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EPIDEMIOLOGICAL ANALYSIS OF CHLAMYDIA AND GONORRHEA CASES IN LA CROSSE COUNTY, WISCONSIN FROM 2001 TO 2020

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EPIDEMIOLOGICAL ANALYSIS OF CHLAMYDIA AND GONORRHEA CASES IN LA CROSSE COUNTY, WISCONSIN FROM 2001 TO 2020

By Abigail Multerer

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Clinical Microbiology.

The candidate has completed the oral defense of the thesis.

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ABSTRACT

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Over 20 million people are diagnosed with a sexually transmitted infection each year in the United States (US). *Chlamydia trachomatis* and *Neisseria gonorrhoeae* are the two most reported bacterial infections in the US, with over 1.5 million and 500,000 cases in 2019, respectively. However, these numbers are likely vastly underreported, in part due to the asymptomatic nature of both chlamydia and gonorrhea. Despite being underreported, chlamydia and gonorrhea infections continue to rise every year in the US. In addition to rising case numbers, it has been shown that significant disparities exist in the rate of infection between age, race, and sex demographic classifications at the national level. Although, the disparities in chlamydia and gonorrhea infections have been well described in the US, little research has been done on a smaller community scale, such as La Crosse County, where both chlamydia and gonorrhea cases have more than doubled in the past two decades. Through analyzing the demographics of the cases in La Crosse County, we have found that certain demographic groups carry a higher rate of infection. The hope is that these findings can provide insight on how to better target prevention and detection of chlamydia and gonorrhea in La Crosse County.

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TABLE OF CONTENTS

PAGE

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

INTRODUCTION

Sexually Transmitted Infections

In the United States (US), an estimated 20 million people are newly diagnosed with a sexually transmitted infection (STI) each year. Microorganisms that cause STIs include: *Chlamydia trachomatis, Neisseria gonorrhoeae*, *Treponema pallidum* ssp. *pallidum*, human papilloma viruses (HPV), herpes simplex viruses, hepatitis B and C viruses, *Haemophilus ducreyi, Trichomonas vaginalis,* and human immunodeficiency viruses (HIV). [1] In the US in 2019, *C. trachomatis* and *N. gonorrhoeae* infections, were the first (over 1.5 million) and second (over 500,000) most reported bacterial infections. [2,3] However, the actual number of *C. trachomatis* and *N. gonorrhoeae* infections are likely double the values reported by the Centers for Disease Control and Prevention (CDC). This underreporting of cases is due in part to the asymptomatic nature of both infections. [1,4]

Clinical Manifestations of Uncomplicated Infections

Chlamydial and gonococcal infections occur due to direct sexual contact, resulting in infections in the urogenital tract, pharynx, or rectum. Unfortunately, up to 77% of individuals infected with *C. trachomatis* and approximately 50% of *N. gonorrhoeae* infections are asymptomatic.[5] Symptomatic males may experience urethritis, painful urination, and penile discharge, whereas, females may display abnormal vaginal discharge, bleeding, or urethritis.[6] Those with pharyngeal infections

rarely experience symptoms, but pharyngitis may occur. Males and females with rectal chlamydia infections are often asymptomatic; however, rectal pain, discharge, or bleeding may occur.[7]

Associated Sequelae

Due to the high propensity for chlamydia and gonorrhea infections to be asymptomatic, both infections often go undiagnosed, and therefore, untreated for long periods of time. The possible complications associated with long-term infections by *C. trachomatis* and *N. gonorrhoeae* result in substantial morbidity, as well as an increased risk for contracting HIV and HPV.[4,8] Patients infected with either *C. trachomatis* or *N. gonorrhoeae* can autoinoculate themselves, causing infections at other body sites.[8-10] Moreover, women with untreated urogenital infections may develop pelvic inflammatory disease (PID), tubal factor infertility (TFI), chronic pelvic pain, and ectopic pregnancies. Pregnant women infected with *C. trachomatis* and *N. gonorrhoeae* have poor maternal outcomes, such as premature labor, premature rupture of amniotic membrane, and post-partem uterine infections. *C. trachomatis* and *N. gonorrhoeae* cause infections in 100,000 and 10,000 pregnant women per year, respectively.[9] Men can also have complications that include prostatitis and testicular pain due to epididymitis. Individuals with long term infections can also experience extremely rare complications, such as reactive arthritis or disseminated gonococcal infections.[4, 6-8]

Chlamydial infections may also be a contributing factor for certain cancers, such as anal and cervical cancers.[4, 8] Rectal infections have been shown to cause proctitis, inflammation of the anus and rectal lining. Infections of the oropharynx, rarely cause symptoms, however, pharyngitis may occur.[7-10]

Besides the onset of complicated chlamydia and gonorrhea infections, an infected woman can transmit *C. trachomatis* and *N. gonorrhoeae* to their newborn infants through vaginal delivery. Many infants infected with *C. trachomatis* can experience trachoma, the most common cause of infectious blindness, and pneumonia.[6] Moreover, infants infected with *N. gonorrhoeae* can develop infections of their eyes, joints, or bloodstream.[11]

Infertility

Long-term chlamydia and gonorrhea infections in women often result in PID and approximately 9% of the world's women suffer from infertility, including 1.5 million in the US.[12] In the US, the most common known cause of infertility (approximately 30%) is due to TFI. As mentioned above, TFI is a complication that can occur due to long-term chlamydia and/or gonorrhea infection, such as salpingitis that is an inflammation of the fallopian tubes.[12] Salpingitis occurs when bacteria travel from the cervix into the endometrium where infection eventually reaches the fallopian tubes and generally presents as PID. Chlamydia accounts for 50% and gonorrhea results in 20% of all PID diagnoses. However, many people are asymptomatic. Salpingitis caused by chlamydia infections is characterized by tubal scarring and occlusions, which are due to an inflammatory response to increased heat shock protein produced by *C. trachomatis. N. gonorrhoeae* causes salpingitis by directly attacking the fallopian tubes, sloughing off the ciliated mucosal cells and reducing the ability to move the ovum into the uterus.[12] Longer and more frequent chlamydia or gonorrhea infections in women, often due to asymptomatic infections, increase the likelihood for PID and subsequent TFI, making *C. trachomatis* and *N. gonorrhoeae* infections the most important and preventable known causes of infertility.[12]

High Risk Associations

While any person who is sexually active is at risk for chlamydia and gonorrhea infections, certain groups of people are known to be at higher risk for contracting *C. trachomatis* and *N. gonorrhoeae.* These risk factors include the following: 15-24 years old, a female, a racial/ethnic minority, multiple sexual partners, low income, an individual with low access to healthcare, poorly educated, and receptive to anal sex.[1,4,9,13-15]

Approximately 50% of all new STIs diagnosed each year in the US, including 66% of *C. trachomatis* and 50% of *N. gonorrhoeae* infections, are in individuals 15-24 years old who only make up about 25% of the US population.[1,4] Diagnosis barriers for young individuals include: stigma related to STIs, lack of knowledge in where and how to get tested, lack of knowledge that infections may be asymptomatic, and poor communication with parents regarding STIs.[16,17] Individuals between the ages of 19 and 36 are the most likely to be uninsured.[18,19] Additionally, individuals between the ages of 15-24 are likely to have multiple sex partners and not use condoms regularly, both of which increase the probability of contracting chlamydia and gonorrhea.[20]

Young women (15-24 years old) are twice as likely to be diagnosed with chlamydia than men of the same age.[1] A possible contributing factor to this disparity may be that women with bacterial vaginosis (BV) have been shown to be up to 25% more likely to become infected with *C. trachomatis* and *N. gonorrhoeae* than women without BV.[21] Because men are at a much lower risk to acquire complications from asymptomatic infections than women, men are not routinely screened for chlamydia, which could account for some of the disparity in rates of infections between the sexes.[4]

Race and ethnicity, like age or sex, also show infection disparities between groups. Those self-identified as White are the least likely group to contract a STI. When compared to White individuals, Black Americans have six times higher STI rates whereas people of Hispanic ethnicity are twice as likely to have an STI.[13,14] Additionally, counties with high rates of chlamydia and gonorrhea were more likely to have a higher population of racial minorities than counties with low rates of infection, with a third of the individuals in high rate counties identifying as Black.[21] Counties with high rates of infection have also been found to have three times as many people of Native American/Native Alaskan race as low rate counties. Low rate counties were found to have White individuals making up approximately 50% of the population.[22] The disparity between chlamydia and gonorrhea in racial and ethnic minorities is also displayed in the distribution of cases as a nation. Southern states, have a larger proportion of Black American individuals making up the population, and in turn, they have higher rates of gonorrhea and chlamydia.[22] The disproportionate number of infections between different races/ethnicities persists even when income is taken into consideration. Thus, race/ethnicity is one of the strongest indicators of risk for STI, particularly gonorrhea infection.[13,14,23]

Although racial differences are weakly associated with income, Black and Hispanic populations have higher percentages of poverty compared to the Caucasian population.[22,18] In 2017, over 20% of Black Americans and 18% of those of Hispanic ethnicity were in poverty compared to under 9% of Caucasian individuals.[18] Additionally, families of racial/ethnic minorities where the head of the household is female are almost three times as likely to be in poverty.[18] Those in poverty have lower access to annual

screening and preventative measures, meaning that lower income individuals are particularly at risk for asymptomatic infections, like chlamydia and gonorrhea. Lower income individuals are also more likely to participate in higher risk activities, such as sex work.[13,23] Like race/ethnicity and access to healthcare, lack of education is also commonly tied to low-income individuals. Individuals who do not go to college have been found to be more likely to begin having sex at a younger age, participate in sex work, and are less likely to use condoms.[15,24,25]

Receptive anal sex is another risk factor for chlamydia and gonorrhea infection among not only men who have sex with men (MSM), but also among women who participate in receptive anal sex. Individuals who participate in anal sex are more likely to forgo condom use, compared to those who participating in vaginal intercourse. Additionally, STI transmission rates are higher when engaged in anal sex versus vaginal sex.[9-11] Women who report anal sex may be tested routinely at the urogenital site, but not the rectal site, missing at least 20% of chlamydia and gonorrhea infections in women with rectal infections and the absence of urogenital infection.[9,10]

Preventive Measures

The best way to prevent chlamydia or gonorrhea infections is to abstain from sex with partners who have not been confirmed to be free of STIs, and correctly use latex male condoms when participating in sex.[26] In addition to practicing safe sex, a low number of sexual partners and being in a monogamous relationship have been shown to prevent STI infection.[15] When infection prevention is not successful, early diagnosis and treatment can prevent further spread of *C. trachomatis* and *N. gonorrhoeae.* Chlamydia infections can be easily cured with azithromycin or doxycycline. Due to the rising

antibiotic resistance among *N. gonorrhoeae*, gonorrhea infections are recommended to be treated with ceftriaxone and azithromycin in combination.[27]

Several studies have recommended that all sexually active women be tested once a year for chlamydia and gonorrhea if they are under 25 or in a high-risk category, such as multiple partners or drug use. At risk women who are pregnant should also be tested during the first trimester, and during the third trimester if the individual tested positive or lives in a high incidence area.[7,27,28] Additionally, all MSM who are actively participating in any type of sexual activity should be tested every year at urethral, rectal and pharyngeal sites. MSM who have multiple partners or use drugs should be tested more frequently.[28] The sexual partners of positive individuals should also be tested and treated, as appropriate.

In addition to screening, encouraging condom use helps to prevent the spread of infection. Having access to free condoms has been shown to not only increase the use of condoms in MSM population, but also has been shown to reduce the risks of disease transmission.[29] Annual risk of becoming infected with gonorrhea was reduced by over 5% in theses MSM populations.[29] Additionally, comprehensive sex education and risk education has been shown to reduce the risk of contracting an STI by 17%.[30] Providing comprehensive sex education, including promotion of condom use and limiting number of sexual partners has been shown to reduce new STIs by 30%.[30]

Economic and Health Care Impact

Despite prevention efforts, the more than 20 million individuals diagnosed with STIs and their associated sequelae each year in the US account for a great economic and

health care impact.[1,31] It is estimated that the cost of treatment for STIs and associated sequelae in the US exceeds $15 billion per year. The average cost to treat each man was $30-79 and $354-364 per woman.[31] Overall, approximately $515 million is spent to treat chlamydia infections, and over $160 million for gonorrhea treatment costs.[31] These estimates do not include the costs of asymptomatic screening for chlamydia and gonorrhea infections. Nor is the cost of infertility and poor fetal outcomes attributed to chlamydial and/or gonococcal infections.[31]

Diagnosing and treating individuals early in infection prevents complications and further spread of chlamydia or gonorrhea to future partners. Screening is the best way to routinely diagnose asymptomatic infections and decrease the numbers of new chlamydia and gonorrhea infections. Increase in federal funding for screening for *C. trachomatis* and *N. gonorrhoeae* has been shown to reduce the number of new infections in the years following the funding increase.[32] Therefore, an increase in federal funding towards screening for STIs would reduce the economic and healthcare cost of complications due to prolonged infections.

OBJECTIVES

Objective 1: Analyze the relationship between age, gender, race, and ethnicity, and positive chlamydia or gonorrhea infcetion in La Crosse County compared to the State of Wisconsin and the United States between 2001 and 2020.

MATERIALS AND METHODS

Data Collection

All laboratory detected incident cases of *C. trachomatis* and *N. gonorrhoeae* in La Crosse County per year that represented years 2001-2020 were collected from the La Crosse County Health Department. The total number of incident laboratory detected postive cases of *C. trachomatis* and *N. gonorrhoeae* in the State of Wisconsin and the United States that represented the years 2001-2020 were collected from the CDC Annual Morbidity and Mortality Reports.[33-51] When available, the rate of positive chlamydia and gonorrhea cases per 100,000 people were also collected for each respective location from their corresesponding data source.[46-68]

All positive cases from 2012-2019 were reported by age, sex, race, and Hispanic ethnicity for La Crosse Crosse County and the State of WI by using data collected from the Wisconsin Department of Health Services Sexually Transmitted Disease Surveillance Annual Reports.[52-68] The total number of chlamydia and gonorrhea cases were broken down by ethnicity, gender, and race for the US using data collected from the CDC Annual Morbidity and Mortality Report.[33-51] Based on data availability, the rate of positive chlamydia or gonorrhea cases per 100,000 population in each demographic group were also collected for each respective location from their corresesponding data

source.[33-68] Cases with missing characterization of age, sex, race, and Hispanic ethnicity were excluded from analysis. Age statistics are not included for the US as the age breakdown was not comparable to the age breakdown for the data from La Crosse County and the State of WI to achieve uniformity. Age group 0 to 4 years of age, 5 to 9 years of age, and 10 to 14 years of age were combined to represent individuals aged 0 to 14 years of age for La Crosse County and the State of WI per 100,000 population.[52-68] The rate of positive chlamydia and gonorrhea cases per 100,000 in those 15 to 19 year olds and 20 to 24 year olds were combined to represent individuals aged 15 to 24 years old in La Crosse County and the State of WI.[52-68] In addition, the rate of positive chlamydia and gonorrhea cases per 100,000 in those 25 to 29 years old, 30 to 34 years old, and 35 to 39 years old were combined to represent individuals aged 25 to 39 years old.[52-68] Finally, the rate of positive chlamydia and gonorrhea cases per 100,000 population in those 40 to 44 years old, 45 to 49 years old, and individuals aged 50+ were combined to represent those aged 40+ in La Crosse County and the State of WI.[52-68] Of the different age groups, those aged 15 to 24 years old have the highest rate of incidence of STIs in the United States. We also wished to see whether chlamydia and gonorrhea incidence rates are increasing in those aged over 25, as recent data may suggest.[69]

Descriptive Analysis

The total annual number of reported incident chlamydia and gonorrhea infections for La Crosse County, the State of WI, and the US, as well as the rate per 100,000 population, when available, were organized into tables. The annual rate of incident chlamydia and gonorrhea infections per 100,000 population in La Crosse County, the State of WI, and the US were graphed from 2011-2019.

