristics of the pathogen itself (e.g. different strains circulating through a population with different transmission potential) or biological associations between host and pathogen populations (e.g. temporal shifts in host immunity at the population level). These and other related possibilities as drivers of NG transmission should all be considered as hypotheses with further research required to address and differentiate between them.

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[2] Satterwhite, C.L., Grier, L., Patzer, R., *et al*. 2011. Chlamydia positivity trends among women attending family planning clinics: United States, 2004-2008. Sex. Transm. Dis. 38:989-994.
Burckhardt, F., Warner, P., Young, H. 2006. What is the impact of change in diagnostic test method on surveillance data trends in *Chlamydia trachomatis* infection? Sex. Transm. Infect. 82:24-30.
Schmutz, C., Burki, D., Frei, R., *et al*. 2012. Testing for *Chlamydia trachomatis*: time trends in positivity rates in the canton of Basel-Stadt, Switzerland. Epidemiol. Infect. 141:1953-1964.

[3] Satterwhite, C. L., Tian, L. H., Braxton, J., *et al*. 2010. Chlamydia prevalence among women and men entering the National Job Training Program: United States, 2003-2007. Sex. Trans. Dis. 37:63-67.
Datta, S. D., Torrone, E., Kruson-Moran, D., *et al*. 2012. *Chlamydia trachomatis* trends in the United States among persons 14 to 39 years of age, 1999-2008. Sex. Trans. Dis. 39:92-96.

2. DIAGNOSTIC TESTING PATTERNS

Section 2 focuses on diagnostic testing without considering test outcome (section 3 incorporates diagnostic outcome). While case counts are readily available to surveillance units, data on negative testing is generally not analyzed nor widely available. Therefore, this section provides background on overall testing patterns. For CT in particular, as discussed in section 3, testing volumes and testing patterns can greatly influence case finding. The analyses in this section are therefore relevant as background information for understanding the challenges of analyzing case numbers in the absence of denominator data.

2.1 Proportion of population tested

This analysis focused on determining the proportion of the Manitoba population tested for CT and/or NG at different points in time. Analysis was restricted to the three most commonly tested age groups with respect to CTNG (14-19, 20-24, and 25-29). Four time points were chosen for analysis – 2001, 2006, 2011, and 2016. Given the use of age categories, this choice ensured that any one individual would only be counted once per time period. Note however, that the same individual can age through each successive age cohort (e.g. an individual aged 15 in 2001 who continues to undergo testing could be captured in each successive age cohort for the years 2006, 2011, and 2016). Data manipulation consisted of extracting all testing records for each of the four study years and identifying the number of unique individuals tested in a given year. Population data stratified by RHA, gender and age group was obtained online from Statscan (www.statcan.gc.ca/eng). These population estimates may differ somewhat from population estimates available through Manitoba sources.

Figure 2.1A shows the proportion of females tested for CT and/or NG, with corresponding data for males in Figure 2.1B (data for these figures is in Appendix 8). For females in all RHAs, the least tested age group, relative to population, are 14-19 year olds. The proportion of the population tested for 20-24 and 25-29 year olds are similar. Trends tend to be similar across RHAs, with NRHA as the notable exception, where the proportion of the population tested always exceeds that of other RHAs. In 2016, there was a consistent trend across all RHAs where the proportion of the female population aged 14-19 or 20-24 decreased in comparison to 2011.

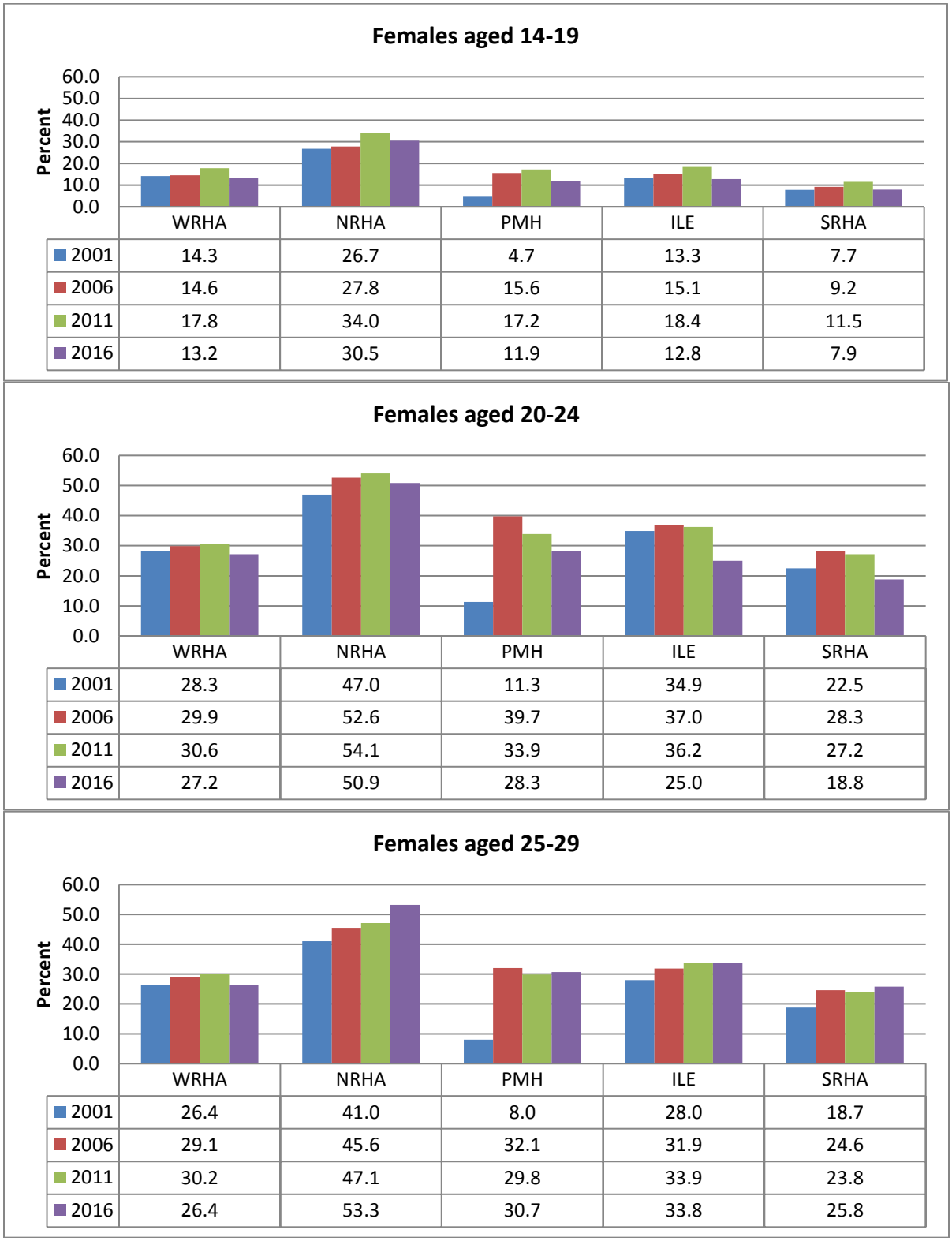
For males, NRHA tests a higher proportion of their male population relative to other RHAs. For all RHAs, the proportion of the male population tested is always less than females. For males, the year to year increase in the population proportion being tested has increased to a greater extent than for females.

The proportion of the Manitoba population tested for CT and NG is not unlike values seen in other countries (Australia[4]; England[5]). Notably, mathematical modelling studies cited by Stephens *et al*.[2] suggest that the proportion of the population being tested overall in MB, as well as the other countries noted, is less than the 40% overall population testing coverage (males and females inclusive) suggested by mathematical modelling as key to achieving a rapid reduction in CT prevalence.

[4] Stephens, N., Coleman, D., Shaw, K. et al. 2017. Testing for chlamydia infection: are we meeting clinical guidelines? Evidence from a state-level laboratory data linkage analysis for 15- to 29-year-olds. Sex. Health. http://dx.doi.org/10.1071/SH16146.

[5] Chandra, N. L., Soldan, K., Dangerfield, C. et al. 2017. Filling in the gaps: estimating numbers of chlamydia tests and diagnoses by age group and sex before and during the implementation of the English National Screening Programme, 2000 to 2012. Euro. Surveill. 22:30453.

Figure 2.1A: Proportion of the female Manitoba population tested for CT and GC at four time points (2001, 2006, 2011, 2016) stratified by RHA and age group. *Note that low values for PMH in 2001 for all age groups are related to some specimens being tested at Westman Laboratory.*

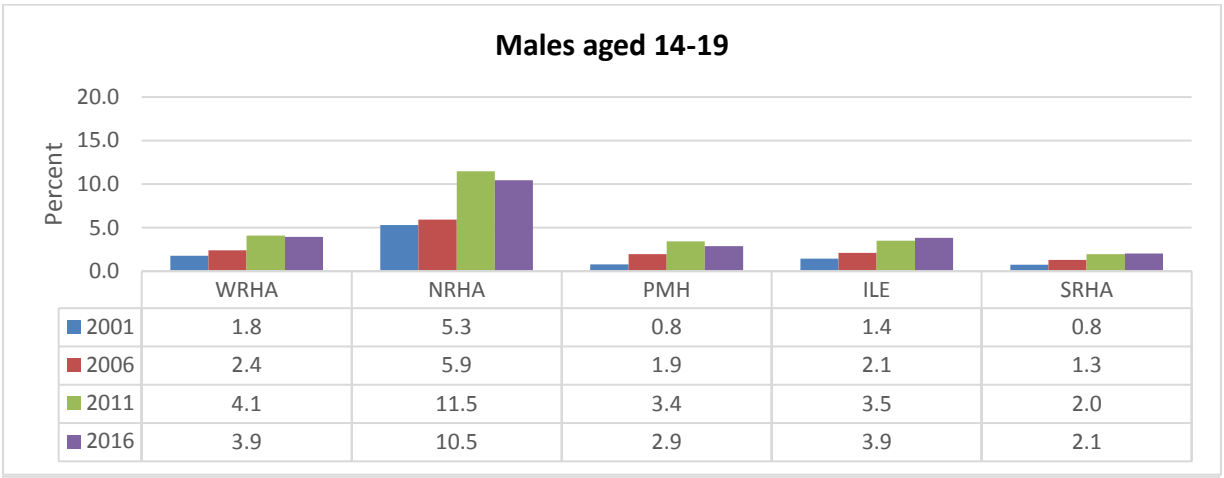


	WRHA	NRHA	PMH	ILE	SRHA
2001	14.3	26.7	4.7	13.3	7.7
2006	14.6	27.8	15.6	15.1	9.2
2011	17.8	34.0	17.2	18.4	11.5
2016	13.2	30.5	11.9	12.8	7.9

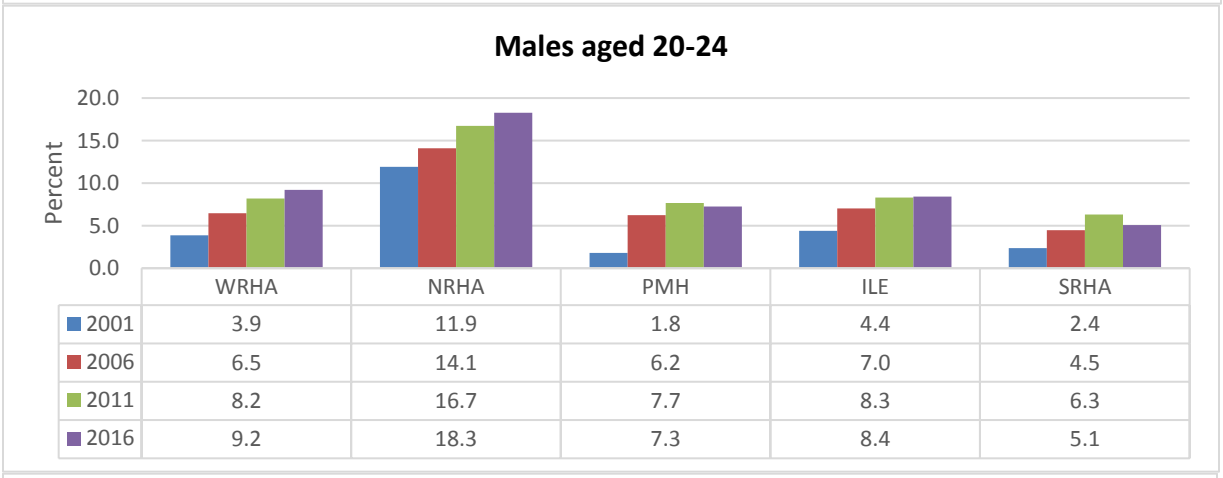
	WRHA	NRHA	PMH	ILE	SRHA
2001	28.3	47.0	11.3	34.9	22.5
2006	29.9	52.6	39.7	37.0	28.3
2011	30.6	54.1	33.9	36.2	27.2
2016	27.2	50.9	28.3	25.0	18.8

	WRHA	NRHA	PMH	ILE	SRHA
2001	26.4	41.0	8.0	28.0	18.7
2006	29.1	45.6	32.1	31.9	24.6
2011	30.2	47.1	29.8	33.9	23.8
2016	26.4	53.3	30.7	33.8	25.8

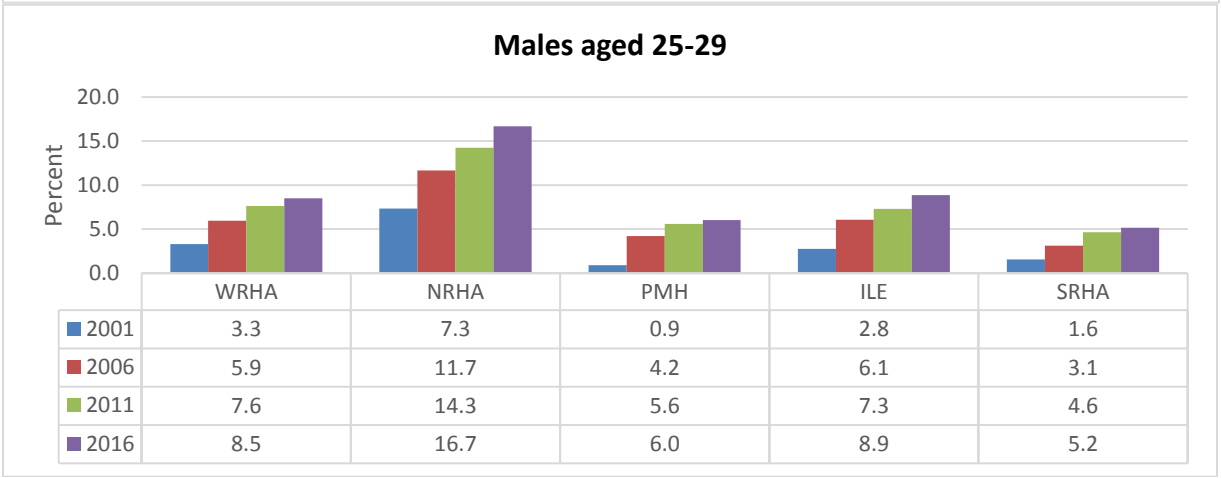
Figure 2.1B: Proportion of the male Manitoba population tested for CT and GC at four time points (2001, 2006, 2011, 2016) stratified by RHA and age group. *Note that low values for PMH in 2001 for all age groups are related to some specimens being tested at Westman Laboratory.*



	WRHA	NRHA	PMH	ILE	SRHA
2001	1.8	5.3	0.8	1.4	0.8
2006	2.4	5.9	1.9	2.1	1.3
2011	4.1	11.5	3.4	3.5	2.0
2016	3.9	10.5	2.9	3.9	2.1



	WRHA	NRHA	PMH	ILE	SRHA
2001	3.9	11.9	1.8	4.4	2.4
2006	6.5	14.1	6.2	7.0	4.5
2011	8.2	16.7	7.7	8.3	6.3
2016	9.2	18.3	7.3	8.4	5.1



	WRHA	NRHA	PMH	ILE	SRHA
2001	3.3	7.3	0.9	2.8	1.6
2006	5.9	11.7	4.2	6.1	3.1
2011	7.6	14.3	5.6	7.3	4.6
2016	8.5	16.7	6.0	8.9	5.2

2.2 Specimen type frequency distribution

Urine specimens, as well as urethral and cervical swabs, are considered an acceptable specimen type for NAAT testing. This contrasts with PACE 2 NAP tests where only swab specimens can be tested. As such, the implementation of NAAT has resulted in shifts in the types of specimens received at CPL for both males and females. This section of the report quantifies these temporal shifts.

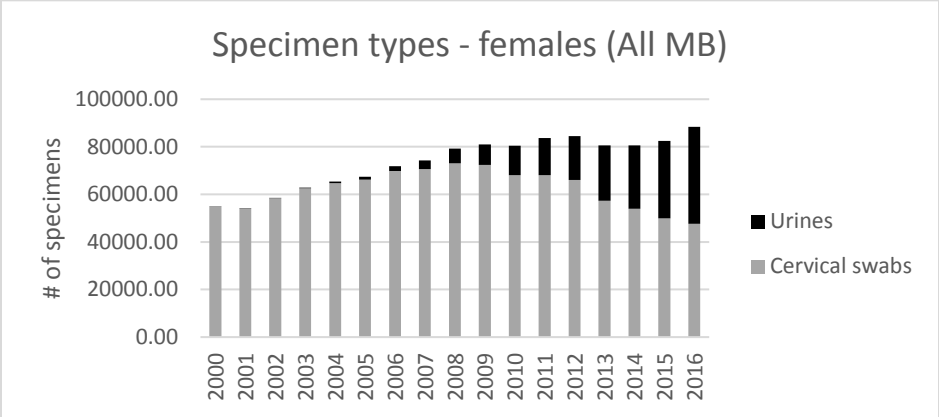
Figures 2.2A and 2.2B show the proportional changes in specimen types received over time for CTNG testing. For females, there has been a continual shift towards urine specimens. For provincial data overall, urines made up 0.25% of the female specimens received at CPL in 2000; by 2016 this value had increased to 46.1%. This trend has generally occurred across all RHAs, although some variation exists. For the latest year of the dataset (2016), regional data for female urine specimens is as follows:

Winnipeg RHA (WRHA) – 44.77%
NRHA – 54.79%
Interlake-Eastern RHA (ILE) – 48.54%
PMH – 37.45%
Southern Health RHA (SRHA) – 48.31%

The trend for males was more pronounced reflecting the initiation of male screening via urine specimens launched in Manitoba in 2004. In 2016, urine specimens now make up nearly 100% of male specimens:

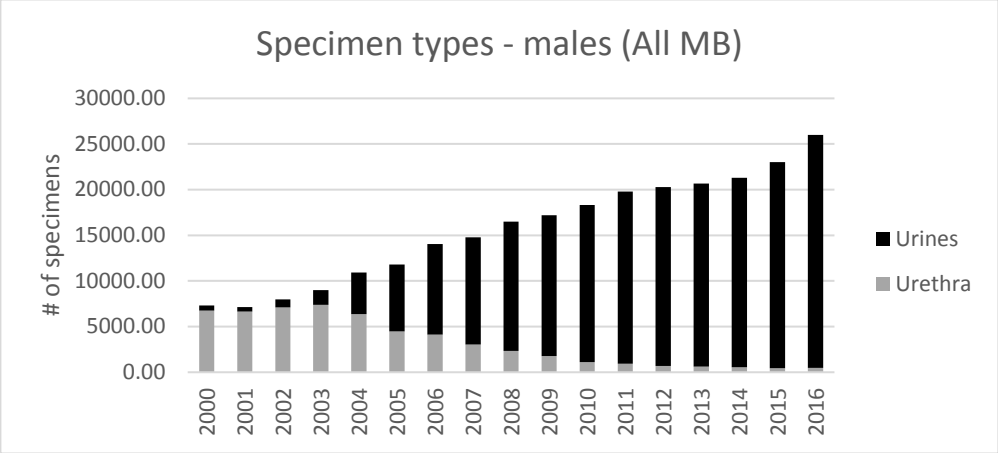
WRHA – 98.81%
NRHA – 95.56%
ILE – 97.64%
PMH – 98.00%
SRHA – 97.09%

Figure 2.2A. Number of cervical swabs and urines received from females by year.



Year	Cervix	Urine	Total
2000	54747 (99.75)	135 (0.25)	54,882
2001	54094 (99.66)	186 (0.34)	54,280
2002	58369 (99.62)	222 (0.38)	58,591
2003	62555 (99.48)	326 (0.52)	62,881
2004	64752 (99.00)	656 (1.00)	65,408
2005	66184 (98.14)	1255 (1.86)	67,439
2006	69822 (97.11)	2078 (2.89)	71,900
2007	70702 (95.26)	3519 (4.74)	74,221
2008	73012 (92.17)	6206 (7.83)	79,218
2009	72404 (89.45)	8541 (10.55)	80,945
2010	68115 (84.73)	12277 (15.27)	80,392
2011	68150 (81.47)	15496 (18.53)	83,646
2012	66089 (78.18)	18442 (21.82)	84,531
2013	57349 (71.13)	23274 (28.87)	80,623
2014	54013 (67.06)	26536 (32.94)	80,549
2015	49922 (60.53)	32558 (39.47)	82,480
2016	47612 (53.90)	40725 (46.10)	88,337

Figure 2.2B. Number of urethral swabs and urines received from males by year.