The annual rates of incident chlamydia and gonorrhea infection per 100,000 population in La Crosse County, the State of WI, and the US were graphed based on sex, race, and Hispanic ethnicity from 2012-2019. Additionally, the annual rates of incident chlmaydia and gonorrhea infection per 100,000 population in La Crosse County and the State of WI were graphed based on combined age group from 2012-2019.

Inferential Statistical Analysis

An Analysis of Variance with two categorical independent variables (Two-Way ANOVA) was performed for each demographic catergory (age, sex, race, and ethnicity) and location for both chlamydia and gonorrhea using Version 28.0.0.0 of SPSS Statistics by IBM. When the F value revealed that statistical significance occured within the Analysis of Variance, the Bonferroni post-hoc test was performed to determine where the statistical significance lied. The Bonferroni post-hoc test was chosen because this test reduces the chance of having a false-postive result.[70] A p-value of ≤ 0.05 was deemed significant. The Bonferroni post-hoc test was performed using Version 28.0.0.0 of SPSS Statistics by IBM.

RESULTS

My results begin with a presentation of the total incident cases of chlamydia and gonorrhea in La Crosse County, the State of WI, and the US. Following which, a graphical display of the annual incident rates per 100,000 population of chlamydia and gonorrhea in La Crosse County, the State of WI, and the US is presented. The next section of my results focuses on the descriptive and inferential statistics of four demographic classifications in regard to annual incident chlamydia rates. In the order discussed, the demographic classifcations are age, sex, race and ethnicity. I first display the annual incident rate in each demographic group at each location, both in table form and graphically. Following which I display the results of a Two-Way ANOVA and the Bonferroni post-hoc test, when applicable. The last section of my results repeats the same analyses that were completed for the annual incidence rates of chlamydia, but in regards to the annual incidence rates of gonorrhea infections among the same demographic classifications.

Total Incident Cases

For this study, the total number of annual incident cases of *C. trachomatis* and *N. gonorrhoeae* in La Crosse County, the State of WI, and the US were collected from 2001 through 2020 (Tables 1 and 2).[33-69] The total number of chlamydia and gonorrhea cases in La Crosse County, the State of WI, and the US appeared to have risen during 2001-2020

(Tables 1 and 2). National case numbers for the year 2019 may be incomplete due to incomplete case numbers from multiple states due to the COVID-19 pandemic.[50] Additionally, case numbers for the US are provisional for the year 2020, as well as all data for La Crosse County and the State of WI.[33-69]

Table 1. Total number of annual reported cases and incidence rates*, when available, of *Chlamydia trachomatis* in La Crosse County, the State of Wisconsin (WI) and the US from 2001-2020.

Year	La Crosse County		WI		US	
	Cases[+]	Rate*[+]	Cases[+]	Rate*[+]	Cases	Rate*
2001	266	NA	16,284	NA	783,242	278
2002	281	NA	17,000	NA	834,555	297
2003	314	NA	17,942	NA	877,478	305
2004	396	NA	19,217	NA	929,462	320
2005	355	NA	20,461	NA	976,445	333
2006	353	NA	20,190	NA	1,030,911	348
2007	335	NA	19,555	NA	1,108,374	370
2008	369	NA	20,996	NA	1,210,523	401
2009	362	NA	20,906	NA	1,244,180	409
2010	364	NA	23,236	NA	1,307,893	426
2011	460	378	24,619	429	1,412,791	457
2012	389	337	23,726	414	1,422,976	457
2013	412	352	23,572	412	1,401,906	447
2014	486	416	23,154	406	1,441,789	456
2015	520	423	24,381	425	1,526,658	475
2016	524	469	26,894	470	1,598,354	495
2017	489	440	27,740	485	1,708,569	525
2018	539	476	26,797	490	1,595,559	538
2019	612	543	29,772	529	1,808,703**	551
2020	598	NA	22,277	NA	1,335,916[+]	NA

Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [33-68]

Abbreviations: Not Available (NA), Wisconsin (WI), United States (US)

*per 100,000 population

[+]Provisional data

**Data may be incomplete due to COVID-19 pandemic.

Table 2. Total number of annual reported cases and incidence rates*, when available, of *Neisseria gonorrhoeae* in La Crosse County, the State of Wisconsin (WI), and the US from 2001-2020.

Year	La Crosse County		WI		United States	
	Cases[+]	Rate[+]	Cases[+]	Rate[+]	Cases	Rate
2001	55	NA	6,011	NA	361,705	129
2002	39	NA	6,341	NA	224,918	125
2003	19	NA	5,663	NA	335,104	116
2004	63	NA	5,053	NA	330,132	114
2005	46	NA	5,869	NA	339,593	116
2006	27	NA	6,927	NA	358,366	121
2007	62	NA	6,752	NA	355,991	119
2008	43	NA	6,087	NA	336,742	112
2009	61	NA	5,201	NA	301,174	99
2010	34	NA	5,091	NA	309,341	101
2011	54	45	4,789	84	321,849	104
2012	51	42	4,704	83	334,826	107
2013	25	22	4,599	81	333,004	106
2014	43	37	4,078	72	350,062	111
2015	54	43	5,260	93	395,216	123
2016	35	30	6,498	115	468,514	145
2017	48	44	7,661	135	555,608	171
2018	145	125	7,619	139	528,013	178
2019	87	77	9,054	161	616,392**	188
2020	163	NA	8,315	NA	564,110[+]	NA

Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [33-68]

Abbreviations: Not Available (NA), Wisconsin (WI), United States (US)

* per 100,000 population

[+]Provisional data

**Data may be incomplete due to COVID-19 pandemic.

Following collection of the available annual incidence rates per 100,000 population of chlamydia and gonorrhea infections in La Crosse County, the State of WI, and the US, it was determined that we had rates for each location for the years 2011 through 2019 (Tables 1 and 2). The annual incidence rates of chlamydia and gonorrhea

from 2011-2019 for La Crosse County, the State of WI, and the US were subsequently graphed (Figures 1 and 2).[43-69]

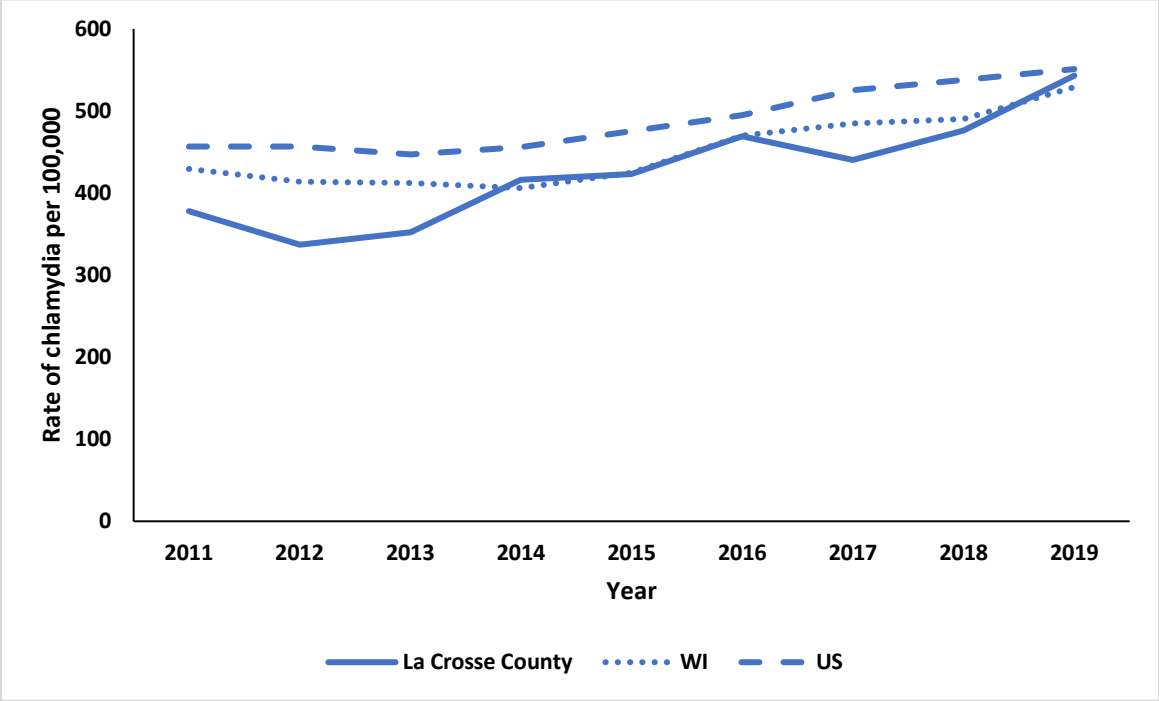


Figure 1. Annual incidence rates of reported chlamydia infections per 100,000 population in La Crosse County, the State of Wisconsin (WI), and the US from 2011 to 2019. Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [43-68]

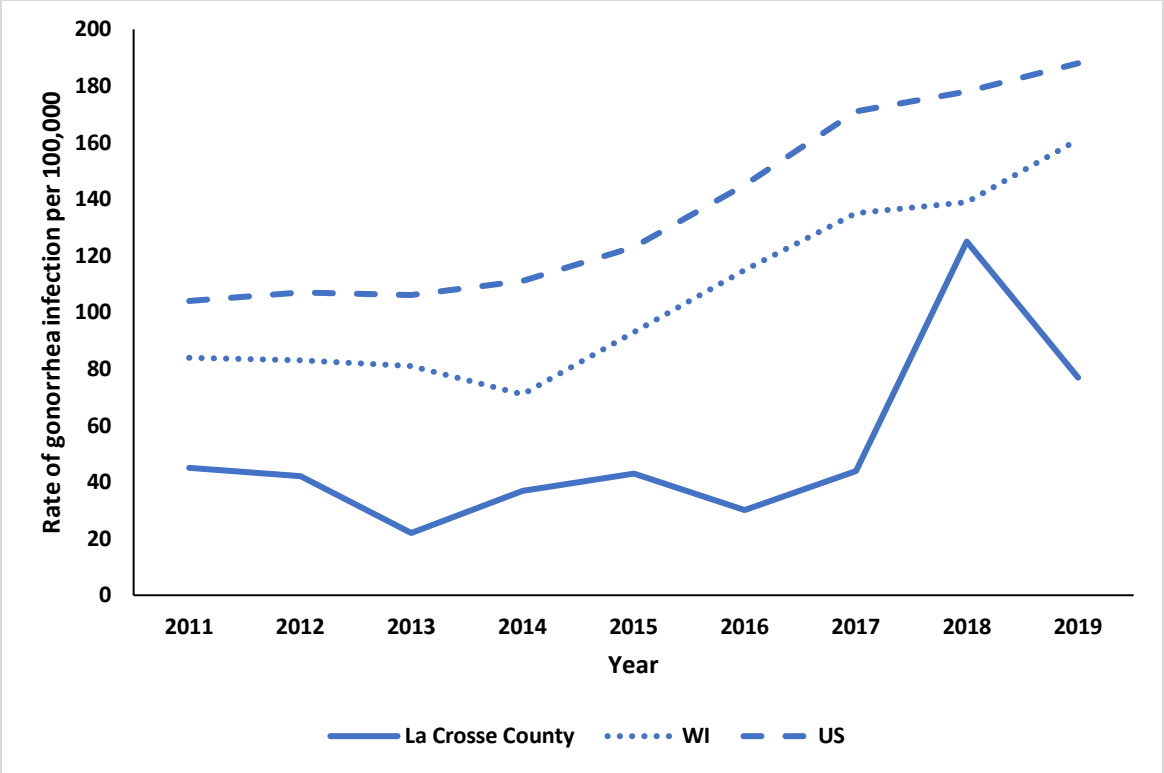


Figure 2**.** Annual incidence rates of gonorrhea infections per 100,000 population in La Crosse County, the State of Wisconsin (WI), and the US from 2011-2019. Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [43-68]

Demographic Analysis of Incident Chlamydia Cases

Age

Age-related data regarding the rate of chlamydia infection per 100,000 population was collected for individuals in four different age groups in La Crosse County from 2012-2019, and the State of WI from 2011-2019 (Table 3). Age data for the US was not included due to differences in age groupings at the national level compared to La Crosse County and the State of WI. Chlamydia infections were the highest in the 15-24 years old age group in both La Crosse County and the State of WI (Figure 3). Additionally, the rate of chlamydia infections in the 15-24 years old age group increased from 2012-2019 in La Crosse County (Figure 3).

Table 3. Annual incidence rate of chlamydia infections per 100,000 population in La Crosse County and the State of WI from 2012-2019. Data were broken up into four age groups: 0-14 years old, 15-24 years old, 25-39 years old, and 40+ years old.

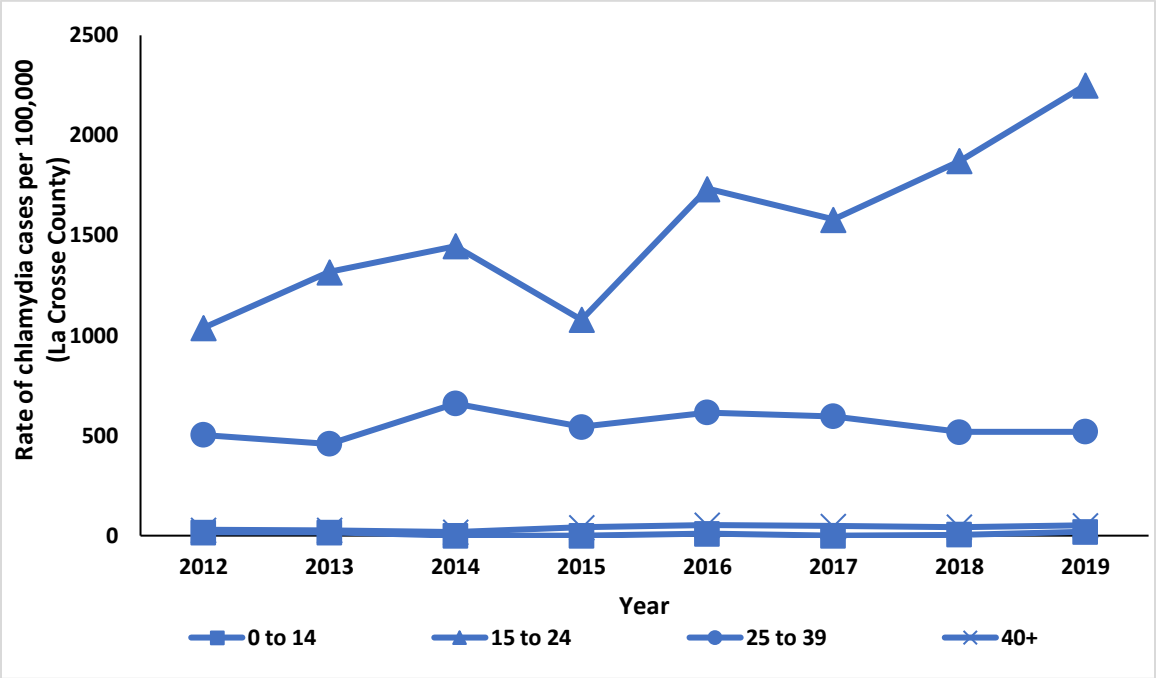
Year	La Crosse County				WI			
	0-14	15-24	25-39	40+	0-14	15-24	25-39	40+
2012	15.7§	1038.5	503.3	28.7	23.7	2010.5	549.7	40.3
2013	15.7§	1317.5	458.0	26.7	21.7	2040.5	565.3	39.7
2014	0§	1446.5	659.7	18.0	19.0	1985.0	568.7	43.7
2015	0§	1079.0	543.0	41.3	18.3	2049.0	617.0	49.7
2016	10§	1732.5	615.30	53.0	21.7	2232.0	696.7	57.3
2017	0§	1579.5	595.7	47.7	18.0	2251.5	750.7	64.0
2018	5§	1872.5	518.0	42.3	24.3	2255.0	771.0	62.7
2019	19.7§	2251.0	520.0	51.7	22.7	2442.0	817.7	77.3

Data were collected and grouped from Wisconsin Department of Health Services sexually transmitted diseases surveillance reports. [53-68]

Abbreviations: Wisconsin (WI)

§= ≤ 5 cases

A



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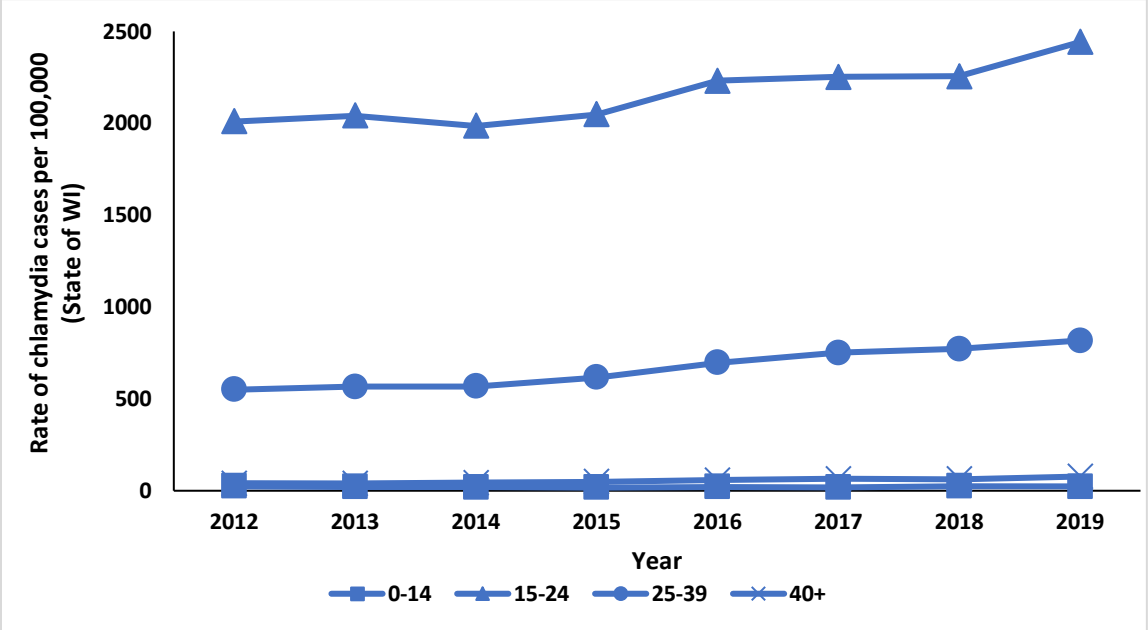


Figure 3. Annual incidence rates of chlamydia infections per 100,000 population for those aged 0-14 years old, 15-24 years old, 25-39 years old, and 40+ years old in La Crosse County (A) and the State of Wisconsin (WI) (B) from 2012-2019. Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [53-68]

To further analyze the relationship between the rate of chlamydia infection and age group, a Two-Way ANOVA F test was performed comparing the average incidence rate, from 2012-2019, of chlamydia infection between location, age group, and the relationship between location and age group. The F test indicated that there was a significant difference ($p<0.001$) in the average rate of chlamydia infections in La Crosse County and the State of WI (Table 4). Additionally, we found that there was significant difference ($p<0.001$) in the average incidence rate of chlamydia infection within the four age groups: 0 to 14 years old, 15 to 24 years old, 25 to 39 years old, and those aged 40+ (Table 4). Lastly, the F test showed that there was significant difference ($p<0.001$) in the average incidence rate of chlamydia infection when looking at the relationship between location and age group (Table 4). Because the relationship between the two categorical, independent variables, location and age group, was deemed significant, a Bonferroni post-hoc test was performed to determine where the significance lied.

Table 4. Two-Way ANOVA F test showing the significance of incident chlamydia infection rate by location (La Crosse County and the State of Wisconsin), age group (0-14 years old, 15-24 years old, 25-39 years old, and 40+ years old) and the relationship between location and age for the years 2012-2019.

Source	F	Significance
Location	22.153	<0.001*
Age	447.986	<0.001*
Location-Age Interaction	12.746	<0.001*

* = Statistically significant, $p\leq0.05$

We first reviewed the average rate of incident chlamydia infection by location within those identified as belonging to each age group. The Bonferroni post-hoc test

indicated that the average incidence rate of chlamydia infection from 2012-2019 among those aged 0 to 14 in La Crosse County was significantly lower (p<0.001) than that of those aged 15 to 24 in the State of WI (Table 5). It was determined that there was no significant difference (p=0.874, p=0.160, p=0.847) in the average incidence rate of chlamydia infection between La Crosse County and the State of WI in those aged 0 to 14, 25 to 39, and 40+ years old (Table 5).

Table 5. Results of the Bonferroni post-hoc test comparing the average rate of chlamydia infection from 2012-2019 between different locations within each age group.

Age Group	Location	Location Comparison	Mean Difference	Significance
0 to 14 years old	La Crosse County	WI	-12.912	0.874
	WI	La Crosse County	12.912	0.874
15 to 24 years old	La Crosse County	WI	-618.562	<0.001*
	WI	La Crosse County	618.562	<0.001*
25 to 39 years old	La Crosse County	WI	-115.475	0.160
	WI	La Crosse County	115.475	0.160
40+ years old	La Crosse County	WI	-15.662	0.847
	WI	La Crosse County	15.662	0.847

Abbreviations: Wisconsin (WI), United States (US)

* = Statistically significant, $p \leq 0.05$

Next, we reviewed the average incidence rate of chlamydia infection by age group within each location. The Bonferroni post-hoc test indicated that the average incidence rate of chlamydia infection from 2012-2019 in La Crosse County and the State of WI in those aged 0 to 14 was not significantly different (p=1.000) from those aged 40+ years old (Table 6). However, we found that in both La Crosse County and the State of WI

those aged 15-24 years old have significantly higher (p<0.001) average incidence rates of chlamydia infection than all other age groups (Table 6). Lastly, those aged 25 to 39 years old were found to have significantly higher (p<0.001) average incidence rates of chlamydia infection than those aged 0 to 14 and 40+ years of age in both La Crosse County and the State of WI (Table 6).

Table 6. Results of the Bonferroni post-hoc test comparing the average rate of chlamydia infection from 2012-2019 between each age group within each location.

Location	Age Group	Age Group Comparison	Mean Difference	Significance
La Crosse County	0 to 14 years old	15 to 24 years old	-1531.362	<0.001*
		25 to 39 years old	-543.362	<0.001*
		40+ years old	-30.412	1.000
	15 to 24 years old	0 to 14 years old	1531.362	<0.001*
		25 to 39 years old	988.000	<0.001*
		40+ years old	1500.950	<0.001*
	25 to 39 years old	0 to 14 years old	543.363	<0.001*
		15 to 24 years old	-988.000	<0.001*
		40+ years old	512.950	<0.001*
	40+ years old	0 to 14 years old	30.412	1.000
		15 to 24 years old	-1500.950	<0.001*
		25 to 39 years old	-512.950	<0.001*
WI	0 to 14 years old	15 to 24 years old	-2137.012	<0.001*
		25 to 39 years old	-645.925	<0.001*
		40+ years old	-33.162	1.000
	15 to 24 years old	0 to 14 years old	2137.013	<0.001*
		25 to 39 years old	1491.087	<0.001*
		40+ years old	2103.850	<0.001*
	25 to 39 years old	0 to 14 years old	645.925	<0.001*
		15 to 24 years old	-1491.087	<0.001*
		40+ years old	612.763	<0.001*
	40+ years old	0 to 14 years old	33.162	1.000
		15 to 24 years old	-2103.850	<0.001*
		25 to 39 years old	-612.763	<0.001*

Abbreviations: Wisconsin (WI)

* = Statistically significant, $p \leq 0.05$

Sex

The rate of incident chlamydia infection per 100,000 population in males and females was collected in La Crosse County, the State of WI, and the US from 2012-2019 (Table 7). The rate of infection in females was higher than the rate of infection in males at the county, state, and national level (Figure 4), but the rate of chlamydia infection appears to be similar by location in both males and females (Figure 4).

Table 7. Annual incidence rate of chlamydia infections per 100,000 population in La Crosse County, the State of WI, and the US, for males and females.

Year	La Crosse County		WI		US	
	Male	Female	Male	Female	Male	Female
2012	226	442	239	584	263	643
2013	200	497	245	577	263	623
2014	225	570	244	565	276	622
2015	284	554	265	584	303	641
2016	302	627	293	644	329	654
2017	290	592	313	654	360	682
2018	313	631	326	651	379	690
2019	357	715	350	704	399	697

Data were collected from the CDC Annual Morbidity and Mortality reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports.[44-51, 53-68]

Abbreviations: Wisconsin (WI), United States (US)

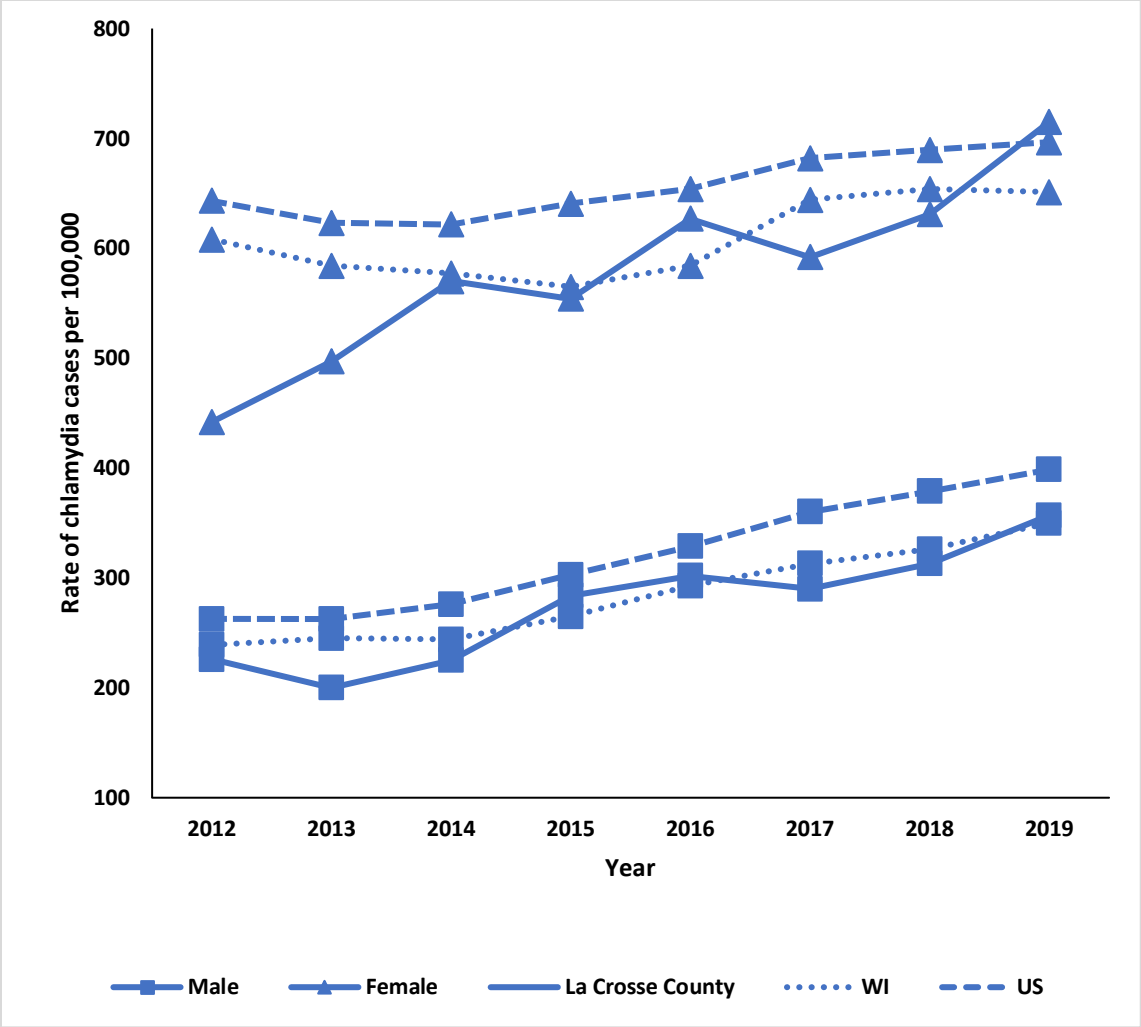


Figure 4. Annual incidence rates of chlamydia infections per 100,000 population for males and females in La Crosse County, the State of Wisconsin (WI), and the United States (US) from 2012-2019. Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports.[44-51, 53-68]

To analyze the relationship between sex and incident chlmaydia infecton rates, a Two-Way ANOVA F test was performed comparing the average incidence rate from 2012-2019 of chlamydia infection between locations, sexes, and the relationship between location and sex. The test indicated that there is a significant difference (p=0.009) in the average rate of chlamydia infections in La Crosse County, the State of WI, and the US

(Table 8). Additionally, we found that the average rate of chlamydia infection in females was significantly higher ($p<0.001$) compared to males (Table 8). The F test, however, did not find significant difference ($p=0.643$) in the average incidence of chlamydia infection when looking at the relationship between location and sex (Table 8). Because the relationship between the two categorical independent variables was found to be insignificant, a Bonferroni post-hoc test was not performed.

Table 8. Two-Way ANOVA F test showing the significance of incident chlamydia infection rate by location (La Crosse County, the State of Wisconsin, and the United States), sex (male and female), and the relationship between location and sex for the years 2012-2019.

Source	F	Significance
Location	5.266	0.009*
Sex	423.664	<0.001*
Location-Sex Interaction	0.446	0.643

* = Statistically significant, $p\leq0.05$

Race

The annual incidence rate of chlamydia infection per 100,000 population was collected for individuals identifying as White, Black, Native American/Alaskan Native, and Asian/Pacific Islander in La Crosse County, the State of WI, and the US from 2012-2019 (Table 9). Individuals identifying as Black or Native American appeared to have a higher chlamydia infection than their White or Asian/Pacific Islander counterparts (Figure 5). Additionally, the rate of chlamydia infection in Black individuals in La Crosse County and the State of WI was higher than the rate of infection at the national level (Figure 5). Native Americans/Pacific Islanders appeared to have higher chlamydia infection rates in La Crosse County in both 2012 and 2014-2016 compared to the rate of infection in the State of WI and the US (Figure 5).

Table 9. Annual incidence rate of chlamydia infection per 100,000 population in La Crosse County, the State of WI, and the US from 2012-2019, for those identifying as White, Black, Native American/Native Alaskan, and Asian/Pacific Islander.