Year	Urethra	Urine	Total
2000	6750 (92.25)	567 (7.75)	7317
2001	6644 (93.08)	494 (6.92)	7138
2002	7102 (89.14)	865 (10.86)	7967
2003	7392 (82.29)	1591 (17.71)	8983
2004	6366 (58.35)	4544 (41.65)	10910
2005	4471 (37.92)	7320 (62.08)	11791
2006	4136 (29.45)	9910 (70.55)	14046
2007	3036 (20.52)	11757 (79.48)	14793
2008	2327 (14.11)	14161 (85.59)	16488
2009	1776 (10.33)	15417 (89.67)	17193
2010	1117 (6.09)	17216 (93.91)	18333
2011	921 (4.65)	18883 (95.35)	19804
2012	683 (3.37)	19600 (96.63)	20283
2013	623 (3.01)	20046 (96.99)	20669
2014	541 (2.54)	20774 (97.46)	21315
2015	460 (2.00)	22570 (98.00)	23030
2016	494 (1.90)	25491 (98.10)	25985

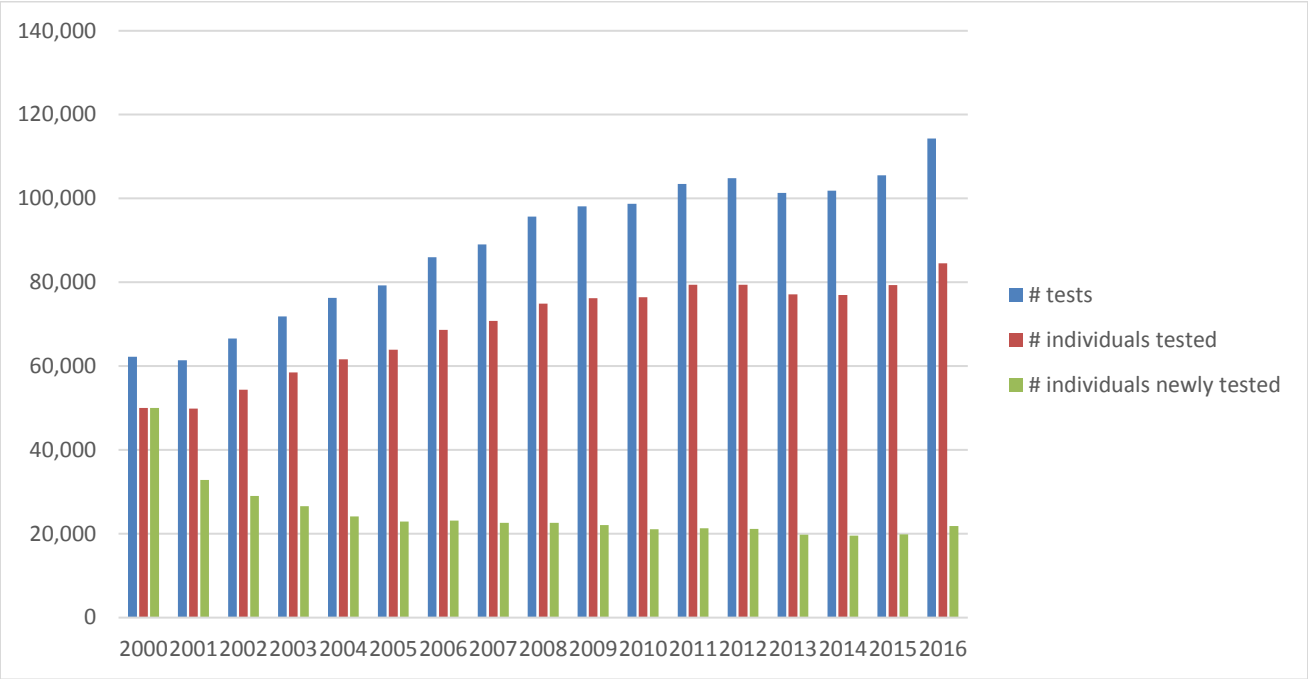
2.3. Specimen vs. patient testing

Given that individual patients can be tested multiple times within and across years, data on specimen numbers does not reveal trends related to the number of individuals experiencing their first-ever CTNG test by year or the relative contribution of new *vs*. repeat testing in a given year. This section differentiates these characteristics. Figure 2.3A is a provincial overview and is not stratified by gender or RHA. This figure is dual-purpose. First, from an analytic perspective, it shows the importance of allowing sufficient time to establish a testing history for any analyses focused on differentiating new from repeat tests. Second, it addresses the issues raised above in terms of beginning the differentiation of index vs. repeat testing. Three sets of data are shown in Figure 2.3A consisting of the number of: a) diagnostic specimens received and tested at CPL for each year of the study period, and b) unique individuals tested in each year of the study period, and c) individuals each year that are being tested for the first time.

In 2000, the values for b) and c) are equal (49,996 individuals) as the lack of pre-2000 data means that no individual can have a testing history for the first year of the study period and all individuals in this year appear as "newly tested" individuals. In subsequent years, the values diverge as some individuals first identified in 2000 begin to have a testing history associated with them allowing their differentiation from new individuals entering the testing population in 2001, 2002, etc. The number of newly tested individuals begins to stabilize and plateau approximately five to six years into the study period. While 2005 or 2006 could have been used as a start point for analysis, the mid-point of 2007 was the point in time where NAP testing was transitioned to NAAT. Therefore, to avoid any confounding associated with changes in test type, 2008 was used as a start point to differentiate new from repeat testing in analyses described below.

The number of newly-tested individuals and the number of unique individuals tested each year are not mutually exclusive. Some newly-tested individuals have repeat testing conducted in the same year and would therefore be counted in both groups. However, the number of newly tested individuals can be directly compared to the total testing volume. Any newly-tested individual represents one new index test. Therefore, the difference between these two variables represents index *vs*. repeat secondary testing for any given year (again with the caveat that this is only true for later years in the study period when it is possible to establish a testing history). These values are shown as part of figure 2.3A, again with no gender or RHA breakdown. The overall data demonstrate that the majority of CTNG testing carried out each year in Manitoba is repeat testing. The proportional amount of repeat testing has increased over the time 2008 to 2016 (76.40% in 2008 to 80.86% in 2016).

Figure 2.3A: Annual number of diagnostic tests, individuals tested and individuals newly tested.



YEAR	# tests	# unique people tested	# newly-tested individuals	per cent repeat secondary tests
2000	62,199	49,996	49,996	
2001	61,418	49,850	32,840	
2002	66,558	54,397	28,996	
2003	71,864	58,501	26,545	
2004	76,318	61,612	24,101	
2005	79,230	63,882	22,899	
2006	85,946	68,671	23,153	
2007	89,014	70,819	22,606	
2008	95,706	74,891	22,587	76.40
2009	98,138	76,198	22,089	77.49
2010	98,725	76,445	21,062	78.67
2011	103,450	80,383	21,338	79.37
2012	104,814	79,446	21,165	79.81
2013	101,292	77,159	19,767	80.49
2014	101,864	76,945	19,587	80.77
2015	105,510	79,297	19,852	81.18
2016	114,322	84,546	21,877	80.86
TOTAL	**1,516,368**	**1,182,101**	**420,460**	

2.3.1. Number of newly tested individuals by year

This analysis extends that shown in figure 2.3A by focusing on the number of individuals new to testing for each year of the study period but stratified by gender and age group. For this analysis, the date of each individual's first CTNG test was identified. This analysis differed from the population analysis described in section 2.1, in that any individual can be counted only once; in the population analysis above an individual can age through successive cohorts and appear in the data multiple times. The present analysis therefore better represents temporal trends over time with respect to the number of individuals per year newly accessing testing.

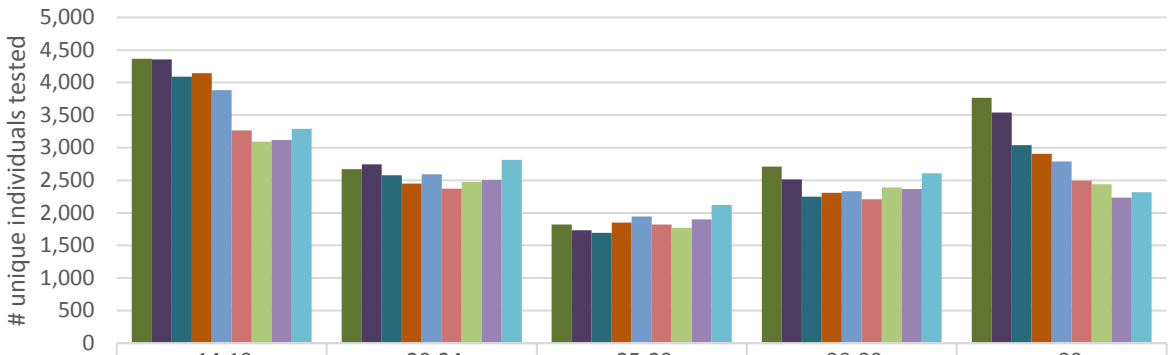
Figures 2.3.1A and 2.3.1B shows overall provincial data for the number of females and males accessing testing for the first time for the years 2008 to 2016, stratified by age group. As described above, data prior to 2008 is not shown as the disproportionate number of individuals newly accessing testing in the early years of the study period is an artifact. Many of these individuals would be repeat testers with their first index test occurring prior to the first year of the study period. Therefore, data is shown from 2008 to 2016 only. At the provincial level, for females, there has been a relatively constant number of individuals between the ages of 20 and 39 accessing testing for the first time each year, with the latest years showing a slight upward trend in numbers. For women aged 14-19 there was a noticeable drop between the years 2012 and 2013 with numbers stabilizing since then. Despite this decrease, in any given year, the number of women aged 14-19 newly accessing testing always exceeds any other age group. For males, there was a steady increase in individuals newly accessing testing over the course of the study period in all age groups. On a year-by-year basis, males aged 20-24 are associated with a slightly greater number of tests relative to any other age group.

Overall, a notable trend when comparing female to male testing numbers is the steady decrease in the female to male testing ratio (i.e. this ratio decreases and approaches 1.0 as the number of males newly accessing testing begins to approach and equal the number of females). In 2008, at the provincial level, for the five respective age groups, the female to male testing ratios are 3.66, 1.50, 1.58, 1.86, and 2.24. The same respective numbers in 2016 are 2.28, 1.39, 1.57, 1.54 and 1.04. This trend is not as apparent when overall specimen testing numbers are examined (i.e. when first and repeat tests are not separated) as females are more likely to engage in repeat testing.

Figure 2.3.1C shows the female to male ratio stratified by RHA for two time points (2006 and 2016) to illustrate changing regional trends over time. In 2006, the female to male testing ratio was skewed towards females. In 2016, in all RHAs, female testing is still more common, however, the ratio has decreased markedly for all RHAs. In 2016, the 14-19 year age group is the only age group across all RHAs where females continue to exceed the number of males newly accessing testing; the ratio varies from a high of 3.16 in PMH to a low of 1.74 in NRHA. For other age groups, NRHA now has more males than females newly accessing testing, although ILE is similar with only the 20 to 24 year slightly exceeding a ratio of 1.0 (1.17).

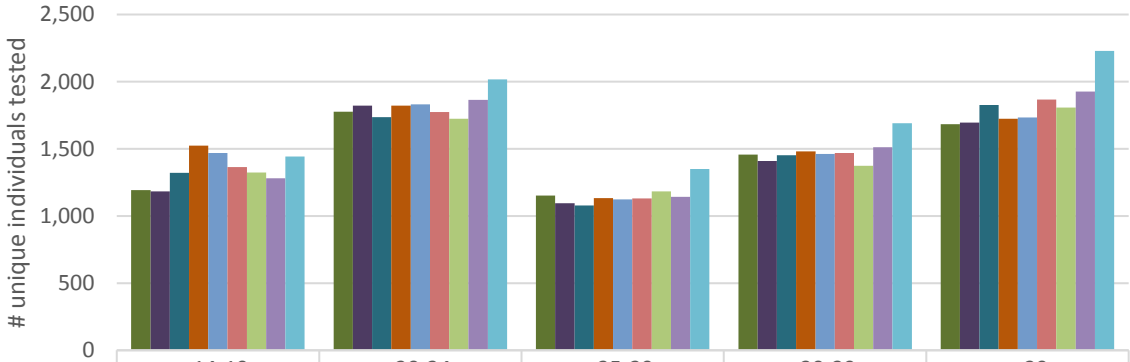
To better illustrate temporal regional trends, data for each year between 2008 and 2016 by age group is shown in figure 2.3.1D. For females, WRHA, PMH and SRHA tend to mimic provincial patterns, while NRHA and ILE tend to have testing skewed towards women aged 14-19. Similar patterns exist for males, where WRHA, ILE, PMH and SRHA mimic overall provincial patterns. The only exception is NRHA where male testing is skewed towards the 14-19 year age group, rather than 20-24 year olds.

Figure 2.3.1A. Overall provincial data showing the number of females accessing their first CTNG test by year and age group. *Each bar represents one year for the years 2008-2016.*



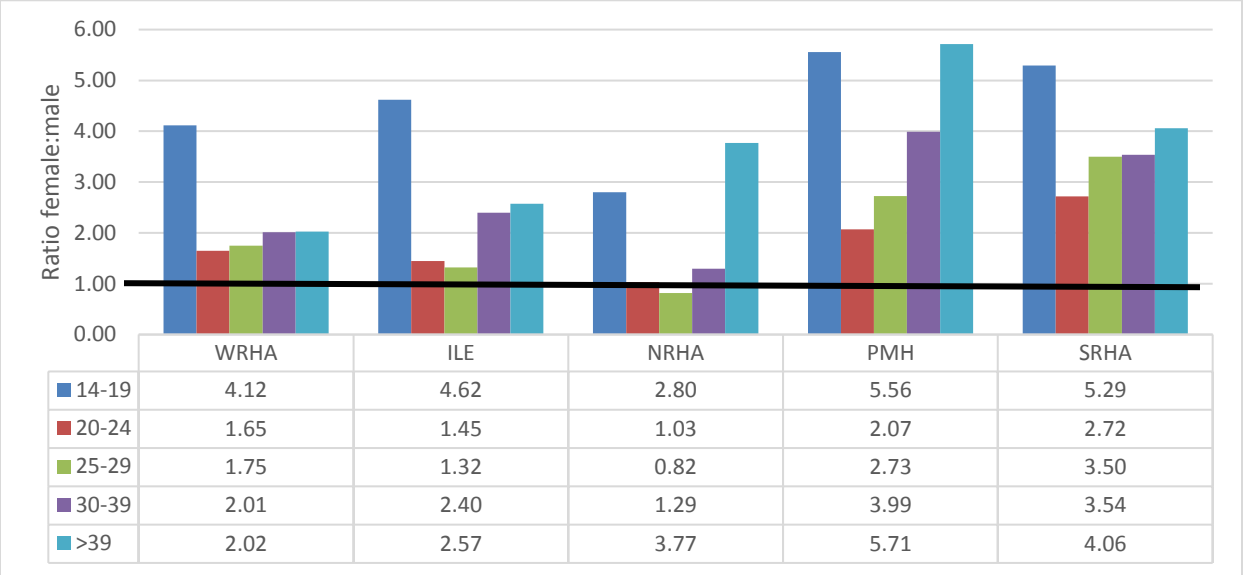
	14-19	20-24	25-29	30-39	>39
2008	4,363	2,669	1,822	2,708	3,764
2009	4,353	2,744	1,732	2,516	3,542
2010	4,091	2,576	1,694	2,247	3,037
2011	4,142	2,450	1,850	2,307	2,906
2012	3,885	2,594	1,945	2,333	2,788
2013	3,266	2,369	1,822	2,209	2,494
2014	3,095	2,476	1,771	2,392	2,439
2015	3,119	2,506	1,899	2,365	2,236
2016	3,291	2,812	2,120	2,606	2,318

Figure 2.3.1B. Overall provincial data showing the number of males accessing their first CTNG test by year and age group. *Each bar represents one year for the years 2008-2016.*

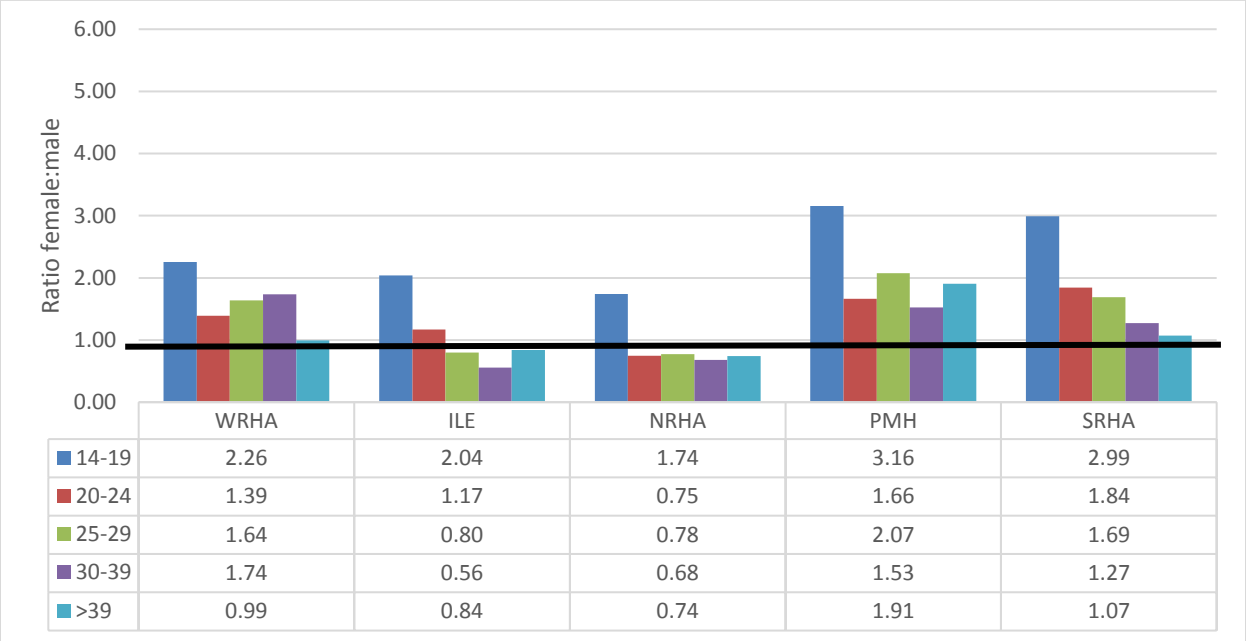


	14-19	20-24	25-29	30-39	>39
2008	1,193	1,776	1,152	1,457	1,683
2009	1,182	1,821	1,094	1,410	1,695
2010	1,322	1,737	1,078	1,453	1,827
2011	1,525	1,822	1,132	1,481	1,723
2012	1,470	1,831	1,124	1,461	1,734
2013	1,364	1,775	1,131	1,470	1,867
2014	1,324	1,724	1,184	1,374	1,808
2015	1,282	1,864	1,142	1,513	1,926
2016	1,444	2,016	1,349	1,691	2,230

Figure 2.3.1C: The provincial female to male ratio with respect to the number of individuals newly accessing CTNG testing in 2006 (A) and 2016 (B) by RHA. *The black line marks a ratio of 1.00 where the number of males and females would be equal. The same vertical axes have been used in A) and B) for comparability.*



	WRHA	ILE	NRHA	PMH	SRHA
14-19	4.12	4.62	2.80	5.56	5.29
20-24	1.65	1.45	1.03	2.07	2.72
25-29	1.75	1.32	0.82	2.73	3.50
30-39	2.01	2.40	1.29	3.99	3.54
>39	2.02	2.57	3.77	5.71	4.06



	WRHA	ILE	NRHA	PMH	SRHA
14-19	2.26	2.04	1.74	3.16	2.99
20-24	1.39	1.17	0.75	1.66	1.84
25-29	1.64	0.80	0.78	2.07	1.69
30-39	1.74	0.56	0.68	1.53	1.27
>39	0.99	0.84	0.74	1.91	1.07

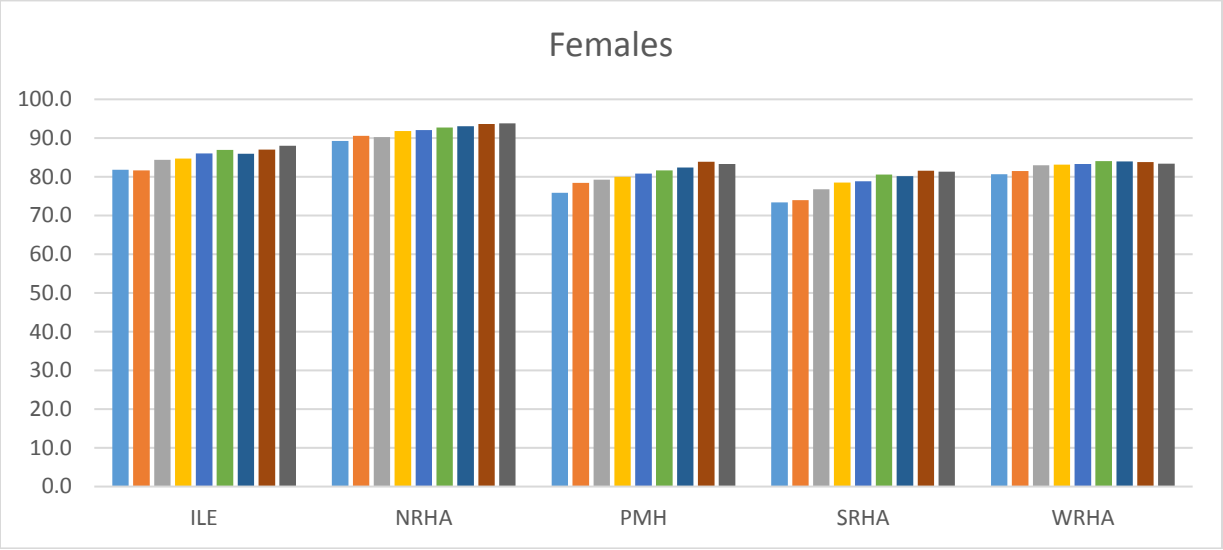
***Figure 2.3.1D: Number of females (left) and males (right) newly accessing testing stratified by RHA**. Note that data is only shown for the years 2008-2016 (each bar for a given age group represents a single year). The same vertical axis scale has been used for ILE, NRHA, PMH and SRHA to facilitate comparisons.*

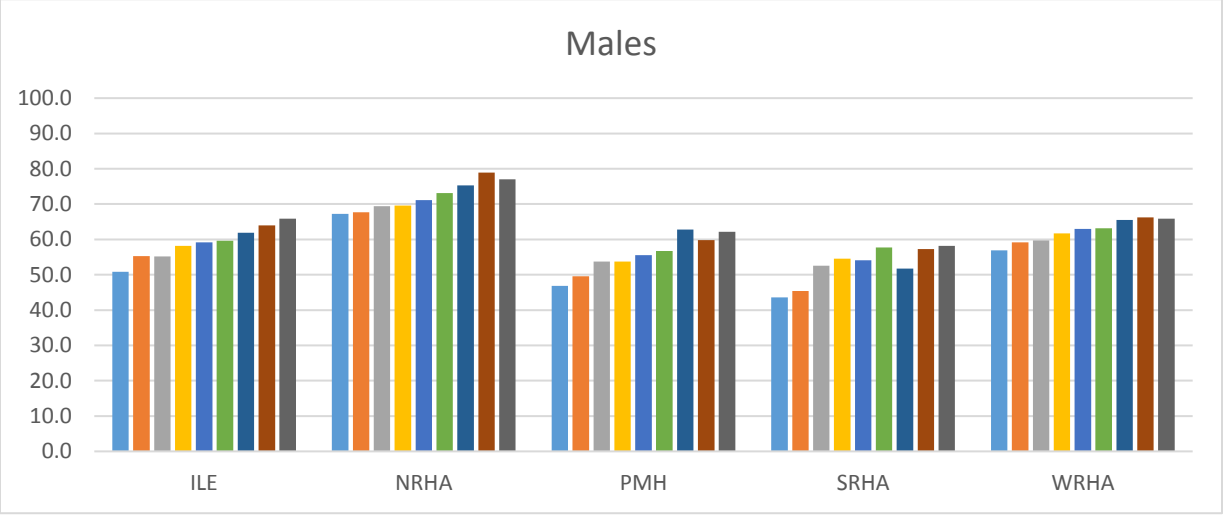
2.3.2. Repeat testing

To give a better representation of temporal trends associated with repeat testing, Figure 2.3.2A shows the percentage of repeat testing for CTNG stratified by gender and RHA. Here, repeat testing was calculated as the difference between total test volume in a year and the number of primary index tests for a given/RHA. The data is presented as a percentage relative to total test volume. An age breakdown is not presented as it did not influence results to any extent. Note that repeat testing by this definition does not equal the number of individuals uniquely tested each year, as some individuals can have multiple repeat tests within the course of a year.

In this analysis, the same trend existed across all RHAs and for both genders. With few exceptions, the overall trend was for a greater percentage of testing in all years to be repeat testing, although the per cent increase in repeat testing over time is more pronounced for males.

Figure 2.3.2A: Percentage of annual testing volume associated with repeat testing for females and males stratified by RHA*. Each bar represents one year of data from 2008-2016.*





3. DIAGNOSTIC TESTS AND CTNG DETECTIONS

Section 2 focused on diagnostic testing patterns overall with no attention given to differentiating positive and negative test results. Section 3 now focuses on that differentiation. Section 3.1 begins with an overview of the average number of tests and infections per individual, followed by analysis of trends related to primary infections *vs*. repeat infections.

3.1. Mean number of tests and infections.

Given the amount of secondary repeat testing undertaken each year in the province, section 3.1 provides additional gender- and RHA-specific data in relation to a person's testing history. Table 3.1A shows summary statistics for the number of individual CTNG tests per person stratified by RHA for the entire study period from 2000-2016. Comparing across RHAs, the mean number of tests showed a wider range for females compared to males (average female values range from 3.33 [SRHA] to 6.65 [NRHA] tests per individual while average values for males ranged from 1.94 [SRHA] to 2.98 [NRHA]).

In general, with respect to both the average number of tests and the average number of CT and/or NG infections per person, NRHA had the highest values. WRHA and ILE tended to be mid-range, while the lowest average number of tests or detections were in SRHA (number of tests and CT infections per person) or PMH (number of GC or CTNG infections per person). While true incidence likely does differ between RHAs, there is a correlation between mean number of tests and mean number of infections suggesting that increasing the number of tests increases the likelihood of identifying infections (i.e. altering public health practice can influence case counts).

Frequency distributions for the province as a whole describing the number of CT or NG infections per individual are provided in Table 3.1B.

Of the 304,049 females tested between 2000 and 2016, CT was detected in 35,730 (11.8%) individuals; 12,970 (36.3%) women experienced two or more CT infections.

For males, CT was detected in 21,630 of 116,411 (18.6%) individuals; 5,460 (26.1%) experienced two or more CT infections.

NG was detected in 7,260 (2.4%) females and 6,375 (5.5%) males; 1,738 (23.9%) females and 1,393 (21.9%) males experienced two or more NG infections.

NG infections did not nest entirely within the CT-infected population. CT was not detected in 1,460 of 7,260 (20.1%) NG-infected females, while 2,426 of 6,375 (38.1%) NG-infected males were not associated with a CT detection.

Table 3.1A: Number, range and mean for tests and infections by gender and RHA. *The "# individuals" column represents either the number of individuals tested or the number of individuals with a given infection type. For the sections covering CT, NG and CTNG detections, the values in parentheses represent the percentage of people tested who were infected by a given pathogen at some point in their testing history. CTNG coinfections are not a mutually exclusive category and some of the individuals tallied in the CT and NG sections would also be included in the CTNG section.*

RHA	**Females**			**Males**		
# tests						
	# individuals	Range	Mean	# individuals	Range	Mean
ILE	25,516	1-79	4.42	9,886	1-51	2.23
NRHA	25,687	1-98	6.65	12,460	1-50	2.98
PMH	36,450	1-115	3.62	11,322	1-39	2.03
SRHA	34,114	1-56	3.33	9,969	1-40	1.94
WRHA	182,282	1-110	3.96	72,774	1-85	2.26
TOTAL	*304,049*			*116,411*		
# CT infected individuals						
ILE	3,517 (13.8)	1-11	1.71	2023 (20.5)	1-13	1.41
NRHA	7,373 (28.7)	1-14	2.11	4472 (35.9)	1-11	1.62
PMH	3,973 (10.9)	1-12	1.48	2245 (19.8)	1-10	1.31
SRHA	2,774 (8.1)	1-9	1.46	1551 (15.6)	1-9	1.30
WRHA	18,093 (9.9)	1-14	1.58	11339 (15.6)	1-11	1.36
TOTAL	*35,730 (11.8)*			*21,630 (18.6)*		
# NG infected individuals						
ILE	774 (3.0)	1-6	1.35	575 (5.8)	1-24	1.39
NRHA	2373 (9.2)	1-9	1.43	1711 (13.7)	1-8	1.36
PMH	403 (1.1)	1-4	1.20	340 (3.0)	1-5	1.24
SRHA	302 (0.9)	1-6	1.29	288 (2.9)	1-6	1.31
WRHA	3408 (1.9)	1-10	1.32	3461 (4.8)	1-9	1.29
TOTAL	*7,260 (2.4)*			*6,375 (5.5)*		
# CTNG co-infected individuals						
ILE	398 (1.6)	1-4	1.16	265 (2.7)	1-7	1.15
NRHA	1455 (5.7)	1-7	1.26	931 (7.5)	1-4	1.18
PMH	195 (0.5)	1-3	1.10	155 (1.4)	1-3	1.12
SRHA	142 (0.4)	1-4	1.17	107 (1.1)	1-3	1.26
WRHA	1546 (0.9)	1-5	1.21	1245 (1.7)	1-5	1.15
TOTAL	*3,736 (1.2)*			*2,703 (2.3)*		

Table 3.1B: Frequency distribution showing the number of individuals that experienced a given number of CT, NG and CTNG coinfections *(the latter category is not mutually exclusive and individuals counted in the CT or NG tables would also appear in the coinfection table).*

	Females	%		Males	%
# CT infections					
1	22,760	63.70		15,990	73.93
2	7,248	83.99		3,682	17.02
3	2,902	92.11		1,242	5.74
4	1,420	96.08		399	1.84
5	664	97.94		170	0.79
6	368	98.97		69	0.32
7	171	99.45		42	0.19
8	77	99.66		12	0.06
9	66	99.85		12	0.06
10	28	99.93		7	0.03
11	15	99.97		4	0.02
12	5	99.98		0	0.00
13	3	99.99		1	0.00
14	3	100.0		0	0.00
# NG infections					
1	5,522	76.05		4,982	78.16
2	1,207	16.62		1,012	15.88
3	348	4.79		242	3.8
4	128	1.76		85	1.33
5	34	0.47		40	0.63
6	13	0.18		6	0.09
7	3	0.04		3	0.05
8	2	0.03		1	0.02
9	3	0.04		2	0.03
10 (females) 24 (males)	1	0.01		1	0.02
# coinfections					
1	3,114	83.35		2,335	86.39
2	479	12.82		307	11.36
3	107	2.86		54	2.00
4	30	0.8		4	0.15
5	4	0.11		2	0.07
6	0	0		0	0.00
7	2	0.05		1	0.04

3.2 Primary and repeat infections

Sections 3.2.1 and 3.2.2 show the number of primary and repeat infections identified over time for CT and NG, respectively. For both CT and NG, primary infections were defined as the first known infection detected for a given individual, regardless of whether or not that infection was identified at the time of their first CTNG test or a later test. A secondary infection was considered any infection detected at any point after the first infection for any given individual. No attempt was made to differentiate second, third, etc. infections for a given person and all were included in the tally of secondary infections. Both overall provincial data as well as data stratified for individual RHAs is presented.

3.2.1 CT Primary and repeat infections

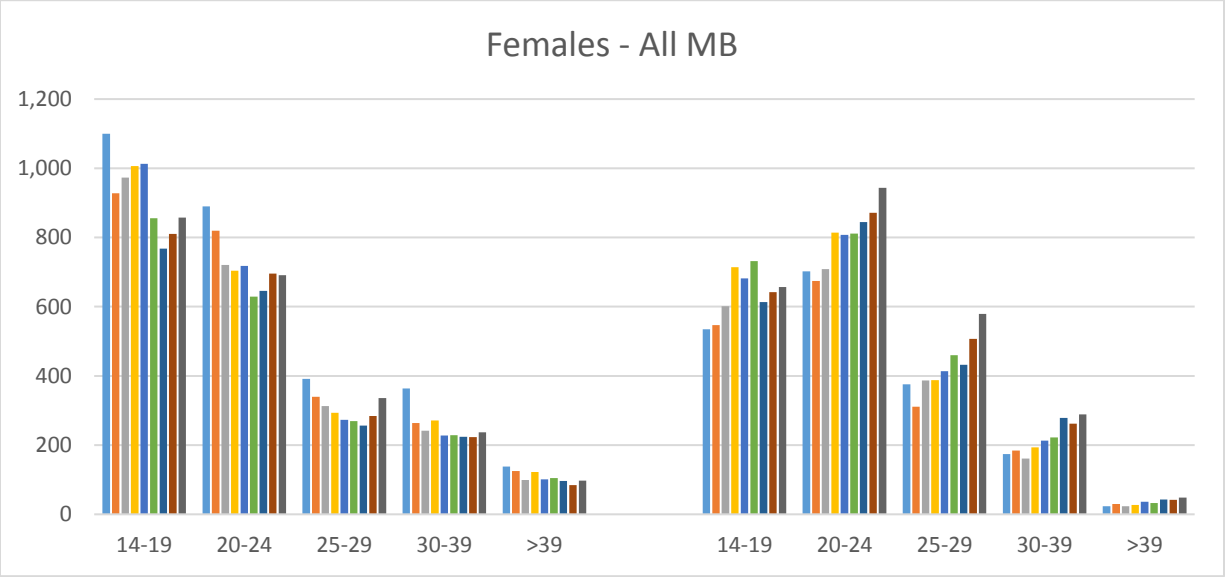
For women, the provincial overview showed a general decline in the number of primary infections identified over time for all age groups, while for men, the number of primary infections identified by year tended to be more stable (Figure 3.2.1A). For both men and women, there was a general increase in the number of secondary repeat infections identified each year.

While these trends could indicate an underlying change in transmission dynamics, there is also a clear correlation between the number of CT infections detected and test volumes. For women, a comparison of the annual number of primary infections (Figure 3.2.1A) with the number of index tests done each year (i.e. the number of individuals newly accessing testing each year) (Figure 2.3.1A) shows that as the amount of index testing declines, the number of primary infections also drops. Unlike women, there is relative stability or slight increases in the number of men newly accessing testing each year (Figure 2.3.1B), and the number of primary infections also reflects this trend. Conversely, for both genders, the amount of repeat testing has steadily increased over time (Figure 2.3.2A), as has the number of secondary infections (Figure 3.2.1A). As the average number of tests per person increases, there would be an expectation of a greater likelihood of successfully identifying secondary infections in a given person.

These correlations suggest that for CT, one of the proximal determinants of the number of primary vs. secondary cases identified annually is test volume. Test volume can be influenced by public health practice and/or associated changes in health-seeking behaviours on the part of patients (e.g. the feasibility of urine testing and its associated ease of specimen collection has likely driven the increased likelihood of repeat testing). While incidence is ultimately driven by the interplay between human behaviour, pathogen characteristics and public health practice, the correlation described above does suggest that overall testing patterns always need to be considered when attempting to interpret the significance of changing CT case numbers.

Figures 3.2.1B and 3.2.1C show the number of primary and secondary CT infections identified in women and men, stratified by RHA. For CT detection in women, all RHAs showed the same general downward trend in the number of primary infections identified over time (with some exceptions – e.g. primary infections are trending upwards in WRHA for women aged 14-19 and 20-24 for 2013 to 2016). Also as per the overall provincial data above, the number of repeat secondary infections in women has been generally trending upwards in all RHAs (with exceptions – e.g. the number of secondary infections in SRHA and PMH appear relatively stable over time). Male trends by RHA also tend to match the general discussion above, with all RHAs tending to show relative stability in the number of primary infections identified and either stability or slight increases in the number of secondary infections identified.

Figure 3.2.1A. The number of primary (left) and secondary (right) CT infections identified in women and men stratified by age category. *Data represents cumulative data for Manitoba overall. Each bar represents one year and shows the number of primary and secondary infections identified in a given year for the years 2008-2016.*



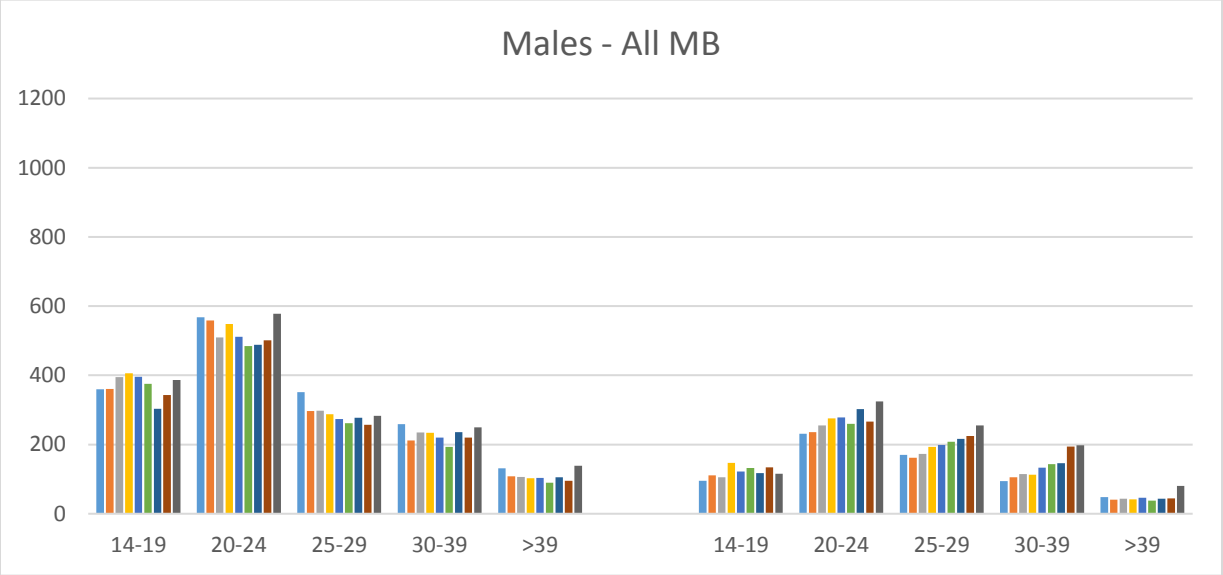
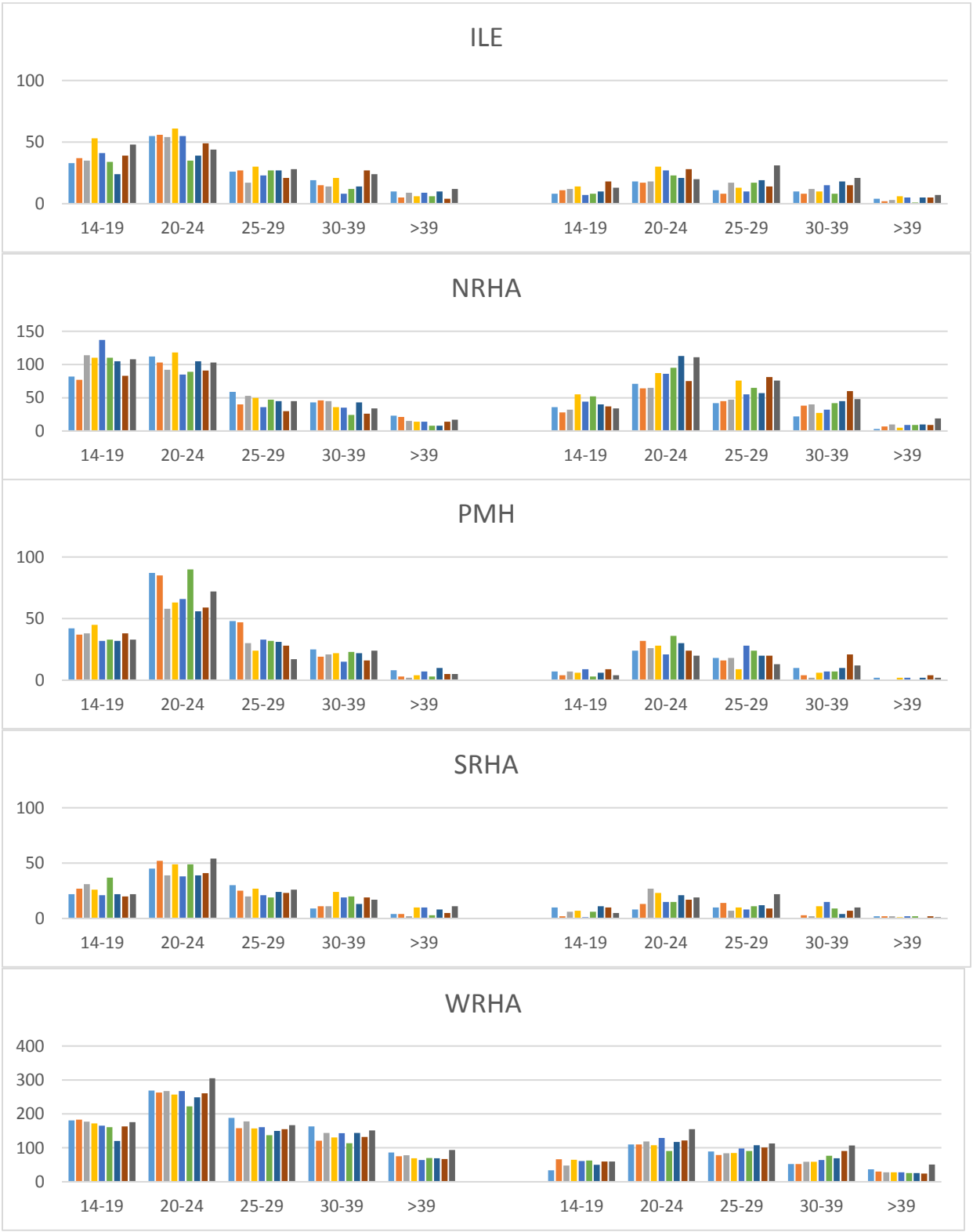


Figure 3.2.1B. The number of primary (left) and secondary (right) CT infections identified in women stratified by age category and RHA. *Each bar represents one year and shows the number of primary and secondary infections identified in a given year for the years 2008-2016.*

Figure 3.2.1C. The number of primary (left) and secondary (right) CT infections identified in men stratified by age category and RHA. *Each bar represents one year and shows the number of primary and secondary infections identified in a given year for the years 2008-2016.*



3.2.2. NG Primary and secondary infections

Figure 3.2.2A shows overall provincial data for the number of NG primary and repeat infections, while figures 3.2.2B and 3.2.2C show RHA-stratified data.

In contrast to CT, NG shows no clear correlation with the testing patterns discussed above, despite essentially all specimens received at CPL being tested for both pathogens. In contrast to clear trends for CT, for NG there is considerable fluctuation in the number of cases on a year-to-year basis. The increase in 2016 is evident in almost all age groups (the lack of an increase in NG secondary infections in 14-19 year males is the notable exception). This distinction from CT trends suggests that changes in test volume or changes in index vs. repeat testing has relatively little effect on NG detections. Annual fluctuations may therefore be driven more by pathogen characteristics and changes in strain types present, rather than changes in host behaviour or public health practice.