Year	La Crosse County				WI				US			
	White	Black	NA	API	White	Black	NA	API	White	Black	NA	API
2012	285	1965	1433	284	186	1908	592	276	188	1079	438	116
2013	318	1094	530[§]	313	196	1770	587	255	189	1011	420	117
2014	345	2360	1237	444	195	1674	530	260	191	984	403	112
2015	362	2303	1767	235	216	1870	567	283	196	974	388	118
2016	395	2478	1237	601	235	2055	528	309	206	998	125	405
2017	368	2476	530[§]	444	236	2092	605	323	218	1036	422	132
2018	409	2476	530[§]	444	252	2631	673	339	214	1055	424	136
2019	436	4030	707[§]	366	265	2911	758	410	208	1091	415	139

Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

Abbreviations: Wisconsin (WI), United States (US), Native American/Alaskan Native (NA), Asian/Pacific Islander (API)

§= ≤5 cases

A

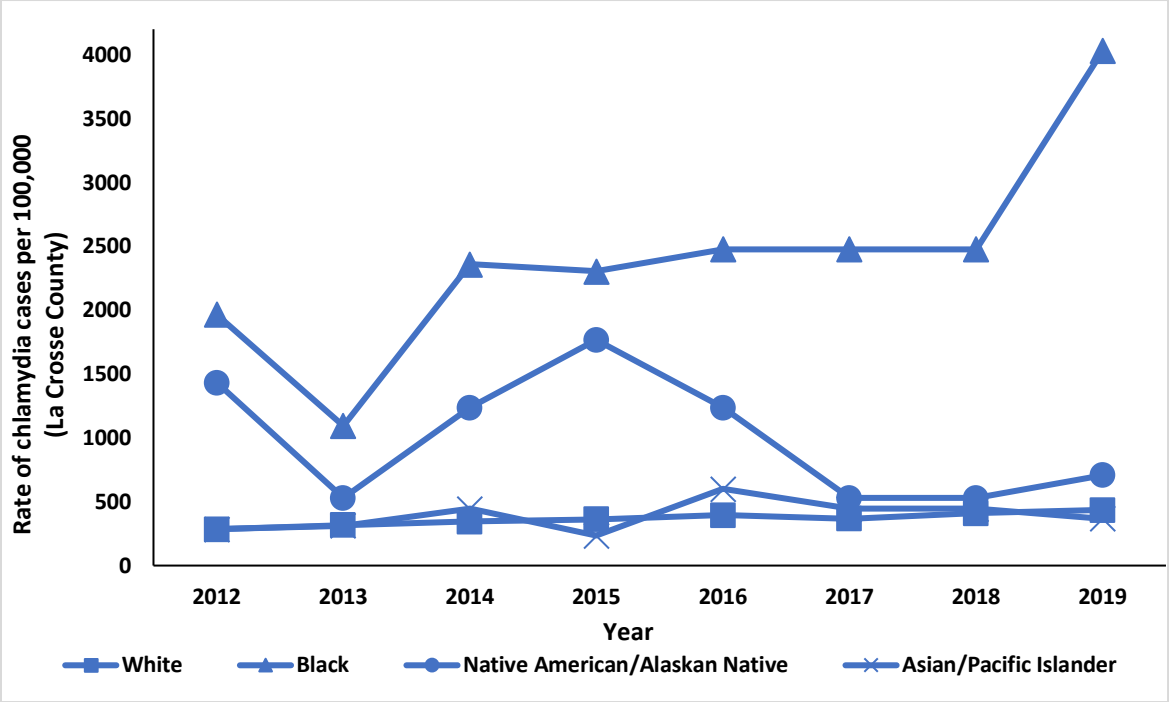
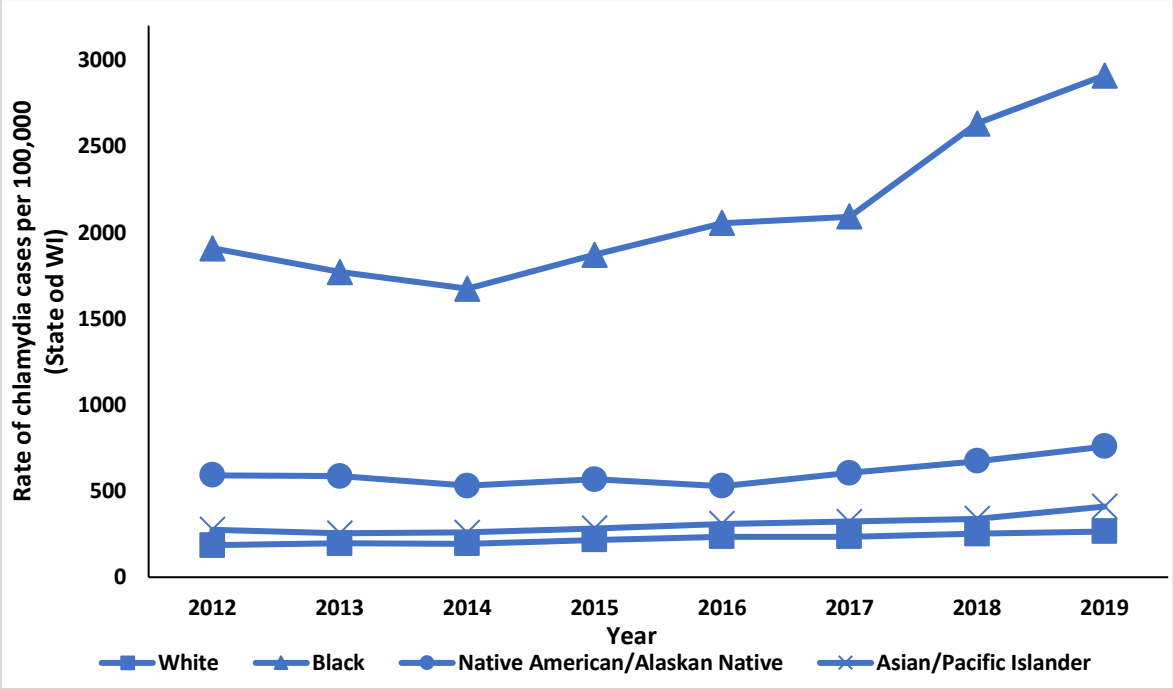


Figure 5. Annual incidence rates of chlamydia infections per 100,000 population identifying as White, Black, Native American/Alaskan Native, and Asian/Pacific Islander in La Crosse County (A), the State of Wisconsin (WI) (B), and the United States (US) (C) from 2012-2019. Data were collected from the CDC annual morbidity and mortality reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

B



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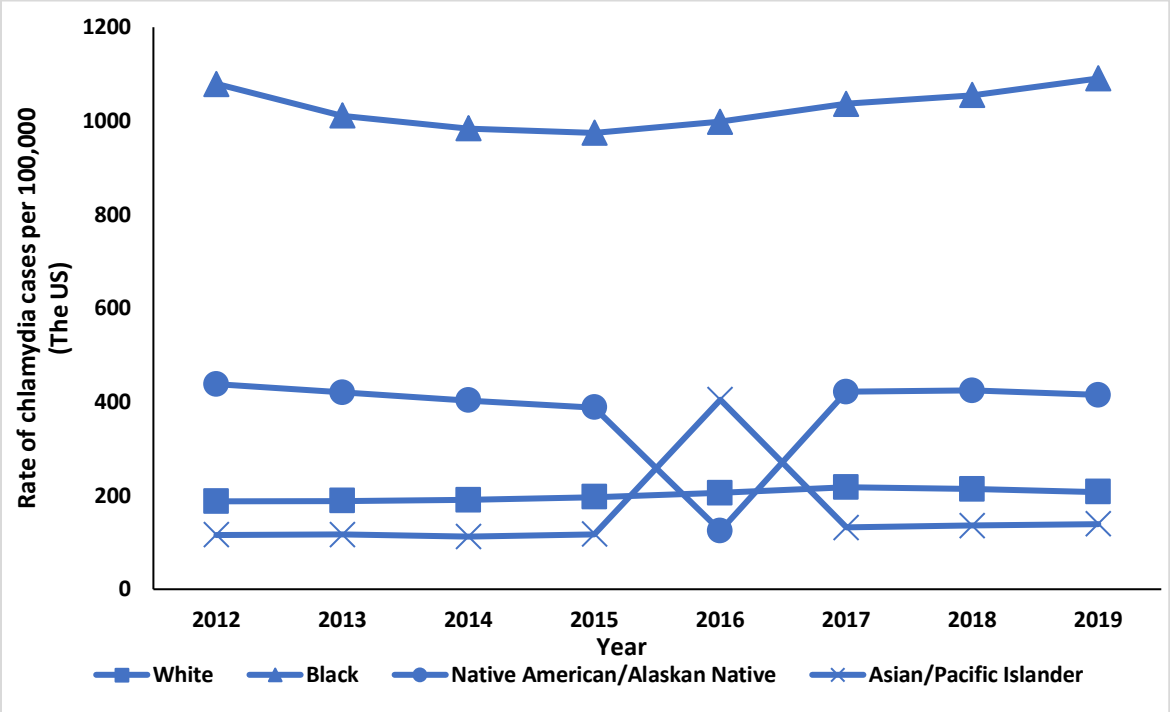


Figure 5. Continued.

A Two-Way ANOVA F test was performed to further compare the average incidence rate from 2012-2019 of chlamydia infections between location, race, and the interaction between location and racial classification. The F test indicated that there was significant difference (p<0.001) in the average rate of chlamydia infections in La Crosse County, the State of WI, and the US (Table 10). Additionally, we found that a significant difference (p<0.001) existed in incidence rate of chlamydia infections between the different racial groups (Table 10). Lastly, the F test showed that there was significant difference (p<0.001) in the average incidence rate of chlamydia infection between location and racial classification (Table 10). Because the relationship between location and racial classification was deemed significant, a Bonferroni post-hoc test was performed to determine where the significance lied.

Table 10. Two-Way ANOVA F test showing the significance of incident chlamydia infection rate by location (La Crosse County, the State of Wisconsin, and the United States), race (White, Black, Native American/Alaskan Native, and Asian/Pacific Islander) and the relationship between location and race for the years 2012-2019.

Source	F	Significance
Location	30.851	<0.001*
Race	141.897	<0.001*
Location-Race Interaction	7.962	<0.001*

* = Statistically significant, $p \leq 0.05$

The average rate of chlamydia infection was first reviewed by location within each racial group. The Bonferroni post-hoc test indicated that the average incidence rates of chlamydia infection from 2012-2019 among those identifying as White or Asian/Pacific Islander in La Crosse County, the State of WI, and the US were not significantly different (p=1.000, p=0.866, p=0.400) when compared to each other (Table

11). However, it was found that the average incidence rate of chlamydia infection in the Black population was higher in both La Crosse County ($p<0.001$) and the State of WI ($p<0.001$) compared to those identifying as Black in the US (Table 8). The average incidence rate of chlamydia infection among those identifying as Black was not significantly different ($p=0.202$) between La Crosse County and the State of WI (Table 11). Lastly, the analysis indicated that the average incidence rate of chlamydia infection among the Native American/Alaskan Native population was significantly higher ($p=0.037$, $p<0.001$) in La Crosse County compared to rates in the State of WI and the US (Table 11). Although, the difference in average incidence rates of chlamydia infection among those identifying as Native American/Alaskan Native in the State of WI and the US was found to be insignificant ($p=0.433$) (Table 11).

Table 11. Results of a Bonferroni post-hoc test comparing the average rate of chlamydia infection from 2012-2019 between different locations within each racial group.

Race	Location	Location Comparison	Mean Difference	Significance
White	La Crosse County	WI	142.125	1.000
		US	163.500	0.866
	WI	La Crosse County	-142.125	1.000
		US	21.375	1.000
	US	La Crosse County	-163.500	0.866
		WI	-21.375	1.000
Black	La Crosse County	WI	283.875	0.202
		US	1369.250	<0.001*
	WI	La Crosse County	-283.875	0.202
		US	1085.375	<0.001*
	US	La Crosse County	-1369.250	<0.001*
		WI	-1085.375	<0.001*
NA	La Crosse County	WI	391.375	0.037*
		US	617.000	<0.001*
	WI	La Crosse County	-391.375	0.037*
		US	225.625	0.433
	US	La Crosse County	-617.000	<0.001*
		WI	-225.625	0.433
API	La Crosse County	WI	84.500	1.000
		US	232.000	0.400
	WI	La Crosse County	-84.500	1.000
		US	147.500	1.000
	US	La Crosse County	-232.000	0.400
		WI	-147.500	1.000

Abbreviations: Wisconsin (WI), United States (US), Native American/Native Alaskan (NA), Asian/Pacific Islander (API)

* = Statistically significant, $p \leq 0.05$

Next, we reviewed the average rate of chlamydia infection by race within each location. The Bonferroni post-hoc analysis indicated that the average incidence rate of chlamydia infection from 2012-2019 in La Crosse County was significantly lower ($p<0.001$) in the populations identifying as White or Asian/Pacific Islander in comparison to those identifying as Black or Native American/Alaskan Native (Table 12).

Additionally, the average rate of chlamydia infection between those identifying as White was not significantly different (p=1.000) than those identifying as Asian/Pacific Islander in La Crosse County (Table 12). However, the average incidence rate of chlamydia infection was significantly higher (p<0.001) in the Black population in La Crosse County when compared to the incidence rate in the Native American/Alaskan Native population (Table 12). Similarly, the State of WI and the US had significantly higher (p<0.001) average incidence rates of chlamydia infection in the Black population compared to all other age groups (Table 12). Lastly, the State of WI (p=1.000, p=0.087, p=0.329) and the US (p=1.000, p=0.926) had average incidence rates of chlamydia infection that were insignificantly different when comparing those identifying as Native American/Alaskan Native, Asian/Pacific Islander, and White (Table 12).

Table 12. Results of a Bonferroni post-hoc test comparing the average rate of chlamydia infection from 2012-2019 between different racial groups at each location.

Location	Race	Race Comparison	Mean Difference	Significance
La Crosse County	White	Black	-2033.000	<0.001*
		NA	-631.625	<0.001*
		API	-26.625	1.000
	Black	White	2033.000	<0.001*
		NA	1401.375	<0.001*
		API	2006.375	<0.001*
	NA	White	631.625	<0.001*
		Black	-1401.375	<0.001*
		API	605.000	<0.001*
	API	White	26.625	1.000
		Black	-2006.375	<0.001*
		NA	-605.000	<0.001*
WI	White	Black	-1891.250	<0.001*
		NA	-382.375	0.087
		API	-84.250	1.000
	Black	White	1891.250	<0.001*
		NA	1508.875	<0.001*
		API	1807.000	<0.001*
	NA	White	382.375	0.087
		Black	-1508.875	<0.001*
		API	298.125	0.329
	API	White	84.250	1.000
		Black	-1807.000	<0.001*
		NA	-298.125	0.329
US	White	Black	-827.250	<0.001*
		NA	-178.125	1.000
		API	41.875	1.000
	Black	White	827.250	<0.001*
		NA	649.125	<0.001*
		API	869.125	<0.001*
	NA	White	178.125	1.000
		Black	-649.125	<0.001*
		Asian/Pacific Islander	220.000	0.926
	API	White	-41.875	1.000
		Black	-869.125	<0.001*
		NA	-220.000	0.926

Abbreviations: Wisconsin (WI), United States (US), Native American/Native Alaskan (NA), Asian/Pacific Islander (API)

* = Statistically significant, $p \leq 0.05$

Hispanic Ethnicity

The rate of chlamydia infection per 100,000 population was collected for those identifying as Hispanic and non-Hispanic in La Crosse County, the State of WI, and the US from 2012-2019 (Table 13). Chlamydia infection rates in individuals identifying as Hispanic appeared to be higher than the rate of infection in their non-Hispanic counterparts in La Crosse County, the State of WI, and the US (Figure 6). Additionally, the rate of chlamydia infection in the Hispanic population in the State of WI appeared to increase from 2011-2019 (Figure 6). The rate of chlamydia infection in Hispanic individuals in La Crosse County appeared to be higher than the State of WI and the US (Figure 6).

Table 13. Annual incidence rate of chlamydia infections per 100,000 population in La Crosse County, the State of WI, and the US, identifying as Hispanic or non-Hispanic.

Year	La Crosse County		WI		US	
	Hispanic	Non-Hisp.	Hispanic	Non-Hisp.	Hispanic	Non-Hisp.
2012	1023	285	456	255	379	263
2013	471	333	473	241	373	264
2014	941	386	429	234	363	270
2015	1255	357	407	232	365	280
2016	1020	374	587	274	369	289
2017	1176	328	690	300	394	319
2018	1176	401	809	362	387	323
2019	1098	388	953	376	383	334

Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

Abbreviations: Wisconsin (WI), United States (US), Non-Hispanic (Non-Hisp.)