Figure 3.2.2A. The number of primary (left) and secondary (right) NG infections identified in women and men stratified by age category. *Data represents cumulative data for Manitoba overall. Each bar represents one year and shows the number of primary and secondary infections identified in a given year for the years 2008-2016.*

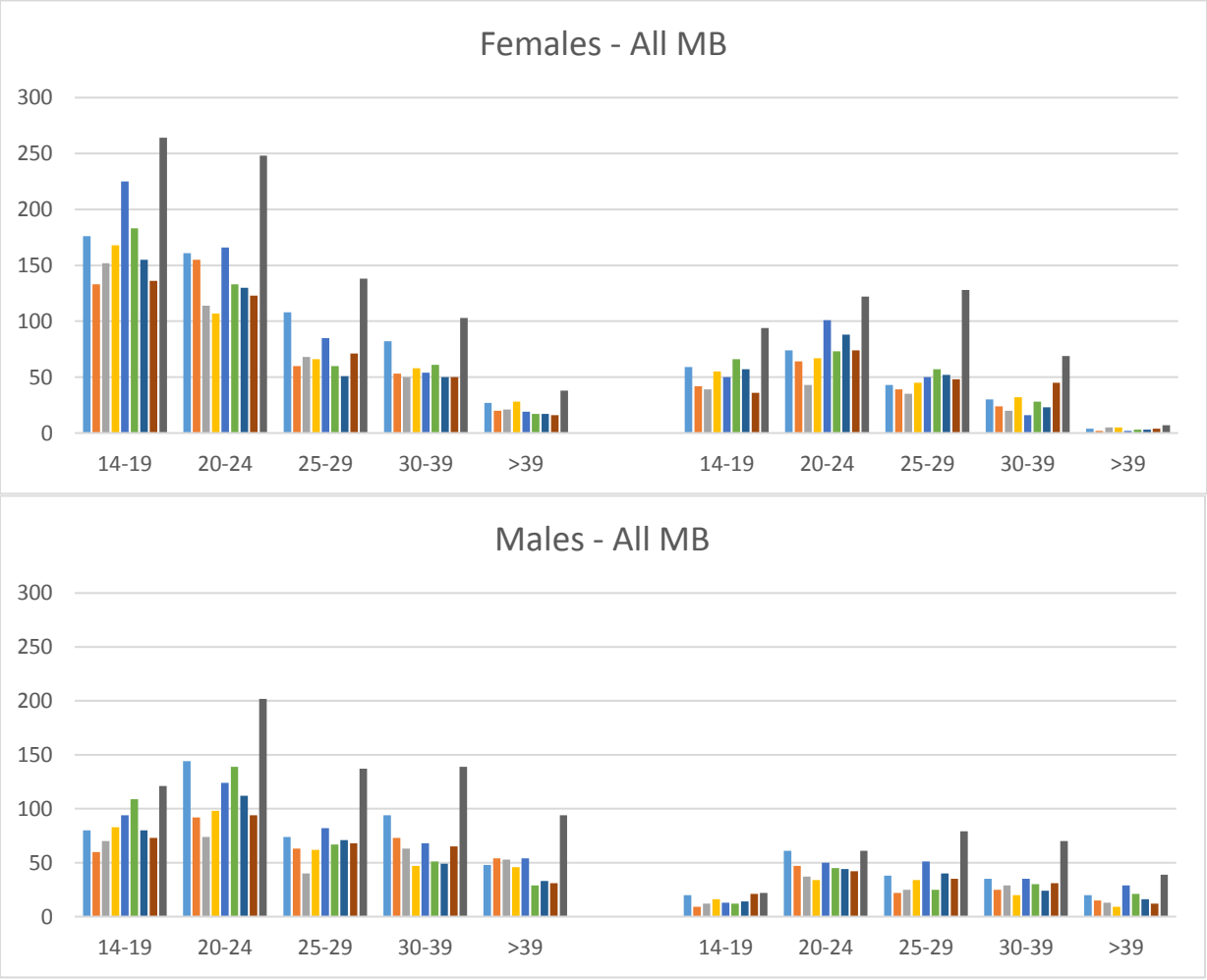


Figure 3.2.2B. The number of primary (left) and secondary (right) NG infections identified in women stratified by age category and RHA. *Each bar represents one year and shows the number of primary and secondary infections identified in a given year for the years 2008-2016.*

Figure 3.2.2C. The number of primary (left) and secondary (right) NG infections identified in men stratified by age category and RHA. *Each bar represents one year and shows the number of primary and secondary infections identified in a given year for the years 2008-2016.*

4. *Chlamydia trachomatis* Incidence and Infection Rates

This section makes use of patient testing histories to calculate incidence rates for both CT. One discrete three year time period (2014 to 2016) was used for this calculation to capture the most recent data available. As noted by Silver *et al*. (2015)[6], large-scale incidence studies for bacterial STIs are lacking in the literature. As such, the analysis described below is one of, if not, the largest population-based study of its kind.

The methodology largely follows that of Silver *et al*.[2] Incident infections are defined as a positive result for CT known to have occurred after one or more negative tests. Analysis began with establishment of a negative-test cohort by exclusion of individuals whose first known test within the timeframe of interest was positive. Without definitive treatment information, the point in time when these individuals cleared their infection would be unknown. Inclusion in the negative-test cohort required evidence of at least two CT tests within the three year analysis period. For individuals who do not test positive in the three year period, person-years of follow-up was defined as the time period between their first known and last known negative test. For individuals who do test positive, their time to infection was calculated as the time between their first known negative test and their first known positive test. Analysis of individuals who test positive multiple times in the three year period was based only on their first positive. Inclusion of additional infections for these individuals could lead to a disproportionate influence on the data given their potential to contribute multiple time periods to the data. Incidence rates were based on the number of incident infections divided by the cumulative person-years of follow-up. Data has been stratified by age group, gender and RHA.

Incidence calculations of this type are associated with numerous limitations. First, incidence as calculated here reflects infections occurring within the testing population, not the population as a whole. Given the risk of infection in individuals who seek testing may differ (and likely exceed) the risk in those who do not test, the rates calculated here may overestimate population rates. Further, only the subgroup within the testing population that specifically seeks testing two or more times within the timeframe of interest can contribute data towards incidence calculations, further limiting the generalizability of results. There is also some censoring inherent in the data as arbitrary three-year time periods create artificial cut-offs. Individuals whose first test is near the start or end point for a given three year period may, in fact, have longer infection-free periods than is evident from the data, potentially leading to some overestimation of rates.

Conversely, some aspects of the analytic approach likely lead to underestimation of incidence. Exclusion of individuals whose first test is positive, eliminates a substantial number of individuals who are clearly at risk of acquiring infection. However, review of the data suggested that many of these individuals do not test positive again, therefore it is difficult to establish the extent to which their exclusion results in over-or under-estimation of rates. Similarly, inclusion of only one incident infection per person, regardless of how many infections a person experiences within the timeframe of interest may lead to some underestimation of rates. However, an overestimation bias would be equally likely if these high-risk individuals were analyzed in such a way that they disproportionately influenced data outcomes.

Given that it is not possible to assess the extent of over- or under-estimation of rates, some caution should be applied if comparing these rates to other published studies from other areas.

[6] Silver BJ, Guy RJ, Wand H *et al*. 2015. Incidence of curable sexually transmissible infections among adolescents and young adults in remote Australian Aboriginal communities: analysis of longitudinal clinical service data. Sex. Transm. Infect. 91:135-141

However, since the data in this report was analyzed using one common analytic approach, it does allow for valid internal comparisons between, for example, RHAs.

This section of the report also shows infection rates per thousand people stratified by gender, age and RHA. This type of calculation was included as public health surveillance units are generally limited to measures of this type. Inclusion of this data allowed for comparisons between this type of calculation *vs*. incidence rate calculations. In contrast to the latter measure, infection rates do not incorporate any aspect of testing volume, whether it be the number of people tested or the amount of testing per person. For infection rates, the most recent data spanning 2016 was examined. All individuals were uniquely identified and the number of individuals with a positive CT detection were tallied. Repeat infections were not included. The infection rate was calculated as the number of cases relative to population size for a given gender, age group and RHA. Population sizes were those used in section 2.1.

Table 4A shows gender, RHA- and age-stratified infection rates per thousand. For both genders, the highest infection rates are in NRHA. Although some variation exists, after NRHA, the order of RHAs with respect to rates is ILE, WRHA, PMH and SRHA. For the youngest age groups of 14-19 and 20-24, where the majority of infections occur, there is approximately a 10-fold difference between infection rates for NRHA and SRHA.

Tables 4B shows gender, RHA- and age-stratified incidence rates per 100 person-years of follow-up. For both genders, the relative order of RHAs is generally the same as that for infection rates: NRHA, ILE, WRHA, PMH and SRHA (some exceptions to this order occur - for men the highest incidence rate for 14-19 year old males is in ILE, not NRHA and the lowest incidence rate for 30-39 year old males is in PMH, not SRHA). Aside from these variations, the most notable difference between infection and incidence rates is the magnitude of the difference between RHAs with high and low rates. While infection rates can vary up to 10-fold, incidence rates typically vary by less than two-fold.

The underlying difference between infection and incidence rates is the denominator data used in the calculation. Infection rates relate overall case counts to total population size. Without data on negative testing, no information on the extent of testing within an RHA is available. Conversely, incidence rates, as calculated here, incorporate additional information related to the overall number of people tested and the extent to which they remain negative over time. While NRHA typically has both the highest infection and incidence rates, they also test a greater proportion of their overall population each year (see Figs. 2.1A and 2.1B) and, on average, test each person a greater number of times (see Table 3.1A). Factors of this type would inflate absolute case counts relative to total population size and skew infection rate comparisons between RHAs.

Overall incidence rates, inclusive of all age groups, for females in Manitoba varied from 4.1 (SRHA) to 10.9 (NRHA) per 100 person-years of follow-up. Comparable results for males were 7.4 (WRHA) to 15.8 (NRHA) per 100 person-years. For both males and females, the highest incidence rates across all RHAs are in 14-19 year olds. These findings are similar to those found by Silver *et al*.[2] for analysis of data from remote Indigenous communities in Australia. These authors found an overall CT incidence of 10.0 and 8.6 per 100 person-years for females and males, respectively, with highest rates in 16-19 year olds. Silver *et al*. noted that their analysis focused on Indigenous communities and rates in the general Australian population were approximately four times lower. As such, the overall Manitoba rates would be considered relatively high compared to Australian rates. However, as noted above, some variation in methods exist between the various studies and caution should be used when making comparisons of this type.

In addition to the limitations noted above, post-analytic review of the results highlights one other consideration. For men, incidence calculations were based only on a total of 659 incident cases for the three year period of 2014-2016 (Table 4D) compared to infection rates based on 1,227 cases for the one year period of 2016 (Table 4C). Comparable data for women are 2,125 incident cases for 2014-2016 (Table 4B) relative to 2,083 cases for the single year 2016 (Table 4A). The difference arises as incidence calculations do not use individuals whose first known test is positive within the time frame of interest, nor do they utilize any repeat positives for a given person within that time frame. As such neither incidence nor infection rates can accurately capture true incidence. However, by incorporation of negative testing data, incidence calculations as carried out here do show that CT transmission dynamics within RHAs may not differ as much as crude infection rates imply.

Table 4A. Number of cases, population estimates and infection rates for women and men for the year 2016.

FEMALES	RHA				
Age group	ILE	NRHA	PMH	SRHA	WRHA
	Number of cases				
14-19	111	325	103	69	596
20-24	128	341	122	77	717
25-29	73	201	59	56	411
30-39	35	104	29	34	275
>39	9	23	7	5	84
TOTAL	**356**	**994**	**320**	**241**	**2083**
	Population estimates				
14-19	5099	3670	6248	8694	25724
20-24	4123	3066	5345	7228	26655
25-29	3019	2751	5373	5555	30210
30-39	6274	4751	10167	12196	56314
>39	34009	12051	40916	41628	179656
TOTAL	**52524**	**26289**	**68049**	**75301**	**318559**
	Infection rate per thousand				
14-19	21.8	88.6	16.5	7.9	23.2
20-24	31.0	111.2	22.8	10.7	26.9
25-29	24.2	73.1	11.0	10.1	13.6
30-39	5.6	21.9	2.9	2.8	4.9
>39	0.3	1.9	0.2	0.1	0.5
Overall *	**6.8**	**37.8**	**4.7**	**3.2**	**6.5**
MALES	RHA				
Age group	ILE	NRHA	PMH	SRHA	WRHA
	Number of cases				
14-19	53	128	35	25	215
20-24	61	197	88	66	403
25-29	53	113	28	45	254
30-39	43	81	34	27	236
>39	18	29	7	11	119
TOTAL	228	548	192	174	1227
	Population estimates				
14-19	5400	3947	6336	9316	27829
20-24	4376	3228	5660	7589	28226
25-29	3442	2804	5835	6137	29558
30-39	6459	4446	9921	11716	55308
>39	34642	12570	39292	41698	169089
TOTAL	54319	26995	67044	76456	310010
	Infection rate per thousand				
14-19	9.8	32.4	5.5	2.7	7.7
20-24	13.9	61.0	15.5	8.7	14.3
25-29	15.4	40.3	4.8	7.3	8.6
30-39	6.7	18.2	3.4	2.3	4.3
>39	0.5	2.3	0.2	0.3	0.7
Overall *	**4.2**	**20.3**	**2.9**	**2.3**	**4.0**

*Overall infection rates by RHA based on total number of cases per total population

Table 4B. Incident cases, person-years of follow-up, and incidence rates for women and men during the years 2014-2016.

FEMALES	RHA				
Age group	ILE	NRHA	PMH	SRHA	WRHA
	Incident cases				
14-19	98	238	82	64	539
20-24	122	312	121	85	745
25-29	71	210	61	50	472
30-39	41	121	36	27	299
>39	9	20	7	4	70
TOTAL	**341**	**901**	**307**	**230**	**2125**
	Person-years (PY) follow-up				
14-19	469.0	820.4	449.6	486.7	2472.1
20-24	1205.6	1910.0	1612.1	1381.6	8081.7
25-29	1250.8	2026.8	1876.1	1515.2	9080.4
30-39	1442.8	2375.7	2177.8	1710.1	13157.4
>39	661.1	1147.3	1101.9	584.3	5520.3
TOTAL	**5029.3**	**8280.2**	**7217.5**	**5677.9**	**38311.9**
	Incidence rate per 100 PY				
14-19	20.9	29.0	18.2	13.1	21.8
20-24	10.1	16.3	7.5	6.2	9.2
25-29	5.7	10.4	3.3	3.3	5.2
30-39	2.8	5.1	1.7	1.6	2.3
>39	1.4	1.7	0.6	0.7	1.3
Overall *	**6.8**	**10.9**	**4.3**	**4.1**	**5.5**
MALES	RHA				
Age group	ILE	NRHA	PMH	SRHA	WRHA
	Incident cases				
14-19	22	49	14	14	116
20-24	28	82	30	22	181
25-29	19	65	19	21	145
30-39	22	52	13	13	145
>39	9	18	4	3	72
TOTAL	**100**	**266**	**80**	**73**	**659**
	Person-years (PY) follow-up				
14-19	66.3	165.8	73.5	72.8	463.3
20-24	236.6	379.4	228.0	173.3	1636.5
25-29	182.4	397.7	257.9	177.5	1905.7
30-39	271.3	393.3	300.1	266.1	2584.9
>39	227.0	351.9	174.2	188.4	2365.6
TOTAL	**983.6**	**1688.1**	**1033.7**	**878.1**	**8956**
	Incidence rate per 100 PY				
14-19	33.2	29.6	19.1	19.2	25.0
20-24	11.8	21.6	13.2	12.7	11.1
25-29	10.4	16.3	7.4	11.8	7.6
30-39	8.1	13.2	4.3	4.9	5.6
>39	4.0	5.1	2.3	1.6	3.0
Overall *	**10.2**	**15.8**	**7.7**	**8.3**	**7.4**

*Overall incidence by RHA based on total incident cases / total PY

5. Index and follow-up testing of population cohorts

Although determination of incidence rate involves analysis of individual testing histories, the output is not in a form that illustrates the extent to which follow-up testing occurs after a positive diagnosis. Current provincial guidelines for both CT and NG suggest a repeat test take place six months after an initial positive result. For CT, the current Manitoba Communicable Disease Management protocol states "Repeat testing in all individuals with *C. trachomatis* infection should be considered six months post-treatment as reinfection risk is high", while the NG protocol states "cases of gonorrhea should be retested six months post-treatment or whenever the patient seeks medical care within the following 12 months as reinfection is common". This section examines the extent to which this guideline is being met as well as temporal trends related to follow-up test positivity.

Three discrete time periods were examined – 2008, 2011, and 2015. The choice of 2008 as the earliest year examined avoided any confounding associated with different test types. By 2008, all specimens were being tested with the same NAAT assay. The choice of 2015 as the most recent year was necessary as a one year follow-up period was needed for the analysis – for 2015, any individual testing up to December 31, 2015, could have up to 365 days of follow-up within which follow-up testing could occur.

For each of the three years, the methodology involved identifying the cohort of individuals who were entering the testing population in that year and experiencing their first ever CTNG test. This test was considered their index test and is referred to as such below. Based on their index test outcome, the cohort of individuals was reduced to those testing positive for CT or NG. The testing history for this subgroup of individuals was established for the 365-day period following the date of their index test. The test most proximal to their index test was identified as the follow-up test of interest. This follow-up test was categorized with respect to the number of months elapsed since their index test. The test outcome of the follow-up test was identified to establish test positivity at time of follow-up. Note that "months" for this analysis are not calendar months; rather a month was based on a 30-day period. To accommodate a full year consisting of 365 days, month 12 was taken to be 35 days.

Two limitations should be noted with respect to this approach. First, follow-up tests in month 1 were not considered as any positive result in this time frame may represent a primary infection that has not yet cleared. Some of these individuals may have had a second follow-up test within the recommended time frame, however these tests were not identified or included in the data summaries below. Second, time 0 was the CPL received date for the specimen associated with the index test. Using treatment date as time 0 would be preferable, however, data of this type was not available. Therefore, some individuals with a follow-up test in month 7 may actually be testing within a six-month post-treatment window.

Tables 5A and 5B show results for CT and NG, respectively. Given small sample numbers for some data associated with follow-up testing, stratification by RHA or age group was not carried out. At the provincial level, more females than males had a follow-up test within the recommended six-month time frame. For women with a CT-positive index test, the percentage with follow-up testing within six months ranged from 43.2% to 44.7%; corresponding values for men were 16.6% to 21.7%. Relative to CT, individuals positive for NG tended to have slightly less follow-up testing (women – 33.3% to 40.8%; men – 14.6% to 17.2%).

For both men and women, follow-up test positivity was always relatively high. For the most recent year of data (2015), overall CT positivity for follow-up tests occurring within the two to six month window was 15.6% for women and 21.7% for men. Corresponding values for NG were 14.3% for

women and 13.6% for men. On a monthly basis for CT in 2015, follow-up test positivity for women increased from 6.4% in month 2 to 30.0% in month 4 and remained near this level for months 5 and 6. For males, CT follow-up positivity reached 27.9% by month 2 and varied from 15.0% to 31.3% for months 4 to 6. Trends for NG are difficult to discern since few follow-up positives are identified. However, combining data from both males and females across the three years examined, the majority of NG positive cases (13) were detected with follow-up tests in months 2-4 *vs*. five cases identified in months five and six.

These results are similar to those found in several other countries. For Swedish youth, aged 12-25, Nielsen *et al*.[7] found approximately half of women and one quarter of men retested within a six month period. In the United States, Hoover *et al*.[8] found that 22.3% of men and 38.0% of non-pregnant women re-tested within 12 months following a positive CT result. In New Zealand, the proportion of individuals retesting within six weeks to six months after a positive CT result was 35.6% for women and 9.5% for men[9]. When follow-up testing does occur, high positivity rates are consistently identified[10].

From a program evaluation perspective, the results above demonstrate that interruption of CT and NG transmission could potentially be enhanced by initiatives aimed at improving follow-up retesting, since the majority of CT or NG positive individuals, especially men, do not re-test within the recommended timeframe. The recommended window of six months for a follow-up test may also be excessively long as follow-up test positivity is common past month 2 of follow-up. Several countries use three months as their recommended re-test window[7]. However, given the suboptimal number of people that retest at all following an index positive result, a simple alteration of guidelines, without any coincident program initiatives to improve re-testing rates, would likely have minimal impact.

High re-infection rates after treatment of an initial positive implies either re-exposure to an existing infected partner(s) or exposure to new infected partners. Re-exposure to an existing infected partner highlights the importance of effective partner notification. While innovative and effective partner notification strategies have been identified[8], at least one study has noted high follow-up positivity rates despite the documentation of partner notification activities in patient charts[11]. Together, these findings demonstrate the value of continuing to develop and evaluate new partner notification strategies, as well as the need to demonstrate the effectiveness of existing partner notification activities. Conversely, if high positivity at follow-up actually represents new infections, it implies association of an individual with high-risk sexual networks where exposure to new partners would be common. A study in the United Kingdom using CT genotype analysis suggested two-thirds of follow-up positives may actually be new infections[12]. Partner notification

[7] Nielsen, A., Marrone, G., and de Costa, A. 2016. *Chlamydia trachomatis* among youth- testing behaviour and incidence of repeat testing in Stockholm County, Sweden 2010-2012.
[8] Hoover, K. W., Tao, G., Nye, M. B., and Body, B. A. 2013. Suboptimal adherence to repeat testing recommendations for men and women with positive chlamydia tests in the United States, 2008-2010. Clin. Infect. Dis. 56:51-7.
[9] Rose, S. B., Garrett, S. M., Stanley, J., and Pullon, S. R. H. 2017. Retesting and repeat positivity following diagnosis of Chlamydia trachomatis and Neisseria gonorrhoea in New Zealand: a retrospective cohort study. BMC Infect. Dis. 17:526.
[10] Hosenfeld, C. B., Workowski, K. A., Berman, S. et al. 2009. Repeat infection with Chlamydia and Gonorrhea among females: a systematic review of the literature. Sex. Transm. Dis. 36:478-489.
[11] Marinelli, T., Chow, E. P. F., Tomnay, J. *et al*. 2015. Rate of repeat diagnoses in men who have sex with men for *Chlamydia trachomatis* and *Neisseria gonorrhoeae*: a retrospective cohort study. Sex. Health. http://dx.doi.org/10.1071/SH14234.
[12] Batteiger, B. E. Tu, W., Ofner, S., *et al*. 2010. Repeated *Chlamydia trachomatis* genital infections in adolescent women. J. Infect. Dis. 201:42-51.

in these situations would have minimal effect suggesting research is needed into how best to identify and screen other network members, many of whom may not be accessing testing.

Table 5A. Provincial overview of index and follow-up CT testing for females and males.

	FEMALES			MALES		
	2008	**2011**	**2015**	**2008**	**2011**	**2015**
# individuals with index test						
	15307	13655	12125	7254	7683	7727
# (%) index test-CT positive individuals [1]						
	891 (5.8)	783 (5.7)	677 (5.6)	1121 (15.5)	1010 (13.2)	807 (10.4)
# (%) index test-CT positive individuals with follow-up test within 2-6 months [2]						
	385 (43.2)	350 (44.7)	294 (43.4)	186 (16.6)	181 (17.9)	175 (21.7)
# (%) index test-CT positive individuals with a follow-up test by month [2]						
Month 2	161 (18.1)	152 (19.4)	141 (20.8)	68 (6.1)	76 (7.5)	76 (9.4)
Month 3	98 (11.0)	75 (9.6)	68 (10.0)	38 (3.4)	34 (3.4)	43 (5.3)
Month 4	57 (6.4)	51 (6.5)	30 (4.4)	28 (2.5)	32 (3.2)	20 (2.5)
Month 5	36 (4.0)	37 (4.7)	28 (4.1)	27 (2.4)	23 (2.3)	20 (2.5)
Month 6	33 (3.7)	35 (4.5)	27 (4.0)	25 (2.2)	16 (1.6)	16 (2.0)
Months 7-12	125 (14.0)	93 (11.9)	89 (13.1)	100 (8.9)	110 (10.9)	84 (10.4)
# (%) individuals CT positive within 2-6 month follow-up [3]						
	55 (14.3)	51 (14.6)	46 (15.6)	38 (20.4)	41 (22.7)	38 (21.7)
# (%) individuals CT positive at follow-up by month [3]						
Month 2	18 (11.2)	18 (11.8)	9 (6.4)	8 (11.8)	5 (6.6)	14 (18.4)
Month 3	9 (9.2)	12 (16.0)	11 (16.2)	8 (21.1)	15 (44.1)	12 (27.9)
Month 4	11 (19.3)	7 (13.7)	9 (30.0)	7 (25.0)	11 (34.4)	4 (20.0)
Month 5	11 (30.6)	9 (24.3)	8 (28.6)	8 (29.6)	5 (21.7)	3 (15.0)
Month 6	6 (18.2)	5 (14.3)	9 (33.3)	7 (28.0)	5 (31.3)	5 (31.3)
Months 7-12	29 (23.2)	18 (19.4)	21 (23.6)	28 (28.0)	22 (20.0)	24 (28.6)

1. denominator is the number of individuals with an index test
2. denominator is the number of individuals with a positive CT result at the time of their index test
3. denominator is the number of individuals with a follow-up test within 2-6 months

Table 5B. Provincial overview of index and follow-up NG testing for females and males.

	FEMALES			MALES		
	2008	**2011**	**2015**	**2008**	**2011**	**2015**
# individuals with index test						
	15297	13655	12125	7255	7683	7727
# (%) index test-NG positive individuals [1]						
	98 (0.6)	72 (0.5)	57 (0.5)	219 (3.0)	136 (1.8)	128 (1.7)
# (%) index test-NG positive individuals with follow-up test within 2-6 months [2]						
	40 (40.8)	24 (33.3)	21 (36.8)	32 (14.6)	21 (15.4)	22 (17.2)
# (%) index test-NG positive individuals with a follow-up test by month [2]						
Month 2	14 (14.3)	12 (16.7)	11 (21.1)	8 (3.7)	7 (5.1)	12 (9.4)
Month 3	7 (7.1)	2 (2.8)	1 (1.8)	10 (4.6)	6 (4.4)	2 (1.6)
Month 4	11 (11.2)	5 (6.9)	3 (7.0)	5 (2.3)	1 (0.7)	4 (3.1)
Month 5	3 (3.1)	3 (4.2)	1 (1.8)	3 (1.4)	4 (2.9)	1 (0.8)
Month 6	5 (5.1)	2 (2.8)	2 (5.3)	6 (2.7)	3 (2.2)	3 (2.3)
Months 7-12	18 (18.4)	14 (19.4)	8 (14.0)	24 (11.0)	15 (11.0)	11 (8.6)
# (%) individuals NG positive within 2-6 month follow-up [3]						
	0 (0.0)	4 (16.7)	3 (14.3)	5 (15.6)	3 (14.3)	3 (13.6)
# (%) individuals NG positive at follow-up by month [3]						
Month 2	0 (0.0)	2 (16.7)	1 (8.3)	1 (12.5)	1 (14.3)	0 (0.0)
Month 3	0 (0.0)	1 (50.0)	0 (0.0)	1 (10.0)	1 (16.7)	0 (0.0)
Month 4	0 (0.0)	0 (0.0)	1 (25.0)	1 (20.0)	0 (0.0)	3 (75.0)
Month 5	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)
Month 6	0 (0.0)	1 (50.0)	1 (33.3)	2 (33.3)	0 (0.0)	0 (0.0)
Months 7-12	1 (5.6)	0 (0.0)	0 (0.0)	0 (0.0)	4 (26.7)	1 (9.1)

1. denominator is the number of individuals with an index test
2. denominator is the number of individuals with a positive CT result at the time of their index test
3. denominator is the number of individuals with a follow-up test within 2-6 months

6. Relationship between chlamydia, gonorrhea and syphilis infection

The time period covered by the data used in this report was coincident with the most recent syphilis (SY) outbreak, therefore a relational analysis between CT, NG and SY was undertaken. By comparing CT and NG testing histories before and after a SY diagnosis, the intention was to determine whether CT/NG positivity acted as a proxy indicator of infection risk or behaviour change.

All individuals with a new laboratory diagnosis of syphilis (SY) in 2014-2016 were identified from CPL records (within this time frame, the earliest syphilis diagnosis date for a given individual was based on the first known record of a positive SY result with the comment "*The results suggest either recent or previous Treponemal infection. Reported to Public Health*" (note – see limitation regarding this comment at the end of this section). Within this time frame, 895 individuals were identified as SY positive. Of these individuals, 801 were matched to at least one CT or NG test in the CTNG specimen-level database. The CTNG testing histories for these 801 individuals were established back to the year 2000. Their SY diagnosis date was used to categorize any CTNG test as either occurring before their SY diagnosis (pre-SY) or after their SY diagnosis (post-SY). Test positivity, stratified in this manner, was determined for each year of the study period (2000-2016). For comparative purposes, all remaining CT and NG test results within the dataset were considered as representative of the general population. The results are shown as percent positivity with additional data provided in the tables accompanying the figures.

Figures 6A and 6B show percent positivity for CT and NG, respectively. For the 801 individuals with a new SY-positive laboratory result in the time period 2014-2016, CT and NG positivity is shown as pre-SY and post-SY. By default, post-SY CTNG tests can occur only in 2014, 2015 or 2016, while pre-SY tests can occur in any year – e.g. a person diagnosed with SY in 2015 could have pre-SY results in any year from 2000-2015, while post-SY results would only be found for 2015 or 2016. For CT, the overall number of CTNG tests associated with SY-infected individuals on a yearly basis ranged from 75 to 431; mean test positivity was 13.3%. After their SY detection, the number of CTNG tests per year ranged from 212 to 713 with an overall test positivity of 3.4%. The CT test positivity for the general population falls between these two values at 6.4%.

For NG, the total number of tests per year varies slightly from CT test numbers, as not all specimens are tested for both CT and NG. For NG, pre-SY, the number of tests per year ranges from 52 to 453 with an overall positivity of 5.2%. Post-SY, the number of tests per year ranges from 210 to 717 with positivity dropping to 2.8%. The NG test positivity for the general population was 1.4%.

These results inform discussion around two areas related to the SY outbreak:
1) Has SY emerged due to a recent change in or adoption of behaviours that are especially conducive to the spread of STIs?
2) Do sexual risk behaviours change after an SY diagnosis?

With respect to the first question, the consistently high CT and NG positivity across all years investigated suggests a network of individuals who exhibited high-risk behaviours for most/all of the time they have been sexually active. With online dating apps only gaining popularity in the last 5-10 years (e.g. Grindr was launched in 2009; Tinder in 2012), those apps have likely not acted as disruptive technologies that dramatically altered any one individual's behaviour. Rather, they may only have provided new avenues by which high-risk individuals could coalesce into sexual networks. Prior to the existence of these apps, these same individuals may have exhibited the same types of high-risk behaviours, but used alternate methods for finding their partners. This

view of long-term stability and consistency of sexual behaviours is consistent with previously published data describing the apparent temporal and spatial stability of sexual networks in Manitoba at the population level[13].

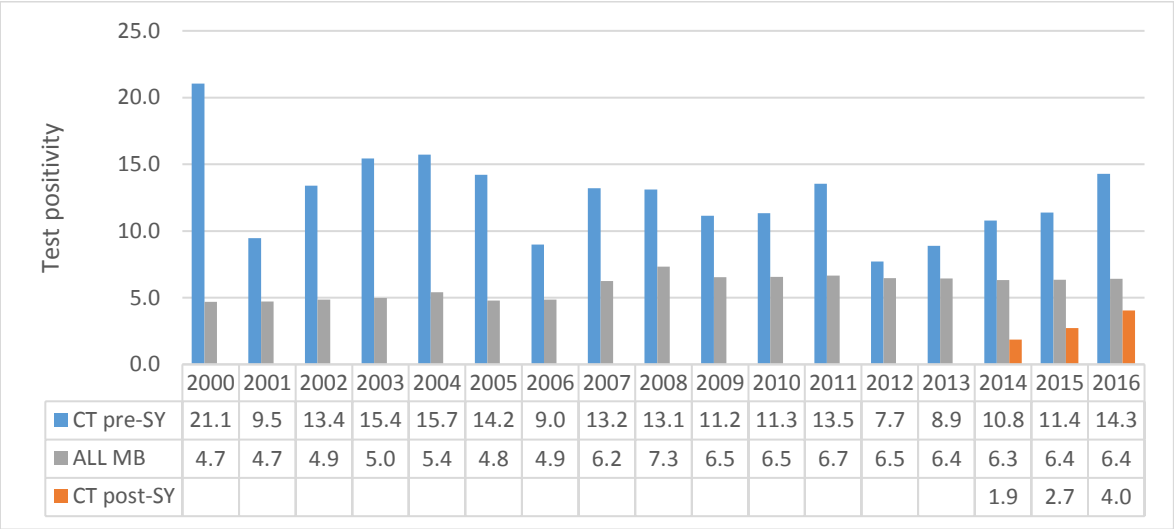
With respect to the second question, the data shown in figures 6A and 6B does suggest a change in sexual risk behaviour or health-care seeking behaviour after a SY diagnosis. For CT, test positivity in the group of SY-infected individuals dropped to a value lower than the general population. NG positivity also dropped although it continued to exceed values seen in the general population. Behavioural change could be multifaceted and be related to:
1) the SY infection itself (e.g. an SY infection may have been taken more seriously than a CT or NG infection);
2) additional, more frequent contact with public health workers; or
3) an increased frequency of CTNG screening with a resulting interruption of historic transmission patterns within this group of individuals.

Regardless of the reason, the drop in CT and NG positivity provides evidence of the importance and positive outcome of public health interaction with individuals at high risk of infection. More research to address questions related to the long-term persistence of high-risk sexual risk behaviours, how those behaviours have or have not been affected by online apps, the reason positivity drops after a diagnosis of SY and the temporal stability of that drop should be considered in future to better understand the phenomenon described above.

A limitation of this analysis is the identification of new syphilis cases by the CPL comment appearing on CPL lab results - "*The results suggest either recent or previous Treponemal infection. Reported to Public Health*". Some of these individuals may in fact represent repeat infections that were not accurately reflected as such or captured in CPL records. This scenario appears to be the case as the 895 individuals identified in CPL records during the period in question exceeds the number of new syphilis cases identified and reported by the province in 20142016 (580 cases). However, a misclassification of this type would tend to mask the effect identified above as behaviour change associated with the true date of diagnosis may have already occurred. Conversely, and regardless of disease stage, the CPL result would still result in contact with public health workers and perhaps drive a similar effect as if the result reflected a new case. Noting this limitation, the CT and NG positivity values identified above "before" and "after" a SY diagnosis may actually be more different than the present analysis has revealed.

[13] J. L. Wylie, S. Shaw, E. DeRubeis, A. M. Jolly. 2010. A network view of the transmission of sexually transmitted infections in Manitoba, Canada. Sex. Transm. Infect. Suppl 3:iii10-16

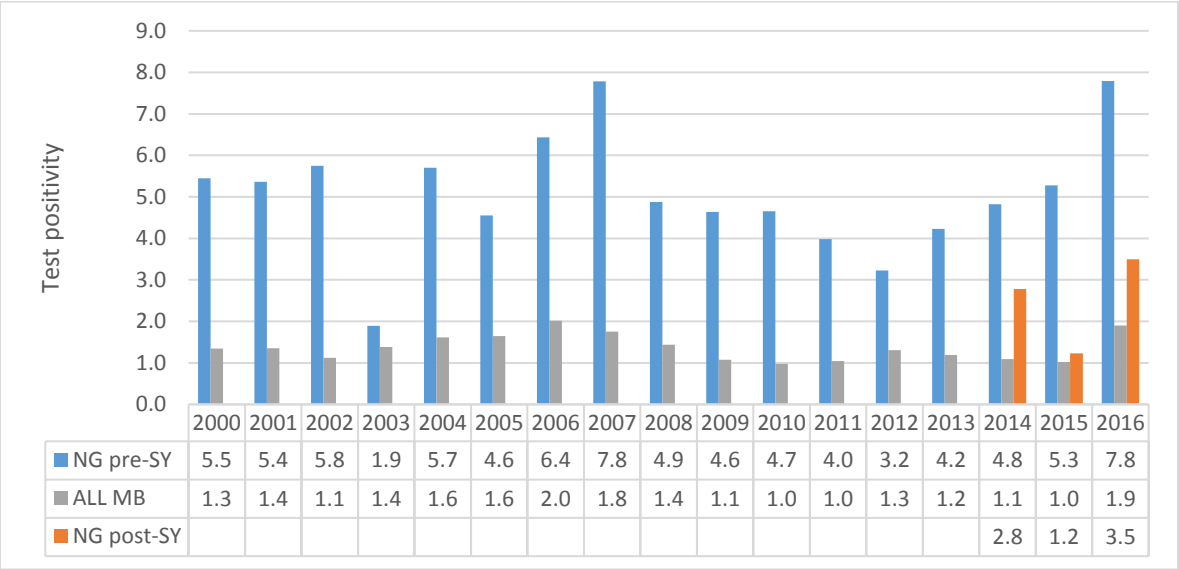
Figure 6A. CT test positivity for individuals associated with a syphilis laboratory detection compared to the general population.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CT pre-SY	21.1	9.5	13.4	15.4	15.7	14.2	9.0	13.2	13.1	11.2	11.3	13.5	7.7	8.9	10.8	11.4	14.3
ALL MB	4.7	4.7	4.9	5.0	5.4	4.8	4.9	6.2	7.3	6.5	6.5	6.7	6.5	6.4	6.3	6.4	6.4
CT post-SY															1.9	2.7	4.0

Chlamydia trachomatis						
YEAR	SY-INFECTED POPN				GEN POPN	
	PRE-SY		POST-SY			
	NEG	POS	NEG	POS	NEG	POS
2000	75	20	-	-	59,248	2,907
2001	86	9	-	-	58,445	2,883
2002	110	17	-	-	63,169	3,221
2003	115	21	-	-	68,075	3,557
2004	161	30	-	-	72,005	4,114
2005	169	28	-	-	75,391	3,783
2006	243	24	-	-	81,702	4,169
2007	243	37	-	-	83,375	5,549
2008	285	43	-	-	88,663	7,000
2009	287	36	-	-	91,696	6,415
2010	305	39	-	-	92,261	6,464
2011	326	51	-	-	96,567	6,883
2012	371	31	-	-	98,045	6,769
2013	431	42	-	-	94,760	6,532
2014	389	47	212	4	95,429	6,435
2015	319	41	394	11	98,810	6,700
2016	132	22	713	30	106,975	7,347

Figure 6B. NG test positivity for individuals associated with a syphilis laboratory detection compared to the general population.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
NG pre-SY	5.5	5.4	5.8	1.9	5.7	4.6	6.4	7.8	4.9	4.6	4.7	4.0	3.2	4.2	4.8	5.3	7.8
ALL MB	1.3	1.4	1.1	1.4	1.6	1.6	2.0	1.8	1.4	1.1	1.0	1.0	1.3	1.2	1.1	1.0	1.9
NG post-SY															2.8	1.2	3.5

	Neisseria gonorrheae					
YEAR	SY-INFECTED POPN				GEN POPN	
	PRE-SY		POST-SY			
	NEG	POS	NEG	POS	NEG	POS
2000	52	3	-	-	27,687	377
2001	53	3	-	-	31,486	433
2002	82	5	-	-	39,155	444
2003	104	2	-	-	47,753	671
2004	149	9	-	-	56,231	923
2005	168	8	-	-	62,572	1,049
2006	233	16	-	-	70,681	1,452
2007	249	21	-	-	80,525	1,435
2008	312	16	-	-	94,267	1,378
2009	308	15	-	-	97,080	1,052
2010	328	16	-	-	97,762	963
2011	362	15	-	-	102,370	1,080
2012	389	13	-	-	103,446	1,368
2013	453	20	-	-	100,083	1,209
2014	415	21	210	6	100,755	1,109
2015	341	19	400	5	104,435	1,075
2016	142	12	717	26	112,147	2,175

7. Urines as a diagnostic specimen

This section of the report revisits an observation identified in section 1 related to urines as a diagnostic specimen for women and men. In section 1, female urine specimens were associated with a greater likelihood of being positive for CT or NG relative to cervical swabs (AOR of 1.28 for CT and 1.47 for NG; sections 1.1 and 1.3). The opposite was true for male urines relative to urethral swabs (AOR of 0.68 for CT and 0.52 for NG; sections 1.2 and 1.4).

Alternate hypotheses that are both consistent with these results were proposed. For women, urines may be a superior diagnostic specimen (hypothesis 1) or the availability of urine testing has encouraged testing by women who are at higher risk of infection (hypothesis 2). In hypothesis 1, specimen type is itself the determinant of the different results, while in hypothesis 2, specimen type acts as a proxy marker of an unmeasured variable – sexual risk. As a proxy measure, specimen type becomes associated with a different likelihood of identifying positives since the different specimen types originate from different population subgroups. The same hypotheses, but worded in the opposite manner could be proposed for men – either urines are an inferior diagnostic specimen (hypothesis 1) or the availability of urine testing has encouraged testing by low-infection-risk males (hypothesis 2).

The question is revisited here, as many of the results and data presented throughout this report are relevant in terms of differentiating between the alternate hypotheses. For example, results from section 2.1 showed that both the proportion of the male population being tested in all RHAs (figure 2.1B) and the number of males experiencing their first-ever CTNG test (figure 2.3.1B) has generally increased over time. Both of these patterns are consistent with the idea that the availability of urine testing has encouraged the entry of new male population subgroups into the overall testing cohort. If these males are at low risk of infection, urine specimens from these individuals would be expected to have a lower likelihood of being associated with a positive result (i.e. be associated with an odds ratio of less than 1 relative to urethral swab specimens).

While the above patterns support hypothesis 2 for males, interpretation of corresponding testing patterns for women are less conclusive. The proportion of the female population being tested has remained relatively stable (figure 2.1A) while the number of females newly accessing testing has decreased or remained stable over time (figure 2.3.1A). These trends are inconsistent with the idea that the availability of urine testing has encouraged the entry of new population subgroups of women who have previously gone untested. Alternatively, if urine testing in women does represent access to a new higher risk subgroup, it would have to imply a matching decrease in testing in a different, lower risk subgroup. The latter is conceivable as changes to cervical cancer screening programs can lead to reductions in CTNG screening[14]. Given that the increase in the number of female urine specimens just shortly preceded changes to the Manitoba Cervixcheck program, the two effects may have balanced, such that overall female testing numbers remained largely the same, but with CTNG screening becoming more appropriately focused on higher risk women.

Section 5 above, provides data that allow the alternate hypotheses to be tested for both men and women. That data examined the first (index) test and subsequent follow-up tests for a given

[14] Naimer, M. S., Kwong, J. C., Bhatia, D. et al. 2017. The effect of changes in cervical cancer screening guidelines on chlamydia testing. Anns. Fam. Med. 15(4):329.
Hsieh, H., Huppert, J., Patel, C. G. et al. 2017. The impact of the American College of Obstetricians and Gynecologists guideline changes in PAP tests on annual chlamydia test rates. J. Adol. Health. http://dx.doi.org/10.1016/j.jadohealth.2017.05.012

individual. Although not utilized in section 5, the specimen type associated with each test was retained in the data. As such, individuals can be categorized in one of four ways, based on the specimen type associated with their respective index and follow-up test: 1) swab/swab; 2) swab/urine; 3) urine/swab; 4) urine/urine.