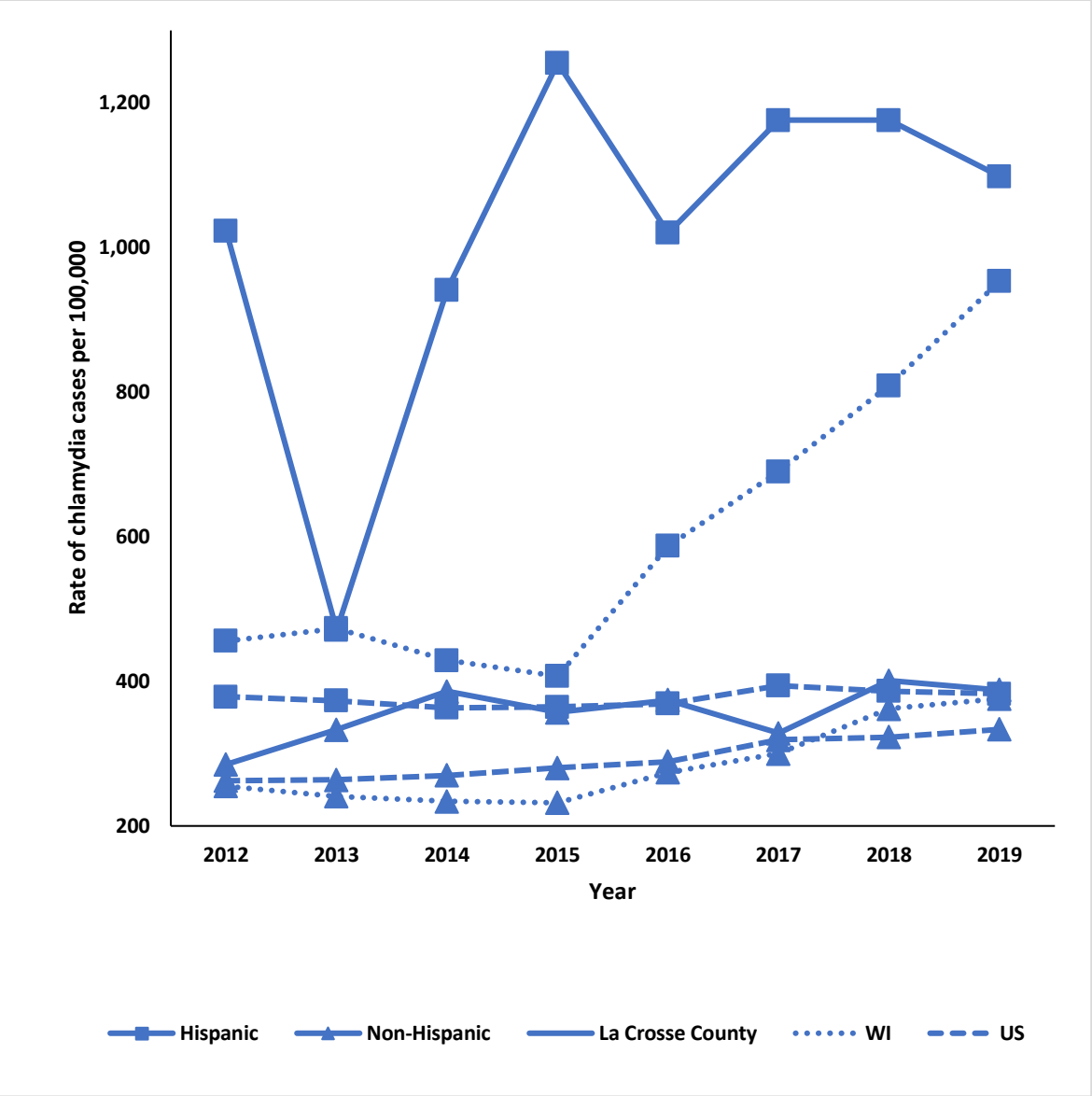


Figure 6. Annual incidence rates of chlamydia infections per 100,000 population for Hispanic and non-Hispanic identifying individuals in La Crosse County, the State of Wisconsin (WI), and the United States (US) from 2012-2019. Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

A Two-Way ANOVA F test was performed comparing the average incidence rate from 2012-2019 of chlamydia infections between locations, Hispanic ethnicity, and the

interaction between location and Hispanic ethnicity. The F test indicated that there was a significant difference (p<0.001) in the average rate of chlamydia infections in La Crosse County, the State of WI, and the US (Table 14). Additionally, we found that the average rate of chlamydia infection was significantly higher (p<0.001) in those identifying as Hispanic compared to those identifying as non-Hispanic (Table 14). Lastly, the F test showed that there was a significant difference (p<0.001) in the average incidence rate of chlamydia infection between location and Hispanic ethnicity (Table 14). The significant relationship between location and Hispanic ethnicity, indicated that a Bonferroni post-hoc test should be performed to further analyze the relationship between the two independent variables.

Table 14. Two-Way ANOVA F test showing the significance of incident chlamydia infection rates by location (La Crosse County, the State of Wisconsin, and the United States), ethnicity (Hispanic and non-Hispanic), and the relationship between location and ethnicity for the years 2012-2019.

Source	F	Significance
Location	29.925	<0.001*
Ethnicity	85.899	<0.001*
Location-Ethnicity Interaction	19.383	<0.001*

* = Statistically significant, p≤0.05

We first reviewed the average chlamydia incidence rate data by location within those identifying as being of Hispanic ethnicity. The Bonferroni post-hoc test indicated that the average rate of chlamydia infection from 2012-2019 among the Hispanic population in La Crosse County was significantly higher (p<0.001) than that of the Hispanic population in the State of WI and the US (Table 15). Additionally, the average

rate of chlamydia infection in the Hispanic population in the State of WI was found to be significantly higher (p=0.005) than the average rate of chlamydia in the US Hispanic population (Table 15). We also investigated whether there was a significant difference in the rate of chlamydia infection by location in the non-Hispanic population. The Bonferroni post-hoc test indicated that the average rate of chlamydia infection from 2012-2019 in the non-Hispanic population was not significantly different (p=0.845, p=1.000) between La Crosse County, the State of WI, and the US (Table 15).

Table 15. Results of the Bonferroni post-hoc test comparing the average rate of incident chlamydia infections from 2012-2019 at each location within either Hispanic or non-Hispanic ethnic groups.

Ethnicity	Location	Location Comparison	Mean Difference	Significance
Hispanic	La Crosse County	WI	419.500	<0.001*
		US	643.375	<0.001*
	WI	La Crosse County	-419.500	<0.001*
		US	223.875	0.005*
	US	La Crosse County	-643.375	<0.001*
		WI	-223.875	0.005*
Non-Hispanic	La Crosse County	WI	72.250	0.845
		US	63.750	1.000
	WI	La Crosse County	-72.250	0.845
		US	-8.500	1.000
	US	La Crosse County	-63.750	1.000
		WI	8.500	1.000

Abbreviations: Wisconsin (WI), United States (US)

* = Statistically significant, $p \leq 0.05$

Next, we reviewed the average incidence rate of chlamydia infection by ethnicity within each location. The Bonferroni post-hoc test indicated that the average rate of chlamydia infection from 2012-2019 in La Crosse County was significantly higher (p<0.001) in those identifying as Hispanic compared to those identifying as non-Hispanic (Table 16). Similar results were found (p<0.001) when comparing the average chlamydia infection rate among those identifying as Hispanic and non-Hispanic in the State of WI (Table 16). Lastly, we found that there was no significant difference (p=0.213) in the average rate of chlamydia infection during 2012-2019 in those identifying as Hispanic versus non-Hispanic in the US (Table 16).

Table 16. Results of the Bonferroni post-hoc test comparing the average incidence rate of chlamydia infection from 2012-2019 between Hispanic and non-Hispanic identifying individuals at each location.

Location	Ethnicity	Ethnicity Comparison	Mean Difference	Significance
La Crosse County	Hispanic	Non-Hispanic	663.500	<0.001*
	Non-Hispanic	Hispanic	-663.500	<0.001*
WI	Hispanic	Non-Hispanic	316.250	<0.001*
	Non-Hispanic	Hispanic	-316.250	<0.001*
US	Hispanic	Non-Hispanic	83.875	0.213
	Non-Hispanic	Hispanic	83.875	0.213

Abbreviations: Wisconsin (WI), United States (US)

* = Statistically significant, p≤0.05

Demographic Analysis of Incident Gonorrhea Cases

Age

The annual incidence rate of gonorrhea infection per 100,000 population in four different age groups was collected in La Crosse County and the State of WI from 2012-2019 (Table 17). Age data for the US was not included due to differences in age groupings at the national level compared to La Crosse County and the State of WI. Gonorrhea infections were the highest in the 20-24 years old age group in the State of WI, and were higher than the rates in La Crosse County (Figure 7). Additionally, the rate of gonorrhea infections in the State of WI in those 25-39 of age appears to higher than those 0-14 years old and 40+ years old (Figure 7). Lastly, the rates of gonorrhea infection in La Crosse County appear to be similar in those 15-24 and 25-39 years of age (Figure 7).

Table 17. Annual incidence rate of gonorrhea infections per 100,000 population in La Crosse County and the State of WI from 2012-2019, identifying as 0-14 years old, 15-24 years old, 25-39 years old, and 40+ years old.

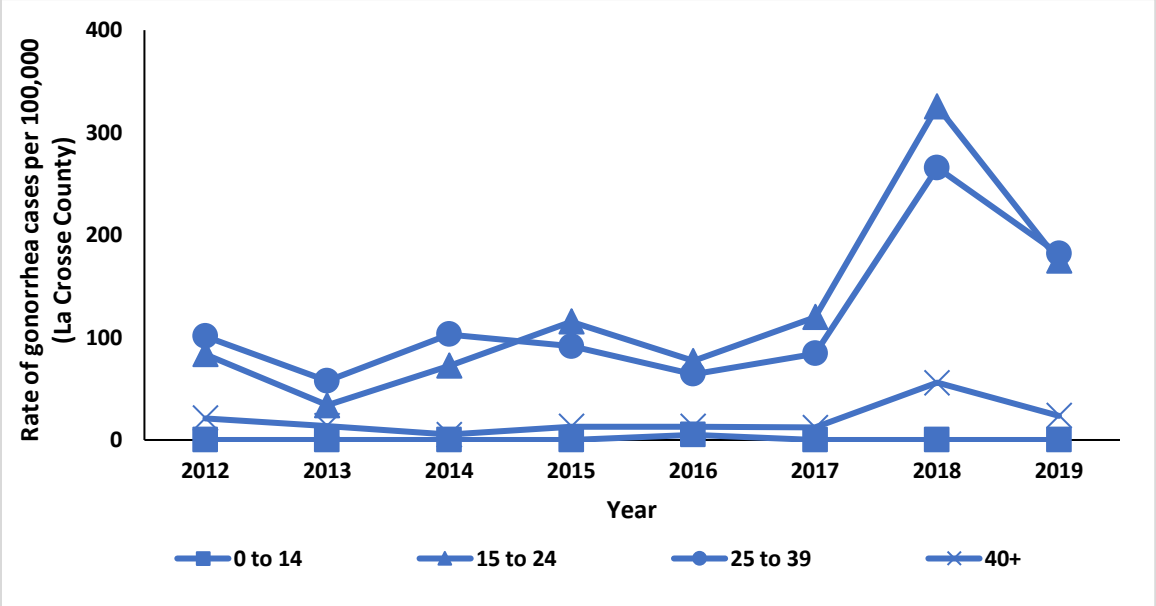
Year	La Crosse County				WI			
	0-14	15-24	25-39	40+	0-14	15-24	25-39	40+
2012	0§	83.5	101	21.3	5	346	135.3	20.3
2013	0§	34	57.7	13.7§	7	337	136.3	19.7
2014	0§	72.5	103	5.3§	3.7	312	118.3	12.7
2015	0§	115.5	91.3	13§	5.3	381	162.3	22.3
2016	5§	77	64.3	13§	7.6	456	205.3	30.3
2017	0§	120	84.3	12§	8.3	509	250.3	41
2018	0§	325.5	265.7	56	8.7	484	280.0	46
2019	0§	175	181.7	23.7	8.3	533.5	333.7	59.7

Data were collected from the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [53-68]

Abbreviations: Wisconsin (WI)

§= ≤5 cases

A



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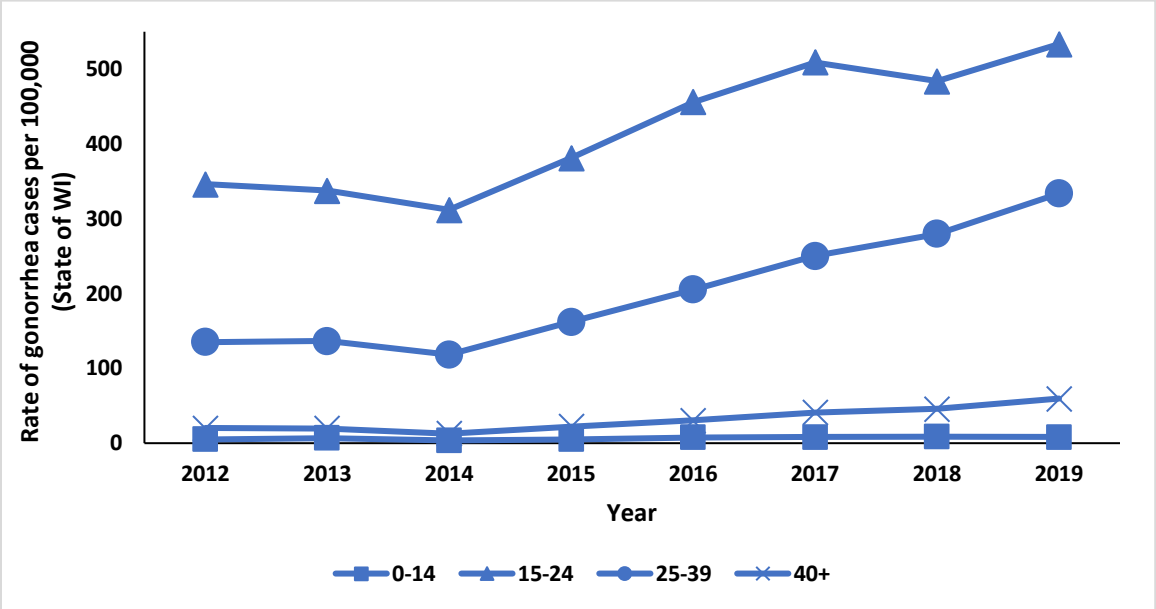

Figure 7. Annual incidence rates of gonorrhea infections per 100,000 population for those aged 0-14 years old, 15-24 years old, 25-39 years old, and 40+ years old in La Crosse County (A) and the State of Wisconsin (WI) (B) from 2012-2019. Data were collected from the Wisconsin Department of Health Services Sexually Transmitted Disease Surveillance Reports.[53-68]

A Two-Way ANOVA F test was performed comparing the average incidence rate, from 2012-2019, of gonorrhea infections between locations, age group, and the interaction between location and age group classification. The test indicated that there was significant difference ($p<0.001$) in the average incidence rate of gonorrhea infections in La Crosse County and the State of WI (Table 18). Additionally, we found that there was a significant difference ($p<0.001$) in the average incidence rate of chlamydia infections between the different age groups (Table 18). Lastly, the F test showed that there was significant difference ($p<0.001$) in the average incidence rate of gonorrhea infection between location and age group classification (Table 18). Because the relationship between location and age group was deemed significant, a Bonferroni post-hoc test was performed to determine where the significance lied.

Table 18. Two-Way ANOVA F test showing the significance of average incident gonorrhea infection rates by location (La Crosse County and the State of WI), age (0-14 years old, 15-24 years old, 25-39 years old, and 40+ years old) and the relationship between location and age for the years 2012-2019.

Source	F	Significance
Location	46.080	<0.001*
Age	73.982	<0.001*
Location-Age Interaction	21.379	<0.001*

* = Statistically significant, $p \leq 0.05$

The average incidence rate of gonorrhea infection was first looked at by location within each age group. The Bonferroni post-hoc test indicated that the average incidence rate of gonorrhea infection from 2012-2019 among those 0 to 14 years old ($p=0.835$) and 40+ years old ($p=0.689$) was not significantly different between La Crosse County and the State of WI (Table 19). However, the test found that the average rate of gonorrhea

infection in those 15 to 24 years old (p<0.001) and 25 to 39 years old (p=0.006) was significantly higher in the State of WI compared to La Crosse County (Table 19).

Table 19. Results of the Bonferroni post-hoc test comparing the average rate of gonorrhea infection from 2012-2019 between different locations within each age group.