Table 7A below show the number of people grouped by these four specimen type combinations for the years 2008-2016 inclusive. Although the combination of a cervical swab at index and a cervical swab at follow-up is most common for women, there are individuals whose specimen type differs at index and follow-up or who have only provided urine specimens. For men, the combination of a urine specimen for both an index and follow-up test dominates, however, as per women, there are individuals within each of the other specimen type combinations.

Table 7A. Specimen type combinations associated with index and follow-up testing. *Data based on the years 2008-2016 inclusive (2008 chosen as the first full year when all testing was by NAAT).*

Females		
	Follow-up test specimen type	
	Cervical swab	Urine
Index test specimen type		
Cervical swab	40,435 (60.4%)	10,699 (16.0%)
Urine	7,721 (11.5%)	8,110 (12.1%)
Males		
	Follow-up test specimen type	
	Urethral swab	Urine
Index test specimen type		
Urethral swab	313 (1.3%)	1,288 (5.2%)
Urine	735 (2.9%)	22,659 (90.7%)

The basis of the alternate hypothesis testing is as follows. Hypothesis 1, for both males and females, assumes that the tests associated with each of the four specimen type combinations are drawn from a uniform mix of individuals whose choice of specimen type is independent of sexual risk behaviour. In this scenario, for women, the test positivity of individuals whose index test is with a cervical swab (regardless of whether the follow-up test is with a swab or urine) should be equivalent. Similarly, the two categories of women whose index test is with a urine should each have an equivalent test positivity at the time of their index test. However, the common positivity for the latter two groups should exceed and be significantly more than that of the first two groups, indicative of urines as a superior specimen type. Conversely, for males, the test positivity for the two groups whose index test is with a urine should be equivalent to each other but be significantly less than that of the two groups whose index test is with a urethral swab, indicative of urines being an inferior specimen type.

For hypothesis 2, a different result outcome is expected. This hypothesis postulates that the four specimen type combinations in table 7A each represent subpopulations that differ in their sexual risk behaviour. In this scenario, each sexual behaviour group is more likely to submit a specific

combination of swab and/or urine, such that the specimen type combination acts as a proxy indicator of sexual risk. For women, urines are associated with an increased odds of a positive test result. Therefore, the group of individuals who test solely by means of a urine specimen are expected to have the largest value for test positivity. Individuals who test only with a swab specimen would be expected to have the lowest test positivity. For men, where urines are associated with a lower likelihood of being positive, the opposite trend is expected. Highest test positivity would be associated with men who test only by way of a urethral swab while individuals who test only with a urine specimen would have the lowest test positivity. For both genders, individuals who test with a mix of specimen types could potentially represent intermediate groups with respect to sexual risk behaviour and associated test positivity.

Table 7B shows the index test CT-positivity for males and females stratified by the specimen type combinations described in table 7A. The results overall are consistent with the results predicted by hypothesis 2. For females, a urine/urine combination for index and follow-up yielded an overall index test positivity of 17.7%, while women testing with a cervical swab at both index and follow-up yielded an index test positivity of 6.0%. For males, the opposite was found; highest index test positivity was associated with individuals who tested with a urethral swab at both index and follow-up (42.2%). Lowest index test positivity for males occurred with those individuals who provided a urine specimen for both index and follow-up test (18.7%). For both males and females, individuals who alternated specimen types at index and follow-up test showed intermediate values (11.3% and 10.1% for females and 24.0% and 22.6% for males).

Table 7B. Index test positivity for CT associated with index testing stratified by the group designations of table 7A. *Data based on the years 2008-2016 inclusive (2008 chosen as the first full year when all testing was by NAAT). Data shown is the number of positive detections (and % positive) for the index test results associated with a given specimen type combination; denominators from table 7B.*

Females		
	Follow-up test specimen type	
	Cervical swab	Urine
Index test specimen type		
Cervical swab	2,412 (6.0%)	1,205 (11.3%)
Urine	783 (10.1%)	1,435 (17.7%)
Males		
	Follow-up test specimen type	
	Urethral swab	Urine
Index test specimen type		
Urethral swab	132 (42.2%)	309 (24.0%)
Urine	166 (22.6%)	4,227 (18.7%)

Results consistent with the predictions of hypothesis 2 suggest that the availability of multiple specimen types and combinations thereof, have facilitated access to and encouraged testing by population subgroups whose sexual risk behaviours differ. The availability of NAAT urine testing for women since approximately 2007/8 appears to have encouraged testing by a high-infection-risk portion of the population who may have typically avoided testing in the past. These individuals may be accessing testing at facilities such drop-in clinics specifically for the purpose of an STI

test. As urine specimens from this subpopulation increased over time (figure 2.2A), the number of positive detections increased such that urines became associated with a greater likelihood of yielding a positive result in the regression analyses of section 1. Conversely, the relatively low CT positivity from women who test only with a cervical swab, likely indicates the testing of low-risk “well women” who are having multiple types of screening tests carried out as part of a pre-planned scheduled appointment.

Prior to the rollout of male screening in 2004, CTNG testing focused on female screening coupled to testing of male contacts, many of whom would be infected. The resultant test positivity of swabs from these men was therefore high. The availability of urine testing allowed CTNG screening of males to be promoted with the expectation of a drop in test positivity as low-infection-risk males increasingly entered the testing cohort. Given the results of table 7B, test positivity from males providing urine specimens only vs. those being tested by way of urethral swabs is consistent with these temporal changes.

The correlations and associations described above are not definitive evidence of a direct link between sexual risk behaviour and specimen type choice. However, the consistency of results predicted by hypothesis 2 and observed results does delineate a potential area of research to both confirm the findings and, if supported by evidence, better understand the exact manner in which the availability of diagnostic testing by way of specific specimen types can facilitate access to different risk groups. Notably, there is a limitation in this analysis that only individuals with a minimum of two CTNG tests over time can be included in the analysis. Men and women with only one recorded CTNG test (51.4% of all individuals tested between 2008 and 2016) cannot be meaningfully characterized or analyzed within the schema utilized.

CONCLUSION

This report is based on analysis of 17 years of CT and NG diagnostic testing data carried out by CPL for the years 2000-2016. Making use of both negative and positive test results, and given the centralized nature of CGNG testing in Manitoba, it represents one of the largest population-based analyses of diagnostic trends associated with these two pathogens. The trends identified either represent new information or alter (in some cases substantially alter) common perceptions of CT and NG transmission dynamics in the province. Normally, the only CTNG data available for review and for description of trends are crude case counts. This limitation is not a reflection on Manitoba itself, as this type of data is typically the only information available for surveillance units, regardless of province or country. Unfortunately, this type of data is limiting as the lack of a denominator (i.e. overall testing volumes and designation of results as positive or negative) severely hampers the types of analyses that can be undertaken and the manner in which the data can be analyzed.

With respect to altered perceptions, a notable example is the likelihood of identifying a CT infection over time. Crude case counts would indicate that the number of CT infections (and by association CT prevalence and incidence) have steadily increased from 2000 to 2016 (2,907 CT detections at CPL in 2000 compared to 7,347 in 2016). Without the means to analyze this trend further, these results could easily be taken as an indication of the inability of a screening program to influence or lower rates as well as potentially implying changes at the population level such as an increase in sexual risk-taking behaviour. Questions could also be raised regarding the value of continuing to fund what may appear to be an ineffective screening program, as well as creating a sense of frustration on the part of front-line workers whose efforts may appear to be having little effect on disease incidence. Finally, research dollars and human resources could be misdirected, if, for example, studies are launched to investigate the underlying determinant of a trend, when in fact the trend itself may not exist.

In contrast to the conclusions suggested by a simple examination of case counts over time, the analysis that focused on identifying the likelihood of identifying an infection indicated a trend that was the opposite to that described above, both in terms of its meaning and its implications. The likelihood analysis suggested that the majority of the increased case counts largely relate to technology changes. Changes such as the implementation of more sensitive tests, the roll-out of male screening using urine specimens, and the availability of urine testing for females have led to the identification of positive cases that would have been previously missed if these changes had not been put in place. By controlling for these changes, the “true” trend in terms of case detection becomes evident. Major public health programs such as male screening initiatives and implementation of newer more sensitive tests correlate with downward shifts in the likelihood of identifying infections. This pattern implies that as case detection improved, transmission cycles were interrupted and incidence and prevalence decreased over time – all indicative of a successful program.

In addition to altering perceptions related to the transmission of CT and NG, the analyses described in this report provide background data relevant to advancing STI control. Within the body of the report, several studies were cited from countries with STI control programs similar to those found in Canada. These studies originate from the United States, Australia, New Zealand, the United Kingdom and Sweden and address similar types of research questions as those addressed here. In many cases, measures that relate to program evaluation such as the proportion of a population tested, the extent of follow-up testing, and positivity of follow-up tests do not vary dramatically from country to country. This similarity suggests that when a NAAT-

based population-focused screening program is introduced a natural plateau may be reached in terms of how far that program can reach into a population and the extent to which follow-up can be expected to occur. If so, the next stage in CTNG control would be a decision on how best to actively move a program forward.

Active development of new initiatives and program elements is a multifaceted process. Obtaining the necessary evidence can be framed within the context of a research program, therefore external research funds should be sought to facilitate the process. The challenge faced by public health, and the focus of the research program, would be to ascertain which direction(s) to proceed and to build an evidence base to support those decisions. The results described in this report suggested three main avenues to explore: 1) Increase the proportion of the population (especially men) being tested each year.
2) Improve partner notification to reduce high re-infection rates.
3) Improve access to sexual networks associated with individuals who experience new infections shortly after an index infection.

With respect to 1), the results of section 2.1 suggested less than optimal population coverage for CTNG screening. With respect to 2) and 3), the high positivity for follow-up testing for both men and women (section 5) suggested that either re-infection from an existing partner is common or high partner turnover is occurring and new infections are being acquired from new partners over short periods of time.

In terms of acquiring an evidence base for decision-making, several research approaches can be used. First, modelling studies could be initiated to predict and compare the expected impact of a given initiative on pathogen transmission dynamics (e.g. modelling the expected impact of increasing population CTNG screening coverage *vs*. modelling the impact of increasing the number of positive cases re-tested after diagnosis). A complimentary line of investigation would be the molecular genotyping of CT and NG at the time of an index diagnosis and the comparable genotype of any positive diagnosis occurring within a few months of that diagnosis (for both CT and NG this type of genotyping can currently be done direct from a NAAT specimen and no isolate is required). Given the discussion in section 5, there is a clear need to understand the extent to which secondary infections are actually re-infections from an existing partner or new infections from new partners. Information of this type would reveal the extent to which partner notification may or may not be an effective approach to lower the likelihood of secondary infections. Also, while there are undoubtedly situations in which partner notification would help to identify infected partners and lower the likelihood of a re-infection, questions around the effectiveness of partner notification suggest that existing methods should be evaluated, as well as research and development of new more innovative approaches.

Finally, the results of sections 6 and 7 warrant further investigation as additional avenues of research. Section 7 provided evidence that the offer and availability of urine testing has led to the entry of women who appear to be at a higher risk of infection. While the data is consistent with this hypothesis the findings can be confirmed in a more direct manner by investigating actual risk behaviours, either via data collected as part of routine STI case investigations or by stand-alone research studies. To my knowledge, the data and the interpretation described in section 7 are novel findings that have not been described or published by any other group and further investigation is warranted.

The results of section 6 suggest a line of investigation that emphasizes the prevention aspect of public health. This section described the pre- and post-SY positivity for both CT and NG. It suggested the long-term exhibition of high-risk sexual behaviours by individuals who ultimately

became infected by SY. The results also suggested the potential for behaviour change and/or the successful interruption of CTNG transmission within this group of individuals. At this stage, the results presented can be taken as proof of principle. The next steps required would be a refinement of the SY diagnosis dates used in this report (i.e. as noted, some of the SY cases were likely first diagnosed prior to 2014), as well as extending the analysis to include all individuals diagnosed with SY over the entire time course of the data available. Further stratification would also be possible in terms of gender, age and RHA. If the patterns described in this report continue to hold following a more refined investigation, the line of investigation could be extended to include other sexually transmitted and bloodborne pathogens, in particular HIV, Hepatitis C and Hepatitis B. The goal would be to assess whether the type of contact between an individual and the health care system and the results of that contact can be used to predict the likelihood of that person ultimately becoming infected with a pathogen such as HIV. In this report, individuals who became infected with SY were characterized by a long history of frequent CT and NG infections. If this approach can be refined, "gateway" infections of this type could be coupled to behavioural and other sociodemographic data to identify individuals at high risk of exposure to pathogens whose societal and personal cost typically far exceeds that of CT or NG.

To summarize, analyses of the type described in this report have demonstrated the ability to alter perceptions of pathogen transmission dynamics and clearly delineate a multi-faceted research program designed to advance STI control. Notably, the population-based testing program within Manitoba for CT and NG provides a unique opportunity to address questions that are not possible or feasible in other areas. The variation between RHAs (e.g. the different proportion of the population tested by RHA [section 2.1] and the variation in the likelihood of identifying a CT infection by RHA [section 1]) provide opportunities to investigate natural experiments that exist within the province. Overall, maintaining and expanding STI research and taking advantage of the unique opportunities inherent to STI testing in Manitoba, would ensure the province remains a national and international leader in this area.

RECOMMENDATIONS

To facilitate future research and program development, the above discussion is reworded below in the form of bulleted recommendations. These recommendations have been taken verbatim from the summary report prepared from this data.

Recommendations related to program evaluation

The evaluation described above used 17 years of CPL data originating from two different data storage formats. With assembly and common coding of this data complete, annual appending of new data and ongoing evaluation is now feasible. The recommendations below pertain specifically to development of an evaluation process.

- ***Program components to monitor***: Of the analyses described in the full report, the most informative were those reported in this summary and future evaluation should focus on:
  - proportion of population screened
  - number of individuals entering the testing cohort each year
  - positivity at time of index test
  - infection vs. incidence rates
  - per cent of infected individuals undergoing follow-up testing and positivity at follow-up
  - adjusted probability of identifying positive results over time

- ***Timeframe for monitoring***: Some program metrics show annual changes (e.g. the number of men and women newly accessing testing each year) while others change less frequently

(e.g. proportion of the population screened). Appropriate time frames should be established for monitoring each program metric to minimize impact on staff workload.

- ***Inclusion of appropriate denominator data*:** CT trends are heavily influenced by testing patterns and testing volumes and surveillance reports for this pathogen should only be carried out with appropriate denominator data. Trends for NG are not as dependent on test volumes and crude case counts can still be informative; however, especially for retrospective comparisons, appropriate denominator data does enhance interpretation of NG trends.

Recommendations related to expanding and refining the CTNG screening program

The analyses described in this report revealed several areas where the performance of the current CTNG screening program is suboptimal and the first three bullet points below focus on these areas. Many of the recommendations below are framed as investigational given that evidence may be lacking to definitively state how or when a program element should be prioritized or addressed.

- ***Proportion of the population screened***: A minority of individuals aged 14-29 are screened for CT and NG in Manitoba, however, a decision to pursue this program improvement requires additional evidence as follows:
  - Population screening varies by RHA and a comparison of program implementation in different parts of the province should be carried out to take advantage of these natural experiments and identify how population screening can be improved.
  - Modelling studies should be undertaken to demonstrate the expected effect of increased screening to determine the extent to which this program activity should be pursued.

- ***Improve follow-up testing***: A minority of individuals, especially men, are re-tested within six months of an index positive. For this aspect of testing, relevant issues to address are:
  - Attempt to re-contact and interview individuals who do not engage in follow-up testing. Before actively attempting to improve on existing re-test rates, it is necessary to assess the proportion of index test-positive individuals who typically would not require follow-up testing (e.g. many individuals may no longer be in a sexual partnership and face no risk of a new- or re-infection).
  - Regardless of what the above investigational area reveals, the much lower follow-up of males vs. females suggests that male re-testing should be improved. An initiative of this type would require a review of existing and/or development of new pilot projects to actively encourage more men to return for follow-up testing and identify barriers associated with male re-testing.
  - High positivity values identified with existing follow-up testing indicate that the recommended time frame for retesting (6 months) should be shortened (e.g. 3 months).

- ***Address the high-positivity for both CT and NG at follow-up***: The first step in this process is an assessment of whether follow-up positives reflect re-infection from an existing partner or acquisition of a new infection from a new partner(s).
  - Evaluate existing partner notification activities by linking the MB Health case/contact database with the CPL diagnostic database to reveal the number of contacts that submit specimens and the number of positive cases identified through these activities.
  - Carry out genotyping analysis of index and follow-up positives direct from NAAT specimens (PCR-based typing for CT and NG-MAST typing for NG) to identify the percentage of follow-up cases that represent new- vs. re-infections. This evidence will inform whether additional effort should be placed on partner notification and treatment of

existing partners *vs*. the development of pilot projects to assess how best to access the larger sexual network within which CT and NG cases are embedded (and which would be acting as the source of new infections).

- ***Urines as a diagnostic specimen***: Evidence presented suggested the availability of diagnostic testing with a urine specimen facilitated testing of women at a higher risk of infection. This possibility should be verified (e.g. prospectively linking behavioural data from STI investigation forms to CPL diagnostic data). If correct, the availability of this specimen type may allow additional targeting of high-risk individuals to improve detection rates and further interrupt transmission of both CT and NG.

Recommendation related to database linkages

The CT, NG and SY data linkage described in this report revealed information that was not previously evident as well as demonstrating the impact of a public health intervention activity. Therefore, this area of investigation should be expanded to include linkage of diagnostic data for all of CT, NG, SY, HIV, Hepatitis C, Hepatitis B and other relevant non-STI pathogens (e.g. tuberculosis). Additional linkages should be considered for any behavioural data available in existing surveillance databases. As demonstrated for SY, the purpose would be two-fold:

- To better understand infection risk over time and behavioural change after infection
- To improve the prevention aspect of public health. The use of indicator organisms, indicator behaviours and other social factors such as area of residence may improve predictive capacity to identify individuals at high risk of infection by pathogens such as HIV, before they become infected.

CONCLUSION

To date, this is the largest program evaluation for CT and NG utilizing both positive and negative diagnostic test results for these pathogens within the province of Manitoba. Despite the limited number of variables available, the analytic potential of the data proved far-reaching as both an evaluative tool and for highlighting areas where CT and NG screening can be improved in future. Given limited opportunity for increased funding levels, data of this kind can assist in determining how best to prioritize public health activities and/or redirect existing resources to maximize impact.

Appendix 1: History of CPL diagnostic testing for CT and NG

Year	Test name	Test manufacturer	Type of test	Rationale for implementation
<1988	Chlamydiazyme Gonozyme	Abbott Laboratories	ELISA	Initiation of province-wide screening program for CT and NG. These two tests were the only commercially available tests with a daily throughput that was sufficient for a high volume screening program.
1998	PACE 2	GenProbe	Nucleic acid probe	PACE 2 offered improved sensitivity over above tests. PACE 2 testing also offered CT and NG testing from one swab *vs*. two separate swabs required for Chlamydiazyme and Gonozyme.
	AMP-CT	GenProbe	Nucleic acid amplification	AMP-CT implemented to complement PACE 2 testing. Urine specimens were not suitable for PACE 2, therefore the AMP-CT test was necessary to allow this type of specimen to be tested.
2004	ProbeTec	Becton-Dickinson	Nucleic acid amplification	ProbeTec was implemented as a replacement for AMP-CT. ProbeTec offered partial automation and provided both CT and NG testing (AMP-CT tested for CT only).
2007	Aptima	GenProbe	Nucleic acid amplification	Aptima was implemented to replace all test types that were currently in use (PACE 2 and ProbeTec). Aptima offered a fully automated platform able to perform nucleic acid amplification testing for CT and NG on all commonly available specimen types (urines and swabs). Aptima also offered improved sensitivity over both PACE 2 and ProbeTec.

Appendix 2: Additional description of the main variables used for analysis.

Variable name	Coding	Notes
Requisition	Numeric, 8 digits (some observations have 5 or 6 digit requisition numbers when LIMS was first implemented).	This variable uniquely identifies a given specimen. It was necessary to de-duplicate this variable; duplication was an issue for some mainframe data where the same requisition could be associated with multiple specimen sources, patients or test results. Since this data formed a very small portion of the entire dataset (i.e. hundreds of observations relative to the 1.5 million observations in the dataset), duplicates were deleted, as discrepancies could not be accurately resolved.
PHIN	Numeric, 9 digits	PHIN was used to identify unique individuals within the dataset.
Age	Numeric	Individual's age at time of test. Ages range from 14-101
Gender	female; male	A very small number (<50) of individuals coded in LIMS as "U" or "A" were removed. Their small sample size would not be analyzable relative to the number of people identified as males or females.
Age groups	14-19; 20-24; 25-29; 30-39; >39	Based on age variable
RHA	ILE; NRHA; PMH; SRHA; WRHA	Numerous records from LIMS had a missing value for RHA if the postal code associated with a person's residence was not in our system. For these missing data, RHA was manually entered based on the person's residence address.
Received date	YMD format	The date a specimen was received at CPL. Because a received date is available for 100% of specimens (as opposed to a specimen collection date), this date was used as the default date for all specimen-related analyses. Dates range from 2000/01/01 to 2016/12/31
Specimen source	cervix; urethra; urine	Only the three main specimen types were retained. All other specimen types were deleted as they represented a very small proportion of the data.
Test type	PACE; NAAT	Describes the type of test used. NAAT covers all three types of NAAT testing that has been used at CPL.
CT result	Negative; Positive	Any ambiguous results (e.g. *unable to interpret*; *test result not available*) were removed. There are 1,515,344 of 1,516,368 observations with a CT result. The remaining 1,024 observations have a GC result only.
NG result	Negative; Positive	As per CT, ambiguous results were removed. There are 1,346,630 of 1,516,368 observations with a NG result. The greater number of CT-only results *vs*. NG-only is expected as it was not uncommon to test for CT-only prior to implementation of Aptima.

APPENDIX 3A: Summation of the 2000-2016 specimen-level data set stratified by RHA

	WRHA	NRHA	PMH	ILE	SRHA	Total
# CT a/o NG tests	907,100	201,969	150,974	124,957	131,368	1,516,868
# individuals tested	273,455	41,441	52,942	42,998	52,132	420,460
# tests/individual (range)	1-114	1-79	1-45	1-54	1-41	1 – 115
Mean # tests/individual	3.32	4.87	2.85	2.91	2.52	3.61
# CT tests	906,476	201,794	150,897	124,867	131,310	1,515,344
# positive CT tests (%)	46,102 (5.1)	22,307 (11.1)	8,525 (5.7)	7,929 (6.4)	5,865 (4.5)	90,728 (6.0)
# NG tests	790,989	182,306	142,586	115,019	115,728	1,346,628
# positive NG tests (%)	9,539 (1.2)	5,536 (3.0)	816 (0.6)	1,600 (1.4)	702 (0.6)	(1.4)
Sex						
Female	739,664 (81.5)	166,140 (82.3)	128,338 (85.0)	103,946 (83.2)	112,235 (85.4)	1,250,323 (82.5)
Male	167,436 (18.5)	35,829 (17.7)	22,636 (15.0)	21,011 (16.8)	19,133 (14.6)	266,045 (17.5)
Age						
14-19	116,821 (12.9)	37,799 (18.7)	23,237 (15.4)	22,024 (17.6)	19,395 (14.8)	219,276 (14.5)
20-24	210,387 (23.2)	50,828 (25.2)	41,561 (27.5)	30,831 (24,7)	34,359 (26.2)	367,966 (24.3)
25-29	188,883 (20.8)	39,846 (19.7)	31,493 (20.9)	22,931 (18.4)	26,961 (20.5)	310,114 (20.5)
30-39	242,398 (26.7)	45,094 22.3)	33,127 (21.9)	28,632 (22.9)	31,027 (23.6)	380,278 (25.1)
>39	148,611 (16.4)	28,402 (14.1)	21,556 (14.3)	20,539 (16.4)	19,626 (14.9)	238,734 (15.7)
Specimen source						
Cervix	630,452 (69.5)	129.538 (64.1)	111,584 (73.9)	87,949 (70.4)	98,368 (74.9)	1,057,891 (69.8)
Urethra	29,893 (3.3)	9,798 (4.9)	5,604 (3.7)	4,708 (3.8)	4,836 (3.7)	54,839 (3.6)
Urine	246,755 (27.2)	62,633 (31.0)	33,786 (22.4)	32,300 (25.9)	28,164 (21.4)	403,638 (26.6)
Year received						
2000	40233 (4.44)	9151 (4.53)	2074 (1.37)*	5833 (4.67)	4908 (3.74)	62199 (4.1)
2001	39897 (4.4)	8509 (4.21)	2242 (1.49)*	5566 (4.45)	5204 (3.96)	61418 (4.05)
2002	40222 (4.43)	8703 (4.31)	5928 (3.93)*	5798 (4.64)	5907 (4.5)	66558 (4.39)
2003	42748 (4.71)	9136 (4.52)	8018 (5.31)	5787 (4.63)	6175 (4.7)	71864 (4.74)
2004	44933 (4.95)	9958 (4.93)	8207 (5.44)	6563 (5.25)	6657 (5.07)	76318 (5.03)
2005	47199 (5.2)	10039 (4.97)	8782 (5.82)	6506 (5.21)	6704 (5.1)	79230 (5.22)
2006	50962 (5.62)	11093 (5.49)	9403 (6.23)	6965 (5.57)	7523 (5.73)	85946 (5.67)
2007	52157 (5.75)	11505 (5.7)	10055 (6.66)	7519 (6.02)	7778 (5.92)	89014 (5.87)
2008	55865 (6.16)	12677 (6.28)	11039 (7.31)	7769 (6.22)	8356 (6.36)	95706 (6.31)
2009	58500 (6.45)	12275 (6.08)	10479 (6.94)	8301 (6.64)	8583 (6.53)	98138 (6.47)
2010	59260 (6.53)	12373 (6.13)	10041 (6.65)	8282 (6.63)	8769 (6.68)	98725 (6.51)
2011	61651 (6.8)	13582 (6.72)	10630 (7.04)	8611 (6.89)	8976 (6.83)	103450 (6.82)
2012	62811 (6.92)	13463 (6.67)	10876 (7.2)	8419 (6.74)	9245 (7.04)	104814 (6.91)
2013	59808 (6.59)	13875 (6.87)	10402 (6.89)	8066 (6.46)	9141 (6.96)	101292 (6.68)
2014	60611 (6.68)	14107 (6.98)	10458 (6.93)	7809 (6.25)	8879 (6.76)	101864 (6.72)
2015	62655 (6.91)	14806 (7.33)	10803 (7.16)	8372 (6.7)	8874 (6.76)	105510 (6.96)
2016	67588 (7.45)	16717 (8.28)	11537 (7.64)	8791 (7.04)	9689 (7.38)	114322 (7.54)

**low specimen numbers from 2000-2002 for PMH would be associated with use of the PACE 2 test at Westman Laboratory. Any specimens that were tested at Westman were not available for inclusion in the above data. In 2003, this testing was moved to CPL.*

APPENDIX 4A: Final multivariable logistic regression model for the overall provincial data showing associations between a positive CT result and year of test, age group, specimen source, test type and RHA – FEMALES (n=1,249,490).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.03	0.97	1.10	0.376
2002	1.07	1.01	1.14	**0.033**
2003	1.09	1.03	1.16	**0.005**
2004	1.12	1.06	1.19	**<0.0001**
2005	0.93	0.88	0.99	**0.02**
2006	0.94	0.89	1.00	**0.045**
2007	0.95	0.89	1.01	0.104
2008	0.88	0.81	0.95	**0.001**
2009	0.75	0.69	0.81	**<0.0001**
2010	0.72	0.66	0.78	**<0.0001**
2011	0.71	0.66	0.77	**<0.0001**
2012	0.70	0.65	0.76	**<0.0001**
2013	0.69	0.64	0.75	**<0.0001**
2014	0.67	0.62	0.72	**<0.0001**
2015	0.68	0.63	0.74	**<0.0001**
2016	0.66	0.61	0.72	**<0.0001**
Age group				
14-19	Reference			
20-24	0.62	0.60	0.63	**<0.0001**
25-29	0.32	0.31	0.33	**<0.0001**
30-39	0.16	0.15	0.16	**<0.0001**
>39	0.07	0.07	0.08	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.28	1.27	1.30	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.82	1.72	1.93	**<0.0001**
RHA				
ILE	Reference			
NRHA	1.82	1.76	1.88	**<0.0001**
PMH	0.88	0.85	0.92	**<0.0001**
SRHA	0.70	0.67	0.73	**<0.0001**
WRHA	0.90	0.87	0.92	**<0.0001**

APPENDIX 4B: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – FEMALES; WRHA (n=739,137).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.08	0.99	1.18	**0.081**
2002	1.15	1.06	1.26	**0.001**
2003	1.14	1.05	1.24	**0.003**
2004	1.20	1.10	1.30	**<0.0001**
2005	0.95	0.88	1.04	0.267
2006	0.97	0.89	1.05	0.462
2007	0.97	0.89	1.07	0.582
2008	0.95	0.86	1.06	0.398
2009	0.82	0.73	0.91	**<0.0001**
2010	0.78	0.70	0.87	**<0.0001**
2011	0.74	0.66	0.83	**<0.0001**
2012	0.74	0.66	0.82	**<0.0001**
2013	0.69	0.62	0.77	**<0.0001**
2014	0.72	0.64	0.80	**<0.0001**
2015	0.73	0.65	0.81	**<0.0001**
2016	0.76	0.68	0.85	**<0.0001**
Age group				
14-19	Reference			
20-24	0.61	0.59	0.63	**<0.0001**
25-29	0.31	0.30	0.32	**<0.0001**
30-39	0.16	0.15	0.16	**<0.0001**
>39	0.08	0.08	0.09	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.29	1.27	1.31	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.90	1.76	2.06	**<0.0001**

APPENDIX 4C: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – FEMALES; NRHA (n=166,011).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	0.93	0.82	1.05	0.262
2002	0.94	0.83	1.06	0.331
2003	1.10	0.97	1.24	0.124
2004	0.97	0.86	1.09	0.588
2005	0.91	0.81	1.03	0.127
2006	0.87	0.77	0.98	**0.021**
2007	0.89	0.78	1.01	0.08
2008	0.73	0.62	0.85	**<0.0001**
2009	0.62	0.53	0.73	**<0.0001**
2010	0.65	0.56	0.76	**<0.0001**
2011	0.67	0.58	0.78	**<0.0001**
2012	0.62	0.53	0.72	**<0.0001**
2013	0.64	0.55	0.75	**<0.0001**
2014	0.59	0.51	0.69	**<0.0001**
2015	0.58	0.50	0.68	**<0.0001**
2016	0.52	0.45	0.61	**<0.0001**
Age group				
14-19	Reference			
20-24	0.63	0.61	0.66	**<0.0001**
25-29	0.37	0.36	0.39	**<0.0001**
30-39	0.18	0.17	0.19	**<0.0001**
>39	0.06	0.06	0.07	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.26	1.23	1.28	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.70	1.52	1.91	**<0.0001**

APPENDIX 4D: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – FEMALES; ILE (n=103,876).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.04	0.85	1.29	0.692
2002	1.11	0.91	1.37	0.298
2003	1.05	0.86	1.29	0.632
2004	1.28	1.05	1.55	0.014
2005	0.93	0.76	1.15	0.522
2006	0.95	0.78	1.17	0.652
2007	1.05	0.84	1.31	0.688
2008	0.95	0.73	1.24	0.702
2009	0.85	0.65	1.11	0.225
2010	0.80	0.62	1.05	0.107
2011	0.94	0.72	1.22	0.629
2012	0.96	0.74	1.25	0.776
2013	0.85	0.65	1.11	0.223
2014	0.77	0.59	1.01	0.055
2015	0.87	0.67	1.13	0.284
2016	0.89	0.69	1.16	0.398
Age group				
14-19	Reference			
20-24	0.63	0.59	0.68	**<0.0001**
25-29	0.31	0.28	0.34	**<0.0001**
30-39	0.15	0.13	0.16	**<0.0001**
>39	0.07	0.06	0.08	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.25	1.20	1.29	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.60	1.32	1.95	**<0.0001**

APPENDIX 4E: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – FEMALES; PMH (n=128,278). As noted in the text, in the first years of the study period, some specimens were sent to Westman Laboratory and were not part of this dataset. To avoid any bias that may create, the multivariable regression was reduce to years > 2005 with 2006 used as the reference year.

Year	AOR	95% CI		*p* value
2000				
2001				
2002				
2003				
2004				
2005				
2006	Reference			
2007	1.03	0.85	1.25	0.754
2008	0.91	0.72	1.15	0.412
2009	0.69	0.54	0.87	0.002
2010	0.65	0.51	0.83	**<0.0001**
2011	0.62	0.48	0.78	**<0.0001**
2012	0.62	0.49	0.79	**<0.0001**
2013	0.68	0.54	0.87	0.002
2014	0.61	0.48	0.77	**<0.0001**
2015	0.62	0.49	0.79	**<0.0001**
2016	0.53	0.41	0.67	**<0.0001**
Age group				
14-19	Reference			
20-24	0.60	0.56	0.65	**<0.0001**
25-29	0.27	0.24	0.30	**<0.0001**
30-39	0.15	0.13	0.17	**<0.0001**
>39	0.06	0.05	0.08	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.37	1.32	1.42	**<0.0001**
Test type				
NAP	Reference			
NAAT	2.04	1.68	2.47	**<0.0001**

APPENDIX 4F: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – FEMALES; SRHA (n=112,188).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.02	0.79	1.32	0.892
2002	1.16	0.91	1.48	0.227
2003	1.05	0.82	1.34	0.708
2004	1.26	1.00	1.60	0.053
2005	1.00	0.79	1.28	0.977
2006	1.12	0.88	1.42	0.345
2007	0.97	0.74	1.27	0.815
2008	1.03	0.74	1.44	0.861
2009	0.87	0.63	1.22	0.43
2010	0.76	0.54	1.06	0.104
2011	0.81	0.58	1.13	0.22
2012	0.87	0.62	1.21	0.394
2013	0.95	0.68	1.32	0.743
2014	0.78	0.56	1.09	0.152
2015	0.81	0.58	1.14	0.225
2016	0.71	0.51	1.00	**0.047**
Age group				
14-19	Reference			
20-24	0.60	0.56	0.65	**<0.0001**
25-29	0.29	0.26	0.32	**<0.0001**
30-39	0.13	0.12	0.15	**<0.0001**
>39	0.06	0.05	0.07	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.35	1.28	1.41	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.52	1.19	1.96	**0.001**

APPENDIX 5A: Final multivariable logistic regression model for overall provincial data showing associations between a positive CT result and year of test, age group, specimen source, test type and RHA – MALES; ALL MANITOBA (n=265,854).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	0.97	0.87	1.08	0.556
2002	0.93	0.84	1.02	0.133
2003	0.91	0.83	1.01	0.079
2004	0.90	0.82	0.99	0.032
2005	0.80	0.72	0.88	**<0.0001**
2006	0.74	0.67	0.82	**<0.0001**
2007	0.78	0.71	0.87	**<0.0001**
2008	0.78	0.71	0.87	**<0.0001**
2009	0.72	0.65	0.80	**<0.0001**
2010	0.70	0.63	0.77	**<0.0001**
2011	0.67	0.60	0.74	**<0.0001**
2012	0.64	0.58	0.71	**<0.0001**
2013	0.60	0.54	0.67	**<0.0001**
2014	0.61	0.55	0.68	**<0.0001**
2015	0.58	0.53	0.65	**<0.0001**
2016	0.60	0.54	0.67	**<0.0001**
Age group				
14-19	Reference			
20-24	0.84	0.81	0.87	**<0.0001**
25-29	0.58	0.56	0.60	**<0.0001**
30-39	0.36	0.34	0.37	**<0.0001**
>39	0.16	0.15	0.17	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.68	0.65	0.72	**<0.0001**
Test type				
NAP	Reference			
NAAT	2.31	2.14	2.50	**<0.0001**
RHA				
ILE	Reference			
NRHA	1.60	1.52	1.68	**<0.0001**
PMH	0.93	0.87	0.98	**<0.0001**
SRHA	0.78	0.73	0.83	**<0.0001**
WRHA	0.76	0.72	0.79	**<0.0001**

APPENDIX 5B: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – MALES; WRHA (n=167,399).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	0.95	0.82	1.09	0.472
2002	0.91	0.79	1.04	0.173
2003	0.93	0.81	1.06	0.291
2004	0.91	0.80	1.04	0.175
2005	0.82	0.72	0.95	**0.007**
2006	0.74	0.65	0.85	**<0.0001**
2007	0.77	0.67	0.89	**<0.0001**
2008	0.82	0.71	0.94	**0.006**
2009	0.71	0.62	0.82	**<0.0001**
2010	0.71	0.62	0.82	**<0.0001**
2011	0.63	0.55	0.73	**<0.0001**
2012	0.64	0.56	0.74	**<0.0001**
2013	0.57	0.49	0.66	**<0.0001**
2014	0.58	0.50	0.67	**<0.0001**
2015	0.58	0.50	0.67	**<0.0001**
2016	0.62	0.54	0.71	**<0.0001**
Age group				
14-19	Reference			
20-24	0.79	0.75	0.82	**<0.0001**
25-29	0.55	0.52	0.58	**<0.0001**
30-39	0.36	0.34	0.38	**<0.0001**
>39	0.17	0.16	0.18	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.62	0.57	0.67	**<0.0001**
Test type				
NAP	Reference			
NAAT	2.38	2.12	2.67	**<0.0001**

APPENDIX 5C: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – MALES; NRHA (n=35,783).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	0.93	0.76	1.15	0.51
2002	0.85	0.69	1.05	0.132
2003	0.89	0.73	1.09	0.253
2004	0.92	0.75	1.11	0.378
2005	0.88	0.72	1.07	0.195
2006	0.84	0.68	1.02	0.083
2007	0.81	0.66	0.99	**0.042**
2008	0.72	0.58	0.90	**0.003**
2009	0.76	0.61	0.94	**0.012**
2010	0.78	0.63	0.96	**0.021**
2011	0.75	0.61	0.93	**0.007**
2012	0.68	0.55	0.84	**<0.0001**
2013	0.66	0.54	0.82	**<0.0001**
2014	0.75	0.61	0.93	0.008
2015	0.60	0.49	0.74	**<0.0001**
2016	0.62	0.51	0.77	**<0.0001**
Age group				
14-19	Reference			
20-24	0.87	0.81	0.93	**<0.0001**
25-29	0.59	0.54	0.64	**<0.0001**
30-39	0.36	0.33	0.39	**<0.0001**
>39	0.14	0.12	0.16	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.71	0.64	0.80	**<0.0001**
Test type				
NAP	Reference			
NAAT	2.41	2.04	2.84	**<0.0001**

APPENDIX 5D: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – MALES; ILE (n=20,991).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	0.96	0.69	1.35	0.824
2002	0.98	0.71	1.35	0.898
2003	0.89	0.65	1.23	0.487
2004	0.85	0.62	1.17	0.319
2005	0.65	0.47	0.91	**0.011**
2006	0.51	0.37	0.72	**<0.0001**
2007	0.62	0.45	0.87	**0.005**
2008	0.64	0.45	0.90	**0.009**
2009	0.57	0.41	0.80	**0.001**
2010	0.61	0.43	0.85	**0.004**
2011	0.70	0.50	0.98	**0.036**
2012	0.56	0.40	0.78	**0.001**
2013	0.48	0.34	0.68	**<0.0001**
2014	0.52	0.37	0.73	**<0.0001**
2015	0.53	0.38	0.74	**<0.0001**
2016	0.55	0.40	0.76	**<0.0001**
Age group				
14-19	Reference			
20-24	0.86	0.77	0.96	**0.007**
25-29	0.62	0.54	0.70	**<0.0001**
30-39	0.35	0.31	0.41	**<0.0001**
>39	0.12	0.10	0.15	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.69	0.58	0.82	**<0.0001**
Test type				
NAP	Reference			
NAAT	2.55	1.97	3.32	**<0.0001**

APPENDIX 5E: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – MALES; PMH (n=22,619). As noted in the text, in the first years of the study period, some specimens were sent to Westman Laboratory and were not part of this dataset. To avoid any bias that may create the multivariable regression was reduced to years > 2005 with 2006 used as the reference year.

Year	AOR	95% CI		*p* value
2000	Reference			
2001				
2002				
2003				
2004				
2005				
2006				
2007	1.17	0.92	1.50	0.204
2008	1.03	0.80	1.33	0.801
2009	0.93	0.72	1.21	0.604
2010	0.75	0.57	0.97	**0.028**
2011	0.76	0.59	0.99	**0.041**
2012	0.82	0.64	1.06	0.138
2013	0.94	0.73	1.21	0.641
2014	0.78	0.60	1.00	0.054
2015	0.78	0.60	1.01	0.058
2016	0.67	0.51	0.86	**0.002**
Age group				
14-19	Reference			
20-24	0.97	0.86	1.09	0.608
25-29	0.63	0.55	0.73	**<0.0001**
30-39	0.37	0.32	0.43	**<0.0001**
>39	0.11	0.09	0.15	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.72	0.62	0.84	**<0.0001**
Test type				
NAP	Reference			
NAAT	2.52	1.85	3.43	**<0.0001**

APPENDIX 5F: Final multivariable logistic regression model of associations between a positive CT result and year of test, age group, specimen source and test type – MALES; SRHA (n=19,122).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.18	0.75	1.86	0.474
2002	1.52	1.00	2.31	**0.05**
2003	1.12	0.73	1.72	0.604
2004	0.95	0.63	1.45	0.827
2005	0.92	0.60	1.42	0.714
2006	0.93	0.61	1.41	0.737
2007	1.07	0.70	1.65	0.75
2008	1.00	0.65	1.56	0.988
2009	1.02	0.66	1.58	0.93
2010	0.82	0.53	1.27	0.374
2011	0.91	0.59	1.40	0.667
2012	0.75	0.48	1.16	0.191
2013	0.84	0.55	1.29	0.425
2014	0.78	0.51	1.21	0.27
2015	0.73	0.47	1.12	0.15
2016	0.77	0.50	1.18	0.225
Age group				
14-19	Reference			
20-24	0.95	0.83	1.07	0.391
25-29	0.69	0.59	0.80	**<0.0001**
30-39	0.37	0.31	0.43	**<0.0001**
>39	0.16	0.13	0.20	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.85	0.71	1.00	**0.053**
Test type				
NAP	Reference			
NAAT	1.75	1.33	2.29	**<0.0001**

APPENDIX 6A: Final multivariable logistic regression model for overall provincial data showing associations between a positive NG result and year of test, age group, specimen source, test type and RHA – FEMALES; ALL MANITOBA (n= 1,096,137).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.02	0.84	1.25	0.84
2002	0.93	0.77	1.14	0.489
2003	1.30	1.08	1.55	**0.005**
2004	1.38	1.16	1.64	**<0.0001**
2005	1.41	1.19	1.67	**<0.0001**
2006	1.62	1.37	1.91	**<0.0001**
2007	1.19	0.99	1.42	0.06
2008	0.79	0.65	0.96	**0.017**
2009	0.57	0.47	0.70	**<0.0001**
2010	0.49	0.41	0.60	**<0.0001**
2011	0.52	0.43	0.63	**<0.0001**
2012	0.62	0.51	0.75	**<0.0001**
2013	0.53	0.44	0.65	**<0.0001**
2014	0.48	0.40	0.59	**<0.0001**
2015	0.44	0.36	0.54	**<0.0001**
2016	0.79	0.66	0.96	**0.017**
Age group				
14-19	Reference			
20-24	0.67	0.63	0.70	**<0.0001**
25-29	0.44	0.42	0.47	**<0.0001**
30-39	0.25	0.24	0.27	**<0.0001**
>39	0.13	0.11	0.14	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.47	1.43	1.51	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.75	1.56	1.96	**<0.0001**
RHA				
ILE	Reference			
NRHA	2.30	2.13	2.48	**<0.0001**
PMH	0.41	0.37	0.46	**<0.0001**
SRHA	0.41	0.37	0.47	**<0.0001**
WRHA	0.94	0.87	1.01	0.095