Age Group	Location	Location Comparison	Mean Difference	Significance
0 to 14 years old	La Crosse County	WI	-6.113	0.835
	WI	La Crosse County	6.113	0.835
15 to 24 years old	La Crosse County	WI	-294.500	<0.001*
	WI	La Crosse County	294.500	<0.001*
25 to 39 years old	La Crosse County	WI	-84.062	0.006*
	WI	La Crosse County	84.062	0.006*
40+ years old	La Crosse County	WI	-11.750	0.689
	WI	La Crosse County	11.750	0.689

Abbreviations: Wisconsin (WI)

* = Statistically significant, $p \leq 0.05$

Next, the average incidence rate of gonorrhea infection was investigated by age group age within each location. The Bonferroni post-hoc test indicated that the average gonorrhea incidence rate from 2012-2019 was significantly lower in those 0 to 14 years old (p<0.001) and 40+ years of age (p<0.001, p=0.004, and p=0.008), compared to those 15 to 24 and 25 to 39 years old in La Crosse County and the State of WI (Table 20). Additionally, those aged 0 to 14 and 40+ years old did not have significantly different (p=1.000) average gonorrhea rates from each other in La Crosse County or the State of

WI (Table 20). However, the average incidence rate of gonorrhea infection in those 15 to 24 years of age was significantly higher ($p<0.001$) than the rate of infection in those 25 to 39 years old in the State of WI (Table 20). Lastly, the average incidence rate of gonorrhea infection in those 15 to 24 years old was not significantly different ($p=1.000$) than those 25 to 39 years of age in La Crosse County (Table 20).

Table 20. Results of the Bonferroni post-hoc test comparing the average rate of gonorrhea infection from 2012-2019 between each age group within each location.

Location	Age Group	Age Group Comparison	Mean Difference	Significance
La Crosse County	0 to 14 years old	15 to 24 years old	-124.750	<0.001*
		25 to 39 years old	-118.000	<0.001*
		40+ years old	-19.125	1.000
	15 to 24 years old	0 to 14 years old	124.750	<0.001*
		25 to 39 years old	6.750	1.000
		40+ years old	105.625	0.004*
	25 to 39 years old	0 to 14 years old	118.000	<0.001*
		15 to 24 years old	-6.750	1.000
		40+ years old	98.875	0.008*
	40+ years old	0 to 14 years old	19.125	1.000
		15 to 24 years old	-105.625	0.004*
		25 to 39 years old	-98.875	0.008*
WI	0 to 14 years old	15 to 24 years old	-413.137	<0.001*
		25 to 39 years old	-195.950	<0.001*
		40+ years old	-24.763	1.000
	15 to 24 years old	0 to 14 years old	413.137	<0.001*
		25 to 39 years old	217.188	<0.001*
		40+ years old	388.375	<0.001*
	25 to 39 years old	0 to 14 years old	195.950	<0.001*
		15 to 24 years old	-217.187	<0.001*
		40+ years old	171.187	<0.001*
	40+ years old	0 to 14 years old	24.763	1.000
		15 to 24 years old	-388.375	<0.001*
		25 to 39 years old	-171.187	<0.001*

Abbreviations: Wisconsin (WI)

* = Statistically significant, $p \leq 0.05$

Sex

The rate of gonorrhea infection per 100,000 population in males and females was collected in La Crosse County, the State of WI, and the US from 2012-2019 (Table 21). The rate of gonorrhea infection appears to be similar between males and females at all locations (Figure 8). Additionally, the rate of gonorrhea infection appears to differ between the locations, with the US being the highest, the State of WI being the second highest, and La Crosse County being the lowest (Figure 8).

Table 21. Annual incidence rate of chlamydia infections per 100,000 population in La Crosse County, the State of WI, and the US from 2012-2019, identified as male or female.

Year	La Crosse County		WI		US	
	Male	Female	Male	Female	Male	Female
2012	34	50	73	93	106	109
2013	24	21	76	87	110	102
2014	46	29	72	72	119	100
2015	51	35	96	91	140	106
2016	36	24	117	113	170	120
2017	42	47	140	130	201	141
2018	117	133	149	129	212	145
2019	84	71	170	151	224	152

Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

Abbreviations: Wisconsin (WI), United States (US)

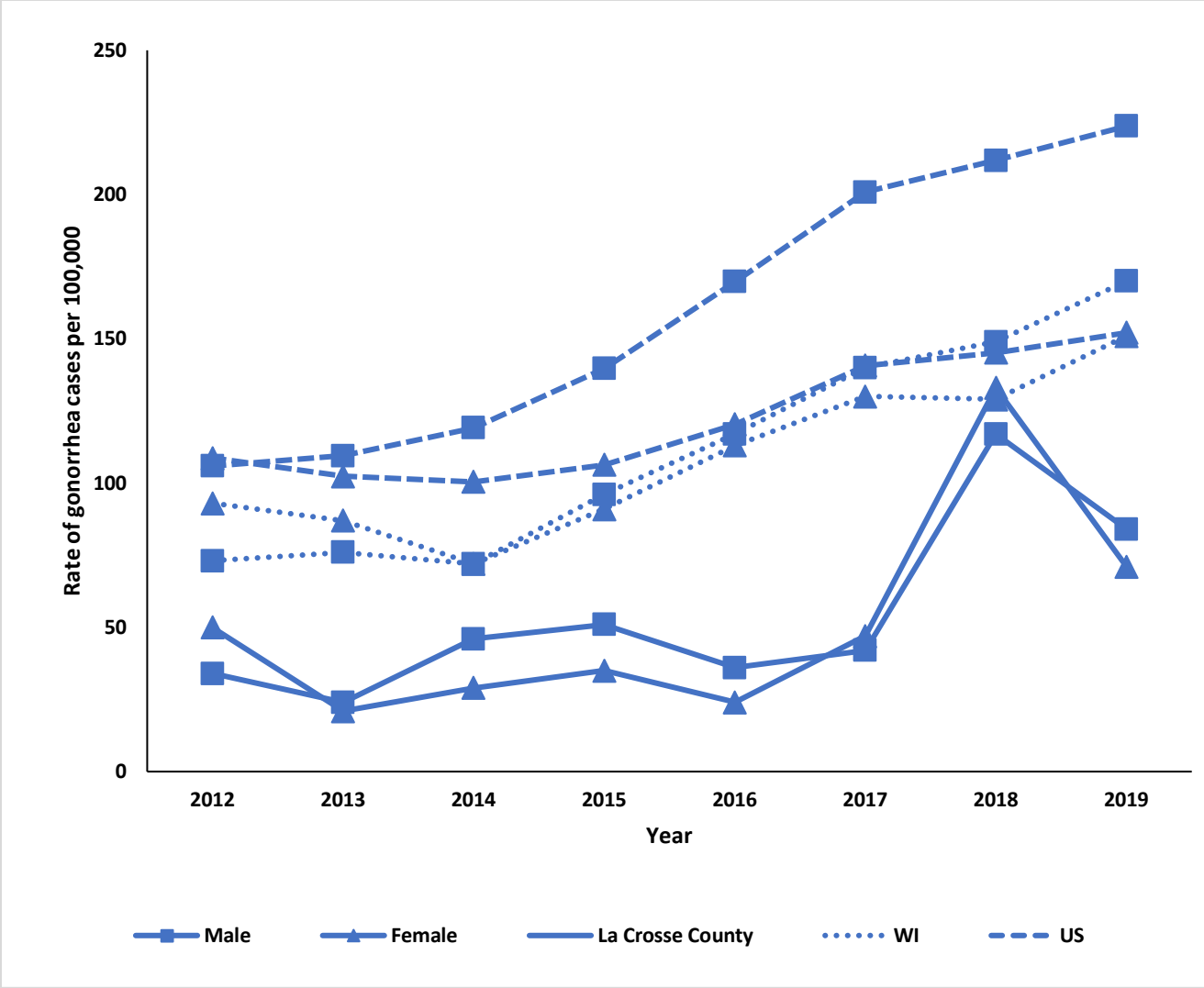

Figure 8. Annual incidence rates of gonorrhea infections per 100,000 population for males and females in La Crosse County, the State of Wisconsin (WI), and the United States (US) from 2012-2019. Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

To further analyze the data, a Two-Way ANOVA F test was performed comparing the average incidence rate, from 2012-2019, of gonorrhea infection between locations, sexes, and the realtionship between location and sex. The F test indicated that there was a significant difference (p<0.001) in the average rate of gonorrhea infections in

La Crosse County, the State of WI, and the US (Table 22). Additionally, the test found no significant difference (p=0.144) in the average gonorrhea incidence rate in females compared to males (Table 22). Lastly, we found no significant relationship (p=0.266) between location and sex when investigating the average incidence rate of gonorrhea infection (Table 22). Because there was not a significant difference in the average gonorrhea incidence rate between location and sex, a Bonferroni post-hoc test was not necessary.

Table 22. Two-Way ANOVA F test showing the significance of average gonorrhea infection incidence rates by location (La Crosse, Wisconsin, and the United States), sex (male and female), and the relationship between location and sex for the years 2012-2019.

Source	F	Significance
Location	26.613	<0.001*
Sex	2.214	0.144
Location-Sex Interaction	1.369	0.266

* = Statistically significant, $p \leq 0.05$

Race

The incidence rate of gonorrhea infection per 100,000 population identifying as White, Black, Native American/Alaskan Native, and Asian/Pacific Islander were collected in La Crosse County, the State of WI, and the US from 2012-2019 (Table 23). The rate of gonorrhea infection in the Black population was higher than the rate of infection in any other racial group in La Crosse County, the State of WI, and the US (Figure 9). Additionally, the rate of infection in the Black population was higher in La Crosse County and the State of WI than in the US (Figure 9). Although the rate of gonorrhea infection was the highest in the Black population, the rate of infection in the

Native American population was higher than the rates in their White and Asian/Pacific Islander counterparts (Figure 9).

Table 23. Annual incidence rate of gonorrhea infections per 100,000 population in La Crosse County, the State of WI, and the US from 2012-2019. Data were broken up by self-identified race as White, Black, Native American/Native Alaskan, and Asian/Pacific Islander.

Year	La Crosse County				WI				US			
	White	Black	NA	API	White	Black	NA	API	White	Black	NA	API
2012	25	983	0§	0§	18	688	89	27	33	398	78	18
2013	15	403	0§	0§	19	650	87	24	36	366	86	18
2014	27	403	0§	52§	18	557	68	22	40	355	98	19
2015	33	576	0§	52§	21	793	80	25	46	376	106	24
2016	22	518	177§	26§	29	879	62	36	57	426	131	30
2017	24	864	177§	26§	35	999	113	59	67	483	163	36
2018	98	979	353§	131§	27	1164	133	74	70	485	178	36
2019	50	1497	353§	26§	51	1415	198	71	72	512	193	40

Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

Abbreviations: Wisconsin (WI), United States (US), Native American (NA), Asian/Pacific Islander (API)

§= ≤5 cases

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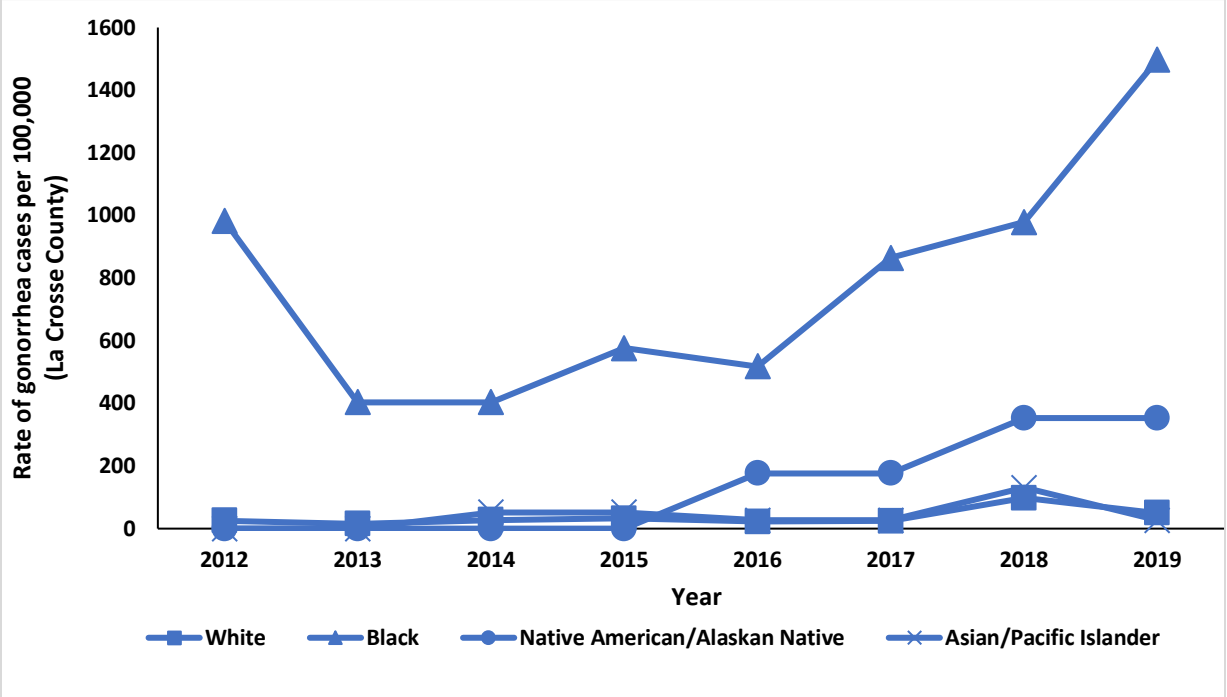

Figure 9. Annual incidence rates of gonorrhea infections per 100,000 population identifying as White, Black, Native American/Alaskan Native, and Asian/Pacific Islander in La Crosse County (A), the State of Wisconsin (B), and the United States (C) from 2012-2019. Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

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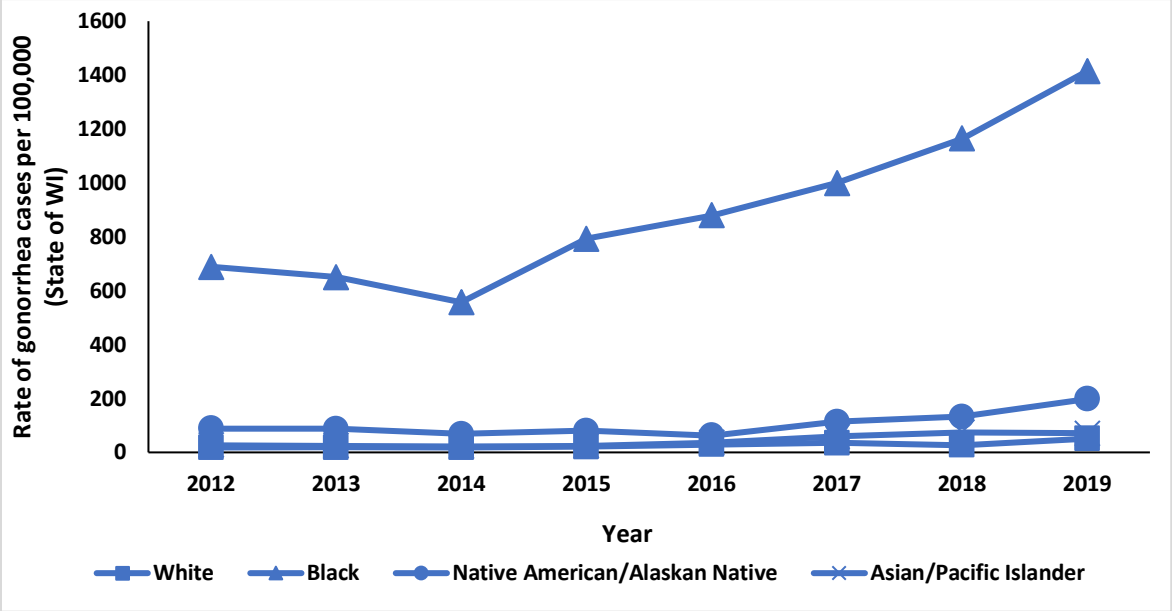

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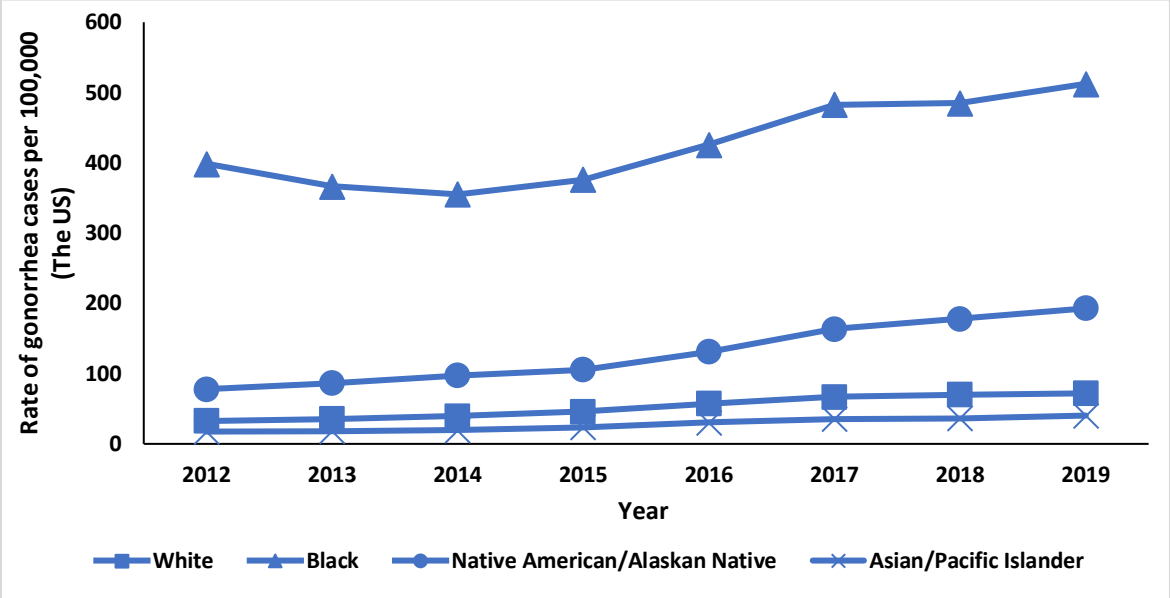

Figure 9. Continued.