APPENDIX 6B: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – FEMALES; WRHA (n=634,496).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.06	0.80	1.42	0.675
2002	0.79	0.59	1.07	0.126
2003	1.38	1.07	1.79	**0.014**
2004	1.62	1.26	2.07	**<0.0001**
2005	1.47	1.15	1.88	**0.002**
2006	1.81	1.42	2.30	**<0.0001**
2007	1.12	0.86	1.45	0.412
2008	0.70	0.52	0.93	**0.014**
2009	0.59	0.44	0.79	**<0.0001**
2010	0.42	0.31	0.56	**<0.0001**
2011	0.47	0.36	0.63	**<0.0001**
2012	0.69	0.52	0.92	**0.01**
2013	0.48	0.36	0.64	**<0.0001**
2014	0.41	0.31	0.55	**<0.0001**
2015	0.44	0.33	0.58	**<0.0001**
2016	1.14	0.87	1.49	0.356
Age group				
14-19	Reference			
20-24	0.58	0.54	0.62	**<0.0001**
25-29	0.38	0.35	0.41	**<0.0001**
30-39	0.22	0.20	0.24	**<0.0001**
>39	0.14	0.12	0.16	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.47	1.41	1.52	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.84	1.57	2.16	**<0.0001**

APPENDIX 6C: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – FEMALES; NRHA (n=147,677).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	0.83	0.59	1.18	0.31
2002	1.03	0.75	1.43	0.842
2003	1.20	0.89	1.63	0.229
2004	1.15	0.85	1.55	0.361
2005	1.57	1.19	2.08	**0.002**
2006	1.59	1.21	2.09	**0.001**
2007	1.46	1.09	1.96	**0.012**
2008	1.06	0.77	1.46	0.733
2009	0.64	0.46	0.89	**0.008**
2010	0.74	0.53	1.02	0.069
2011	0.74	0.53	1.02	0.062
2012	0.58	0.42	0.81	**0.001**
2013	0.65	0.47	0.90	**0.01**
2014	0.65	0.47	0.90	**0.01**
2015	0.52	0.37	0.72	**<0.0001**
2016	0.46	0.33	0.64	**<0.0001**
Age group				
14-19	Reference			
20-24	0.81	0.74	0.88	**<0.0001**
25-29	0.56	0.50	0.62	**<0.0001**
30-39	0.33	0.29	0.37	**<0.0001**
>39	0.09	0.07	0.12	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.41	1.35	1.47	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.52	1.25	1.84	**<0.0001**

APPENDIX 6D: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – FEMALES; ILE (n=95,067).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.50	0.89	2.54	0.126
2002	1.23	0.73	2.09	0.439
2003	1.38	0.83	2.31	0.215
2004	1.09	0.65	1.82	0.74
2005	1.10	0.65	1.83	0.73
2006	1.12	0.68	1.85	0.666
2007	1.12	0.65	1.91	0.682
2008	0.55	0.29	1.03	0.062
2009	0.47	0.25	0.88	**0.019**
2010	0.45	0.24	0.85	**0.014**
2011	0.45	0.24	0.83	**0.012**
2012	0.61	0.33	1.13	0.116
2013	0.67	0.36	1.22	0.188
2014	0.47	0.25	0.88	**0.018**
2015	0.38	0.20	0.71	**0.003**
2016	0.82	0.45	1.48	0.512
Age group				
14-19	Reference			
20-24	0.63	0.53	0.74	**<0.0001**
25-29	0.40	0.32	0.49	**<0.0001**
30-39	0.24	0.19	0.31	**<0.0001**
>39	0.11	0.07	0.16	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.39	1.27	1.52	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.67	1.13	2.47	**0.009**

APPENDIX 6E: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – FEMALES; PMH (n=95,156).

Year	AOR	95% CI		*p* value
2000				
2001				
2002				
2003				
2004				
2005				
2006	Reference			
2007	0.64	0.35	1.17	0.149
2008	0.49	0.25	0.95	**0.034**
2009	0.19	0.09	0.39	**<0.0001**
2010	0.11	0.05	0.24	**<0.0001**
2011	0.15	0.07	0.31	**<0.0001**
2012	0.20	0.10	0.41	**<0.0001**
2013	0.18	0.09	0.37	**<0.0001**
2014	0.28	0.14	0.55	**<0.0001**
2015	0.19	0.09	0.38	**<0.0001**
2016	0.18	0.09	0.35	**<0.0001**
Age group				
14-19	Reference			
20-24	0.72	0.56	0.93	**0.013**
25-29	0.49	0.36	0.66	**<0.0001**
30-39	0.23	0.16	0.34	**<0.0001**
>39	0.08	0.04	0.17	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.80	1.59	2.04	**<0.0001**
Test type				
NAP	Reference			
NAAT	3.38	1.87	6.14	**<0.0001**

APPENDIX 6F: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – FEMALES; SRHA (n=97,968).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	0.85	0.12	6.07	0.875
2002	2.76	0.60	12.81	0.194
2003	2.89	0.63	13.20	0.171
2004	1.95	0.41	9.21	0.398
2005	2.80	0.64	12.29	0.171
2006	4.70	1.12	19.72	**0.034**
2007	2.24	0.49	10.15	0.297
2008	1.49	0.30	7.28	0.623
2009	1.56	0.32	7.55	0.582
2010	1.15	0.24	5.63	0.861
2011	0.60	0.12	3.09	0.545
2012	1.45	0.30	6.99	0.642
2013	1.25	0.26	6.04	0.778
2014	0.74	0.15	3.63	0.706
2015	0.83	0.17	4.03	0.815
2016	1.37	0.29	6.53	0.692
Age group				
14-19	Reference			
20-24	0.89	0.68	1.16	0.382
25-29	0.54	0.39	0.75	**<0.0001**
30-39	0.31	0.22	0.46	**<0.0001**
>39	0.26	0.16	0.43	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	1.93	1.68	2.22	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.91	0.98	3.71	0.057

APPENDIX 7A: Final multivariable logistic regression model for overall provincial data showing associations between a positive NG result and year of test, age group, specimen source, test type and RHA – MALES; ALL MANITOBA (n= 250,491).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.14	0.93	1.39	0.207
2002	0.91	0.75	1.11	0.364
2003	1.11	0.92	1.34	0.256
2004	1.36	1.14	1.63	**0.001**
2005	1.39	1.17	1.66	**<0.0001**
2006	1.75	1.47	2.08	**<0.0001**
2007	1.33	1.11	1.59	**0.002**
2008	1.06	0.88	1.28	0.533
2009	0.78	0.65	0.95	**0.014**
2010	0.68	0.56	0.83	**<0.0001**
2011	0.68	0.56	0.83	**<0.0001**
2012	0.92	0.76	1.10	0.356
2013	0.79	0.66	0.96	**0.017**
2014	0.72	0.59	0.87	**0.001**
2015	0.65	0.54	0.79	**<0.0001**
2016	1.21	1.01	1.45	**0.042**
Age group				
14-19	Reference			
20-24	0.84	0.79	0.90	**<0.0001**
25-29	0.69	0.64	0.74	**<0.0001**
30-39	0.58	0.54	0.62	**<0.0001**
>39	0.45	0.42	0.49	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.52	0.48	0.58	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.38	1.22	1.57	**<0.0001**
RHA				
ILE	Reference			
NRHA	1.66	1.53	1.81	**<0.0001**
PMH	0.44	0.38	0.49	**<0.0001**
SRHA	0.52	0.46	0.59	**<0.0001**
WRHA	0.83	0.77	0.90	**<0.0001**

APPENDIX 7B: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – MALES; WRHA (n=156,493).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.13	0.85	1.50	0.392
2002	0.80	0.60	1.06	0.125
2003	1.15	0.88	1.50	0.293
2004	1.41	1.09	1.81	**0.008**
2005	1.59	1.23	2.04	**<0.0001**
2006	1.96	1.53	2.51	**<0.0001**
2007	1.31	1.01	1.71	**0.04**
2008	0.99	0.75	1.29	0.92
2009	0.76	0.58	1.00	0.053
2010	0.62	0.47	0.82	**0.001**
2011	0.59	0.45	0.78	**<0.0001**
2012	0.98	0.76	1.28	0.91
2013	0.72	0.55	0.94	**0.018**
2014	0.59	0.45	0.78	**<0.0001**
2015	0.68	0.52	0.89	**0.005**
2016	1.43	1.11	1.85	**0.006**
Age group	Reference			
14-19	0.76	0.69	0.84	**<0.0001**
20-24	0.62	0.56	0.68	**<0.0001**
25-29	0.55	0.50	0.61	**<0.0001**
30-39	0.47	0.43	0.52	**<0.0001**
>39				
Specimen source				
Cervix	Reference			
Urine	0.44	0.38	0.50	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.42	1.18	1.70	**<0.0001**

APPENDIX 7C: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – MALES; NRHA (n=34,629).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	0.97	0.69	1.37	0.874
2002	1.01	0.72	1.41	0.95
2003	0.91	0.65	1.27	0.568
2004	1.37	1.01	1.86	**0.046**
2005	1.29	0.94	1.76	0.11
2006	1.55	1.14	2.09	**0.005**
2007	1.56	1.14	2.14	**0.005**
2008	1.39	1.00	1.94	0.052
2009	1.05	0.74	1.48	0.786
2010	0.92	0.65	1.30	0.632
2011	1.03	0.74	1.44	0.874
2012	0.93	0.67	1.31	0.689
2013	1.07	0.77	1.49	0.688
2014	1.09	0.78	1.52	0.626
2015	0.75	0.53	1.06	0.102
2016	0.90	0.64	1.25	0.527
Age group				
14-19	Reference			
20-24	0.92	0.82	1.03	0.168
25-29	0.75	0.66	0.86	**<0.0001**
30-39	0.56	0.48	0.64	**<0.0001**
>39	0.32	0.27	0.39	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.63	0.54	0.75	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.30	1.02	1.65	**0.034**

APPENDIX 7D: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – MALES; ILE (n=19,952).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.41	0.82	2.42	0.218
2002	1.41	0.83	2.38	0.202
2003	1.16	0.68	1.97	0.582
2004	1.17	0.70	1.95	0.553
2005	1.04	0.61	1.76	0.889
2006	1.42	0.86	2.35	0.17
2007	1.15	0.68	1.94	0.61
2008	0.72	0.41	1.29	0.273
2009	0.51	0.28	0.94	**0.03**
2010	0.68	0.38	1.20	0.181
2011	0.58	0.33	1.04	0.068
2012	0.75	0.43	1.31	0.304
2013	0.53	0.29	0.95	**0.033**
2014	0.52	0.29	0.94	**0.031**
2015	0.51	0.28	0.90	**0.02**
2016	0.92	0.54	1.57	0.756
Age group				
14-19	Reference			
20-24	0.87	0.70	1.08	0.213
25-29	0.74	0.58	0.95	**0.016**
30-39	0.77	0.61	0.97	**0.025**
>39	0.44	0.34	0.58	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.76	0.53	1.09	0.133
Test type				
NAP	Reference			
NAAT	0.93	0.60	1.44	0.74

APPENDIX 7E: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – MALES; PMH (n=18,516).

Year	AOR	95% CI		*p* value
2000				
2001				
2002				
2003				
2004				
2005				
2006	Reference			
2007	0.78	0.44	1.38	0.396
2008	0.96	0.54	1.71	0.898
2009	0.45	0.23	0.86	**0.016**
2010	0.45	0.23	0.86	**0.016**
2011	0.49	0.26	0.93	**0.03**
2012	0.61	0.33	1.13	0.113
2013	0.58	0.31	1.08	0.084
2014	0.85	0.48	1.53	0.594
2015	0.32	0.16	0.64	**0.001**
2016	0.80	0.45	1.44	0.461
Age group				
14-19	Reference			
20-24	0.90	0.65	1.23	0.501
25-29	0.65	0.45	0.93	**0.02**
30-39	0.50	0.34	0.74	**0.001**
>39	0.40	0.25	0.63	**<0.0001**
Specimen source				
Cervix	Reference			
Urine	0.49	0.35	0.69	**<0.0001**
Test type				
NAP	Reference			
NAAT	1.91	0.99	3.69	0.055

APPENDIX 7F: Final multivariable logistic regression model of associations between a positive GC result and year of test, age group, specimen source and test type – MALES; SRHA (n=17,760).

Year	AOR	95% CI		*p* value
2000	Reference			
2001	1.43	0.34	6.06	0.629
2002	1.05	0.25	4.45	0.946
2003	2.05	0.56	7.45	0.277
2004	1.93	0.55	6.81	0.306
2005	2.43	0.71	8.36	0.157
2006	3.23	0.97	10.81	0.057
2007	2.54	0.73	8.78	0.142
2008	1.87	0.52	6.74	0.335
2009	1.64	0.46	5.92	0.448
2010	1.34	0.37	4.85	0.655
2011	0.94	0.26	3.46	0.925
2012	1.46	0.41	5.21	0.562
2013	2.06	0.59	7.23	0.259
2014	1.24	0.34	4.48	0.743
2015	1.15	0.32	4.17	0.829
2016	2.40	0.69	8.31	0.168
Age group				
14-19	Reference			
20-24	1.21	0.87	1.69	0.261
25-29	1.17	0.82	1.68	0.377
30-39	0.72	0.49	1.05	0.091
>39	0.63	0.42	0.95	**0.027**
Specimen source				
Cervix	Reference			
Urine	0.58	0.41	0.82	**0.002**
Test type				
NAP	Reference			
NAAT	1.16	0.69	1.97	0.569

Appendix 8: Population estimates, number of individuals tested for CTNG and percent of the population tested for the years 2001, 2006, 2011, and 2016 – males and females.

		Males	Females		Males	Females		Males	Females		Males	Females
			2001			2006			2011			2016
MANITOBA												
Population	14-19	50926	48283		53249	51221		53184	51389		52828	49435
	20-24	39885	38315		42999	40457		44651	43300		49079	46417
	25-29	39311	37086		38971	37515		42439	41677		47776	46908
	30-39	85441	82023		77506	75017		77989	80407		87850	89702
	>39	240490	261023		264958	282039		280106	292307		297291	308260
	Total	456053	466730		477683	486249		498369	509080		534824	540722
Individuals	14-19	863	6127		1,280	7,677		2,212	9,232		2,091	6,600
tested	20-24	1572	10441		2,883	13,303		3,770	14,101		4,354	12,709
	25-29	1195	9041		2,243	11,311		3,127	12,780		3,951	13,548
	30-39	1391	11849		2,622	14,761		3,665	16,286		5,283	19,188
	>39	1093	6278		2,520	10,071		3,478	10,795		5,222	11,600
% of POPN	14-19	1.7	12.7		2.4	15.0		4.2	18.0		4.0	13.4
	20-24	3.9	27.3		6.7	32.9		8.4	32.6		8.9	27.4
	25-29	3.0	24.4		5.8	30.2		7.4	30.7		8.3	28.9
	30-39	1.6	14.4		3.4	19.7		4.7	20.3		6.0	21.4
	>39	0.5	2.4		1.0	3.6		1.2	3.7		1.8	3.8
WRHA												
Population	14-19	26056	25248		27530	26912		27816	27113		27829	25724
	20-24	23934	23860		25788	24977		26293	26067		28226	26655
	25-29	24031	22883		24274	23525		25965	25821		29558	30210
	30-39	50501	48309		45795	44362		46482	48158		55308	56314
	>39	134564	153170		148388	164466		157075	169976		169089	179656
	Total	259086	273470		271775	284242		283631	297135		310010	318559
Individuals	14-19	467	3,600		660	3,923		1,143	4,815		1,096	3,400
tested	20-24	922	6,762		1,667	7,469		2,151	7,973		2,599	7,246
	25-29	797	6,043		1,443	6,846		1,979	7,807		2,509	7,983
	30-39	944	7,932		1,797	9,151		2,365	10,337		3,424	12,276
	>39	797	3,963		1,816	5,648		2,489	6,531		3,556	7,025
% of POPN	14-19	1.8	14.3		2.4	14.6		4.1	17.8		3.9	13.2
	20-24	3.9	28.3		6.5	29.9		8.2	30.6		9.2	27.2
	25-29	3.3	26.4		5.9	29.1		7.6	30.2		8.5	26.4
	30-39	1.9	16.4		3.9	20.6		5.1	21.5		6.2	21.8
	>39	0.6	2.6		1.2	3.4		1.6	3.8		2.1	3.9
PMH												
Population	14-19	7451	6981		7243	7018		6607	6442		6336	6248
	20-24	4981	4656		5280	4829		5498	5287		5660	5345
	25-29	4719	4473		4600	4371		5275	4962		5835	5373
	30-39	10380	10113		9274	9013		9707	9791		9921	10167

	>39	36940	39682		38658	41033		39202	40698		39292	40916
	Total	64471	65905		65055	66264		66289	67180		67044	68049
Individuals	14-19	58	325		141	1,094		227	1,110		183	742
tested	20-24	89	527		329	1,919		421	1,793		411	1,514
	25-29	43	358		194	1,402		296	1,481		352	1,648
	30-39	36	319		161	1,463		342	1,673		462	2,092
	>39	22	178		139	1,120		220	1,148		336	1,420
% of POPN	14-19	0.8	4.7		1.9	15.6		3.4	17.2		2.9	11.9
	20-24	1.8	11.3		6.2	39.7		7.7	33.9		7.3	28.3
	25-29	0.9	8.0		4.2	32.1		5.6	29.8		6.0	30.7
	30-39	0.3	3.2		1.7	16.2		3.5	17.1		4.7	20.6
	>39	0.1	0.4		0.4	2.7		0.6	2.8		0.9	3.5
ILE												
Population	14-19	5635	5022		5913	5428		5829	5509		5400	5099
	20-24	3322	2773		3663	3044		3904	3464		4376	4123
	25-29	3165	2736		2808	2512		3148	2829		3442	3019
	30-39	8121	7918		7059	6859		6469	6585		6459	6274
	>39	27418	26702		31437	30595		33287	32133		34642	34009
	Total	47661	45151		50880	48438		52637	50520		54319	52524
Individuals	14-19	81	669		124	819		205	1,014		208	655
tested	20-24	146	968		257	1,126		324	1,255		369	1,030
	25-29	88	766		170	801		230	958		305	1,020
	30-39	110	1,140		161	1,201		256	1,217		404	1,310
	>39	97	622		206	887		247	1,050		424	940
% of POPN	14-19	1.4	13.3		2.1	15.1		3.5	18.4		3.9	12.8
	20-24	4.4	34.9		7.0	37.0		8.3	36.2		8.4	25.0
	25-29	2.8	28.0		6.1	31.9		7.3	33.9		8.9	33.8
	30-39	1.4	14.4		2.3	17.5		4.0	18.5		6.3	20.9
	>39	0.4	2.3		0.7	2.9		0.7	3.3		1.2	2.8
NRHA												
Population	14-19	3680	3572		4106	4004		4030	3871		3947	3670
	20-24	2453	2463		2702	2610		2972	2886		3228	3066
	25-29	2617	2534		2432	2441		2582	2626		2804	2751
	30-39	5357	4993		5001	4733		4505	4635		4446	4751
	>39	10472	9534		11592	10598		12335	11410		12570	12051
	Total	24579	23096		25833	24386		26424	25428		26995	26289
Individuals	14-19	195	955		244	1,115		463	1,318		413	1,120
tested	20-24	292	1,158		381	1,373		497	1,560		590	1,560
	25-29	192	1,039		284	1,112		368	1,238		468	1,465
	30-39	221	1,369		338	1,601		395	1,548		557	1,699
	>39	109	873		202	1,382		327	1,096		520	1,251
% of POPN	14-19	5.3	26.7		5.9	27.8		11.5	34.0		10.5	30.5
	20-24	11.9	47.0		14.1	52.6		16.7	54.1		18.3	50.9

	25-29	7.3	41.0		11.7	45.6		14.3	47.1		16.7	53.3
	30-39	4.1	27.4		6.8	33.8		8.8	33.4		12.5	35.8
	>39	1.0	9.2		1.7	13.0		2.7	9.6		4.1	10.4
SRHA												
Population	14-19	8104	7460		8457	7859		8902	8454		9316	8694
	20-24	5195	4563		5566	4997		5984	5596		7589	7228
	25-29	4779	4460		4857	4666		5469	5439		6137	5555
	30-39	11082	10690		10377	10050		10826	11238		11716	12196
	>39	31096	31935		34883	35347		38207	38090		41698	41628
	Total	60256	59108		64140	62919		69388	68817		76456	75301
Individuals	14-19	62	578		111	726		174	975		191	683
tested	20-24	123	1,026		249	1,416		377	1,520		385	1,359
	25-29	75	835		152	1,150		254	1,296		317	1,432
	30-39	80	1,089		165	1,345		307	1,511		436	1,811
	>39	68	642		157	1,034		195	970		386	964
% of POPN	14-19	0.8	7.7		1.3	9.2		2.0	11.5		2.1	7.9
	20-24	2.4	22.5		4.5	28.3		6.3	27.2		5.1	18.8
	25-29	1.6	18.7		3.1	24.6		4.6	23.8		5.2	25.8
	30-39	0.7	10.2		1.6	13.4		2.8	13.4		3.7	14.8
	>39	0.2	2.0		0.5	2.9		0.5	2.5		0.9	2.3