To further analyze these relationships, a Two-Way ANOVA F test was performed comparing the average incidence rate, from 2012-2019, of gonorrhea infections between

locations, race, and the interaction between location and racial classification. The F test indicated that there was a significant difference (p=0.003) in the average incidence rate of gonorrhea infections in La Crosse County, the State of WI, and the US (Table 24). Additionally, we found that there were significant differences (p<0.001) among the average incidence rate of chlamydia infections between the different racial groups (Table 24). Lastly, the F test revealed that there was a significant difference (p<0.001) in the average incidence rate of gonorrhea infection between location and racial classification (Table 24). The significant relationship between location and racial classification indicates that the Bonferroni post-hoc test be performed to determine where the significance lied.

Table 24. Two-Way ANOVA F test showing the significance of average gonorrhea infection incidence rates by location (La Crosse, the State of Wisconsin, and the United States), race (White, Black, Native American/Native Alaskan, and Asian/Pacific Islander) and the relationship between location and race for the years 2012-2019.

Source	F	Significance
Location	6.326	0.003*
Race	107.789	<0.001*
Location-Race Interaction	5.935	<0.001*

* = Statistically significant, $p \leq 0.05$

The average incidence rate of gonorrhea infection was first looked at by location within each racial group. The Two-Way ANOVA plus Bonferroni post-Hoc test indicated that the average incidence rate of gonorrhea infection from 2012-2019 among those identifying as White (p=1.000), Native American (p=0.231, p=0.405, and p=1.000) or Asian/Pacific Islander (p=1.000) was not significantly different when comparing La Crosse County, the State of WI, and the US (Table 25). However, the average gonorrhea

incidence rate in the Black population was significantly higher in La Crosse County (p<0.001) and the State of WI (p<0.001) when compared to the rate in the US (Table 25). Lastly, the rate of gonorrhea infection in La Crosse County was not significantly lower (p=0.362) than the rate of infection in the State of WI in the Black population (Table 25).

Table 25**.** Results a Bonferroni post-hoc test comparing the average rate of gonorrhea infection from 2012-2019 between different locations within each racial group.

Race	Location	Location Comparison	Mean Difference	Significance
White	La Crosse County	WI	9.500	1.000
		US	-15.875	1.000
	WI	La Crosse County	-9.500	1.000
		US	-25.375	1.000
	US	La Crosse County	15.875	1.000
		WI	25.375	1.000
Black	La Crosse County	WI	-115.250	0.362
		US	352.750	<0.001*
	WI	La Crosse County	115.250	0.362
		US	468.000*	<0.001*
	US	La Crosse County	-352.750*	<0.001*
		WI	-468.000*	<0.001*
NA	La Crosse County	WI	161.250	0.231
		US	135.875	0.405
	WI	La Crosse County	-161.250	0.231
		US	-25.375	1.000
	US	La Crosse County	-135.875	0.405
		WI	25.375	1.000
API	La Crosse County	WI	9.917	1.000
		US	24.542	1.000
	WI	La Crosse County	-9.917	1.000
		US	14.625	1.000
	US	La Crosse County	-24.542	1.000
		WI	-14.625	1.000

Abbreviations: Wisconsin (WI), United States (US), Native American (NA), Asian/Pacific Islander (API)

* = Statistically significant, $p<0.05$

Next, the average incidence rate of gonorrhea infection was looked at by racial group within each location. The Two-Way ANOVA plus Bonferroni post-Hoc test indicated that the average gonorrhea incidence rate, from 2012-2019, was significantly higher in the Black population in La Crosse County ($p<0.001$), the State of WI ($p<0.001$), and the US ($p<0.001$) when compared to all other racial groups (Table 26). There was not a significant difference in average gonorrhea incidence rate found between those identifying as White, Native American, or Asian/Pacific Islander in La Crosse County ($p=0.076$, $p=0.166$, and $p=1.000$), the State of WI ($p=1.000$), or the US ($p=1.000$) (Table 26).

Table 26. Results of a Bonferroni post-hoc test comparing the average rate of gonorrhea infection from 2012-2019 between different racial groups at each location.

Location	Race	Race Comparison	Mean Difference	Significance
La Crosse County	White	Black	-741.125	<0.001*
		NA	-228.250	0.079
		API	-15.417	1.000
	Black	White	741.125	<0.001*
		NA	512.875	<0.001*
		API	725.708	<0.001*
	NA	White	228.250	0.079
		Black	-512.875	<0.001*
		API	212.833	0.166
	API	White	15.417	1.000
		Black	-725.708	<0.001*
		NA	-212.833	0.166
WI	White	Black	-865.875	<0.001*
		NA	-76.500	1.000
		API	-15.000	1.000
	Black	White	865.875	<0.001*
		NA	789.375	<0.001*
		API	850.875	<0.001*
	NA	White	76.500	1.000
		Black	-789.375	<0.001*
		API	61.500	1.000
	API	White	15.000	1.000
		Black	-850.875	<0.001*
		NA	-61.500	1.000
US	White	Black	-372.500	<0.001*
		NA	-76.500	1.000
		API	25.000	1.000
	Black	White	372.500	<0.001*
		NA	296.000	<0.001*
		API	397.500	<0.001*
	NA	White	76.500	1.000
		Black	-296.000	<0.001*
		API	101.500	1.000
	API	White	-25.000	1.000
		Black	-397.500	<0.001*
		NA	-101.500	1.000

Abbreviations: Wisconsin (WI), United States (US), Native American (NA), Asian/Pacific Islander (API)

* = Statistically significant, $p<0.05$

Hispanic Ethnicity

The rate of gonorrhea infection per 100,000 population identifying as Hispanic and non-Hispanic was collected in La Crosse County, the State of WI, and the US from 2012-2019 (Table 27). The rate of gonorrhea infection in the non-Hispanic population was higher than the rate of infection in the Hispanic population in the US. In comparison, the rate of infection in Hispanic population was higher than the rate of infection in the non-Hispanic population in La Crosse County and the State of WI (Figure 10). Additionally, the rate of gonorrhea infection in the Hispanic population was higher in La Crosse County than in the State of WI and the US (Figure 10).

Table 27. Annual incidence rate of gonorrhea infections per 100,000 population in La Crosse County, the State of WI, and the US from 2012-2019. Data were broken up by self-identified ethnicity as Hispanic or non-Hispanic.

Year	La Crosse County		WI		US	
	Hispanic	Non-Hisp.	Hispanic	Non-Hisp.	Hispanic	Non-Hisp.
2012	73[§]	32	58	52	61	73
2013	157[§]	21	59	45	65	75
2014	78[§]	33	59	42	70	80
2015	0[§]	41	51	45	79	89
2016	0[§]	25	94	58	95	105
2017	157[§]	31	129	79	111	125
2018	157[§]	110	256	110	114	130
2019	314[§]	66	192	129	117	139

Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

Abbreviations: Wisconsin (WI), United States (US), Non-Hispanic (Non-Hisp.)

§= ≤5 cases

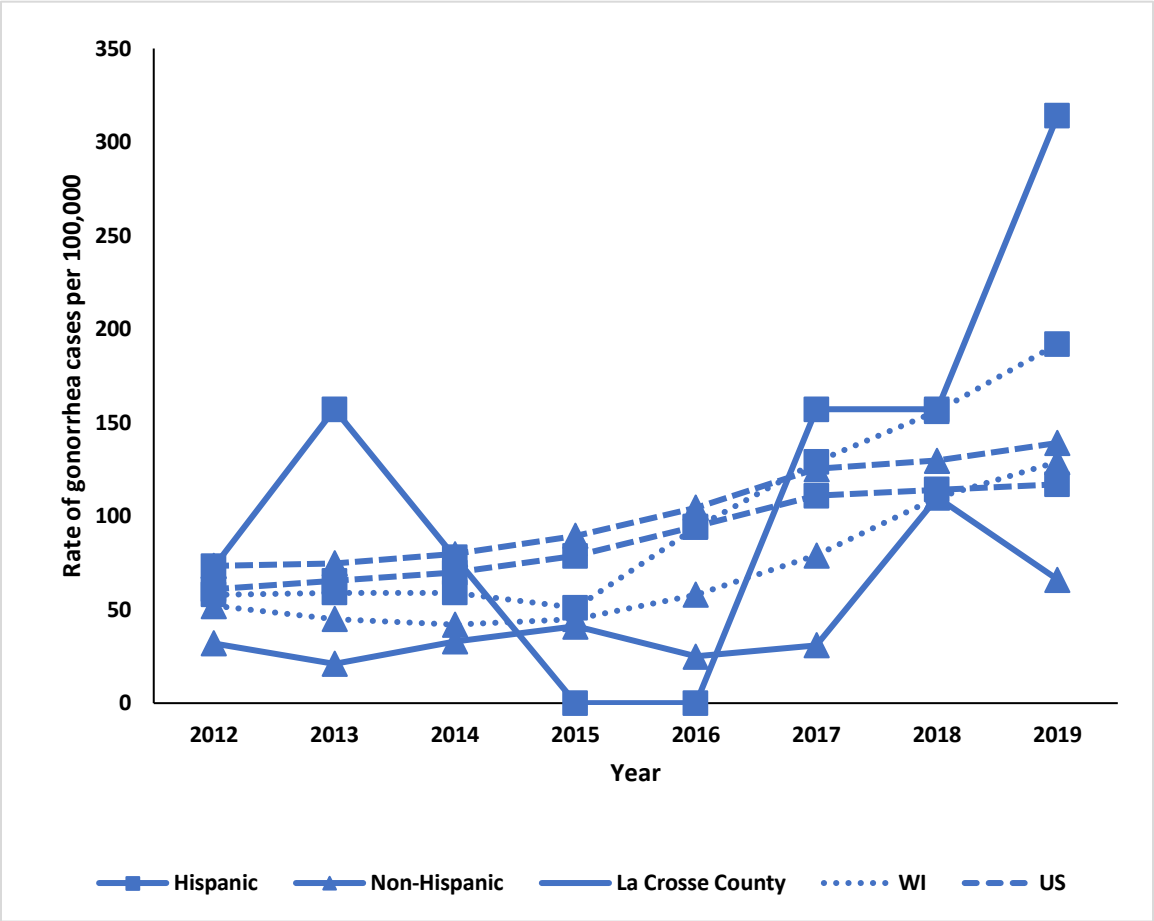

Figure 10. Annual incidence rates of gonorrhea infections per 100,000 population for Hispanic and non-Hispanic identifying individuals in La Crosse County, the State of Wisconsin (WI), and the United States (US) from 2012-2019. Data were collected from the CDC Annual Morbidity and Mortality Reports, and the Wisconsin Department of Health Services Sexually Transmitted Diseases Surveillance Reports. [44-51, 53-68]

A Two-Way ANOVA F test was performed comparing the average incidence rate, from 2012-2019, of gonorrhea infections by location, Hispanic ethnicity, and the relationship between location and Hispanic ethnicity. The test indicated that there was not a significant difference (p=0.625) in the average incidence rate of gonorrhea infections in

La Crosse County, the State of WI, and the US (Table 28). Additionally, the F test found that there was a significant (p=0.003) difference in the average rate of gonorrhea infection between those identifying as Hispanic compared to those of non-Hispanic ethnicity (Table 28). Lastly, when looking at the average rates of gonorrhea infection and the relationship between location and Hispanic ethnicity, the test found that there was a significant difference (p=0.002) in the incidence rate of gonorrhea infection (Table 28). Because the relationship between location and Hispanic ethnicity was deemed significant, a Bonferroni post-hoc test was performed to determine where the significance lied.

Table 28. Two-Way ANOVA F test showing the significance of incident gonorrhea infection by location (La Crosse, the State of Wisconsin, and the United States), ethnicity (Hispanic and non-Hispanic), and the relationship between location and ethnicity for the years 2012-2019.

Source	F	Significance
Location	0.475	0.625
Ethnicity	10.271	0.003*
Location-Ethnicity Interaction	7.209	0.002*

* = Statistically significant, $p<0.05$

The average incidence rate of gonorrhea infection was first looked at by location within either Hispanic or non-Hispanic ethnicity. The Bonferroni post-hoc test indicated that the average incidence rate of gonorrhea infection from 2012-2019, in the Hispanic population was significantly higher (p=0.026) in La Crosse County compared to the US (Table 29). However, the rate of gonorrhea in the Hispanic population was not significantly different (p=0.076) between La Crosse County and the State of WI (Table 29). Similarly, the average incidence rate of gonorrhea infection in the Hispanic

population was not significantly different (p=1.000) when comparing the rate in the State of WI to the US (Table 29). The post-hoc test showed that the average incidence rate of gonorrhea infection in the non-Hispanic population was significantly higher (p=0.044) in La Crosse County compared to the US (Table 29). Lastly, the test indicated that there was not a significant difference in the average incidence rates of gonorrhea infection in the non-Hispanic population in La Crosse County compared to the State of WI (p=0.807) or the State of WI compared to the US (p=0.484) (Table 29).

Table 29. Results of a Bonferroni post-hoc test comparing the average rate of gonorrhea infection from 2012-2019 at each location within each either Hispanic or non-Hispanic ethnic groups.

Ethnicity	Location	Location Comparison	Mean Difference	Significance
Hispanic	La Crosse County	WI	56.250	0.076
		US	67.000	0.026*
	WI	La Crosse County	-56.250	0.076
		US	10.750	1.000
	US	La Crosse County	-67.000	0.026*
		WI	-10.750	1.000
Non-Hispanic	La Crosse County	WI	-25.125	0.807
		US	-57.125	0.044*
	WI	La Crosse County	25.125	0.807
		US	-32.000	0.484
	US	La Crosse County	57.125	0.044*
		WI	32.000	0.484

Abbreviations: Wisconsin (WI), United States (US)

* = Statistically significant, p<0.05

Next, the average incidence rate of gonorrhea infection was looked at by ethnicity within each location. The Bonferroni post-hoc test indicated that the average incidence

rate of gonorrhea infection from 2012-2019 in La Crosse County was significantly higher (p<0.001) in the Hispanic population compared to the non-Hispanic population (Table 30). Additionally, the test indicated that there was not a significant difference in the average incidence rate of gonorrhea infection between those identifying as Hispanic versus non-Hispanic in the State of WI (p=0.192) or the US (p=0.565) (Table 30).

Table 30. Results of a Bonferroni post-hoc test comparing the average rate of gonorrhea infection from 2012-2019 between Hispanic and non-Hispanic identifying individuals at each location.

Location	Ethnicity	Ethnicity Comparison	Mean Difference	Significance
La Crosse County	Hispanic	Non-Hispanic	111.125	<0.001*
	Non-Hispanic	Hispanic	-111.125	<0.001*
WI	Hispanic	Non-Hispanic	29.750	0.192
	Non-Hispanic	Hispanic	-29.750	0.192
US	Hispanic	Non-Hispanic	-13.000	0.565
	Non-Hispanic	Hispanic	13.000	0.565

Abbreviations: Wisconsin (WI), United States (US)

* = Statistically significant, p<0.05

DISCUSSION

Despite advancements in detection and screening of STIs, chlamydia and gonorrhea rates continue to rise.[1-4] Previously, both types of infections have been treatable with antibiotics, however in recent years, antibiotic resistant gonorrhea infections have emerged and continue to rise in frequency.[27] Untreated chlamydia and gonorrhea infections run the risk of causing serious long-term effects, especially in females of reproductive age. We have known for decades that certain demographic groups are more negatively impacted by chlamydia and gonorrhea.[1,4,9,13-15] The purpose of this study was to track chlamydia and gonorrhea rates at the County, State, and National level over a 20-year period from 2001-2020 and assess demographic changes pertaining to age, sex, race, and ethnicity regarding both diseases.

Previous studies have demonstrated a rise in per capita rate of chlamydia and gonorrhea rates at the National level.[1-4] From 2011 to 2019 our study found an increase in the annual per capita rate of chlamydia cases at the National level from 457 to 551. Similarly, the State of WI saw a rise in rate per capita from 2011 to 2019 from 429 to 529 for chlamydia; and La Crosse County a rise from 378 to 543 cases per capita. Our study shows a steady increase in chlamydia cases from 783,242 cases in 2001 to 1,335,916 cases in 2020 in the US. Moreover, we demonstrate a simultaneous increase at the State level with 16,284 cases in 2001 to 22,277 in 2020 in the State of WI, and at the County level, with 266 cases 2001 to 598 in 2020 in La Crosse County. All three locations

demonstrate increased cases over time; however, the case load is likely underestimated due to the asymptomatic nature of chlamydia. Furthermore, a drop in case number in seen at the County, State, and National level from 2019 to 2020. This may be due to a lack of incomplete testing and reporting due to the Covid-19 pandemic.

Like chlamydia, our study saw an increase in the number of cases of gonorrhea over time. At the National level we saw an increase from 2001 to 2020 from 361,705 to 564,110 in the US, this is further supported by an increase in cases per capita from 2011 to 2019 of 104 to 188 per 100,000. The increase at the State level was less drastic, and during the early 2010s (2008-2014) a brief decrease was even seen. From 2001 to 2020 the State of WI went from 6,011 cases of gonorrhea to 8,315 cases with a low of 4,078 in 2014. However, a near doubling in the cases per capita from 2011 to 2019 of 84 to 161 adds support for a rise in gonorrhea cases in the State of WI. La Crosse County on the other hand, is much less predictable in terms of gonorrhea cases, in 2001 La Crosse County had 55 cases and in 2020, 163 cases, however greater fluctuation exists year to year. This fluctuation is also seen in the number of cases per capita, from 45 in 2011 to 77 in 2019, although, a steep peak is seen in 2018 with 125 cases per 100,000. However, the high cases count in 2018 of 145 and 163 in 2020, provides possible flags that gonorrhea cases are beginning to rise quicker in La Crosse County, or that antibiotic resistance may be emerging.

Past studies have shown over 50% of newly diagnosed STIs in the US are in those 15 to 24-years-old, and those percentages may be even higher in those with chlamydia and gonorrhea.[1,4] Further, some studies have suggested that rates of both diseases may be rising in those 25 years of age and older.[69,70] When we looked at the average incidence

rate of chlamydia infections from 2012-2019, those 15 to 24-years-old had the highest rates in La Crosse County and the State of WI that matched previous studies.[1,4] Additionally, we also saw that the rate of chlamydia infection in those 25 to 39-years-old, was lower than the 15 to 24-year-old age group, but was significantly higher in La Crosse County and the State of WI than either the under the age of 15 or the 40+ age groups. The rise in chlamydia cases in the higher age groups in WI is a concern because, these individuals are not within the age group where annual screening protocols for asymptomatic chlamydia and gonorrhea infections occur.[7,27,28]

Besides chlamydia and gonorrhea numbers changing over a 20-year time period, we also noted significant disparities in average gonorrhea incidence rates among the different age groups in this study. In both La Crosse County and the State of WI, most gonorrhea cases were in those 15 to 24-years-old. On the other hand, the rate of infection in those 25 to 39-years-old was equal to the 15 to 24 -years-old age group in La Crosse County. In the State of Wisconsin, the number of cases in those 25 to 39-years-old was lower than in those 15 to 24-years-old, but still significantly higher than in all other age groups. Thus, our data suggests STI rates are rising in older populations.

Surprisingly, despite the large number of college students who call La Crosse County home for the majority of the year, the average incidence rate of both chlamydia and gonorrhea infections in La Crosse County was lower than the State of WI. One explanation is students report their infections to their home counties rather than La Crosse County if they are only there for school. Moreover, as noted above, a demographic age shift has emerged at the County and State levels regarding gonorrhea rates. This could suggest that increasing the annual screening age past the age of 24, as

currently recommended by the CDC, may help to better prevent and detect chlamydia and gonorrhea infections in older populations.[7, 27, 28]

Besides the higher number of STIs in certain age groups, sex is another parameter. Historically, we have seen higher rates of chlamydia in females compared to males.[1] This study reaffirms this gender disparity for chlamydia cases. However, the average rates of gonorrhea infection, did not differ when comparing males to females at the County, State, or National level. Such differences in infection rates for gonorrhea and chlamydia in males versus females between does not necessarily mean that chlamydia infects males less than females. The disparity in infection rates could be due to a lack of diagnosis, which is not uncommon due to the asymptomatic nature of chlamydia and the lack of screening policy for men who have sex with women (MSW).[1,4,5]

Past work has demonstrated that racial and ethnic minorities (e.g. Black, Native American, and Hispanic) have large disparities in incidence rates of chlamydia and gonorrhea infections. [13,14,21-23] When looking at the incidence rates of chlamydia in relation to different racial groups, both La Crosse County and the State of WI had significantly higher average incident rates of chlamydia infection in the Black population than the rate in the US. Additionally, the chlamydia rate in Native Americans in La Crosse County was higher than both the State of WI and the US, but no difference in the rates were noted when the State of WI was compared to the US. The same relationship was seen between location and incidence of gonorrhea infection among Black Americans, where La Crosse County and the State of WI had higher rates than that of the US.

When chlamydia rates were analyzed, Black and Native Americans had significantly higher average incidence rates compared to White and Asian

Americans/Pacific Islanders. This trend was more apparent for Black Americans in La Crosse County, who had higher rates than their Native American counter parts. Similarly, Black Americans have higher average incidence rates of chlamydia infections than all other racial groups in the State of WI and the US. These are important statistics to consider as Black Americans do not just have higher rates of STIs, but also the long-term effects associated with them, which include, higher rates of infertility and maternal-fetal mortality among Black women.[9,12-14,31]

Higher rates of STIs in Black and Native Americans versus White Americans have been shown previously noted and were observed in our study.[13,14,23] Those of Hispanic ethnicity have also been shown to have higher rates of chlamydia and gonorrhea incidence.[13,14,23] In our study, the average rate of chlamydia infections in the Hispanic population was significantly highest in La Crosse County, followed the State of WI, and lastly, by the US. This finding is different from the average incidence rates of chlamydia infections in the non-Hispanic population which was found to be not statistically different at all locations. Our results comparing the average incidence rate of gonorrhea infections at each location by Hispanic or non-Hispanic ethnicity were less straight-forward. The average rate of infection was higher in La Crosse County than the US for both Hispanic and non-Hispanic populations, however, was not statistically different between La Crosse County and the State of WI or the State of WI and the US.

When we looked at the relationships reversed, the average incidence rates of chlamydia infection in La Crosse County, the State of WI, and the US, we found that at the State and County levels, rates of infection were significantly higher in the Hispanic population than the non-Hispanic population. At the national level, there was no

significant difference between chlamydia infection rate in the Hispanic and non-Hispanic populations. Similar findings were described in relation to gonorrhea in La Crosse County and the US. In La Crosse County, the rate of gonorrhea infection was higher among those who identified as Hispanic compared to their non-Hispanic counterparts. Unlike La Crosse County, this study showed the State of WI and the US did not have significantly higher rates of gonorrhea infection in their Hispanic populations compared to their non-Hispanic populations.

The initial goal of this study was to examine data from years 2001 to 2020 for La Crosse County, the State of WI, and the US, including breakdowns for the four demographic groups (age, sex, race, and ethnicity), however various limitations should be noted. Demographic data for rates before 2012 could not be obtained due to a change in the monitoring software used. Although 2020 data became available, the demographic groupings were not consistent with previous years data, and therefore, the data was difficult to make accurate comparisons with past years. Another factor in the analysis was the population of La Crosse County was rather small from 2000 to 2020 (107,308 to 120,784).[71,72] Thus, there were limited case counts in a variety of chlamydia (age – 0 to 14, race – Native American) and gonorrhea (age – 0 to 14 and 40+, race – Native American and Asian American/Pacific Islander, Ethnicity – Hispanic) demographic categories. Each of these categories had at least one year with less than five cases, which was noted in each corresponding table, however, this opens up the possibility for skewing the statistical analysis. Therefore, additional, and more in-depth statistical analysis of this data should be done to ensure that these disparities are accurately described. Additionally, other factors could be investigated, including the relationship between gonorrhea and

chlamydia rate and socio-economic status, as well as looking at the rate of infection with age adjustment.

Because chlamydia and gonorrhea rates continue to climb, even at the La Crosse County level, there is a need to increase outreach in the form of prevention and detection to our demographic groups with the highest disparities in chlamydia and gonorrhea infections. These include not just performing abstinence with un-tested partners and limiting the number of sexual partners, but also correctly using condoms to prevent the transmission of STIs while participating in sexual practices. Moreover, better access to comprehensive and accurate sex education, affordable contraception, and screening, particularly among young women may help to decrease the burden of chlamydia and gonorrhea infections. Our data suggests that increasing the age of recommending screening past 24 years old may better detect incident chlamydia and gonorrhea rates in older populations. Furthermore, routine testing in the MSW population would likely catch more cases of gonorrhea and chlamydia in males, but also help to prevent the spread of asymptomatic infections into females. Additionally, we must make sure these services are equitably accessible to our racial and ethnic minority populations, as our study has shown demographic age, sex, race, and ethnic disparities exist at the county level in La Crosse County amid existing knowledge of disparities in the state of WI and the US.

REFERENCES

1. Satterwhite CL, Torrone E, Meites E, Dunne EF, Mahajan R, Ocfemia MCB, Su J, Xu F, Weinstock H. Sexually transmitted infections among US women and men: prevalence and incidence estimates, 2008. *Sex Trans Dis*. 2013;40:187–193.

2. TABLE 1g. Weekly cases* of notifiable diseases, United States, U.S. Territories, and Non-U.S. Residents weeks ending December 28, 2019 (week 52). https://wonder.cdc.gov/nndss/static/2019/52/2019-52-table1g.html. Accessed April 21, 2020.

3. TABLE 1m. Weekly cases* of notifiable diseases, United States, U.S. Territories, and Non-U.S. Residents weeks ending December 28, 2019 (week 52). https://wonder.cdc.gov/nndss/static/2019/52/2019-52-table1m.html. Accessed April 21, 2020.

4. Miller WC, Ford CA, Morris M, Handcock MS, Schmitz JL, Hobbs MM, Cohen MS, Harris KM, Udry JR. Prevalence of chlamydial and gonococcal infections among young adults in the United States. *JAMA*. 2004;291:2229–2236.

5. Farley TA, Cohen DA, Elkins W. Asymptomatic sexually transmitted diseases: the case for screening. *Prev Med*. 2003;36:502–509.

6. O'Connell CM, Ferone ME. *Chlamydia trachomatis* genital infections. *Microb Cell*. 2016;3:390–403

7. Chan PA, Robinette A, Montgomery M, Almonte A, Cu-Uvin S, Lonks JR, Chapin KC, Kojic EM, Hardy EJ. Extragenital infections caused by *Chlamydia trachomatis* and *Neisseria gonorrhoeae*: A review of the literature. *Infect Dis Obstet Gynecol*. 2016;2016:5758387.

8. Tao G, Hoover KW, Nye MB, Peters PJ, Gift TL, Body BA. Infrequent testing of women for rectal chlamydia and gonorrhea in the United States. *Clin Infect Dis*. 2018;66:570–575.

9. Llata E, Braxton J, Asbel L, Chow J, Jenkins L, Murphy R, Pathela P, Schumacher C, Torrone E. Rectal *Chlamydia trachomatis* and *Neisseria gonorrhoeae* infections among women reporting anal intercourse. *Obstet Gynecol*. 2018;132:692–697.

10. Tao G, Hoover KW, Nye MB, Peters P, Gift TL, Peruvemba R, Body BA. Rectal infection with *Neisseria gonorrhoeae* and *Chlamydia trachomatis* in men in the United States. *Clin Infect Dis*. 2016;63:1325–1331.

11. Blatt AJ, Lieberman JM, Hoover DR, Kaufman HW. Chlamydial and gonococcal testing during pregnancy in the United States. *Am J Obstet Gynecol*. 2012;207:55.e1-8.

12. Tsevat DG, Wiesenfeld HC, Parks C, Peipert JF. Sexually transmitted diseases and infertility. *Am J Obstet Gynecol*. 2017;216:1–9.

13. Harling G, Subramanian S, Bärnighausen T, Kawachi I. Socioeconomic disparities in sexually transmitted infections among young adults in the United States: examining the interaction between income and race/ethnicity. *Sex Transm Dis.* 2013;40:575–581.

14. Springer YP, Samuel MC, Bolan G. Socioeconomic gradients in sexually transmitted diseases: a geographic information system–based analysis of poverty, race/ethnicity, and gonorrhea rates in California, 2004–2006. *Am J Public Health*. 2010;100:1060–1067.

15. Huneeus A, Schilling A, Fernandez MI. Prevalence of *Chlamydia trachomatis, Neisseria gonorrhoeae,* and *Trichomonas vaginalis* infection in Chilean adolescents and young adults. *J Pediatr Adolesc Gynecol*. 2018;31:411–415.

16. Tilson EC, Sanchez V, Ford CL, Smurzynski M, Leone PA, Fox KK, Irwin K, Miller WC. Barriers to asymptomatic screening and other STD services for adolescents and young adults: focus group discussions. *BMC Public Health*. 2004;4:21.

17. Cunningham SD, Kerrigan DL, Jennings JM, Ellen JM. Relationships between perceived STD-related stigma, STD-related shame and STD screening among a household sample of adolescents. *Perspect Sex Reprod Health*. 2009;41:225–230.

18. STDs in Racial and Ethnic Minorities - 2018 Sexually Transmitted Diseases Surveillance. https://www.cdc.gov/std/stats18/minorities.htm. Published October 8, 2019. Accessed May 3, 2020.

19. Berchick ER, Hood E, Barnett JC. Health Insurance Coverage in the United States: 2017. https://www.census.gov/content/dam/Census/library/publications/2018/demo/p60-264.pdf. Published 2018. Accessed October 24, 2020.

20. Youth Risk Behavior Surveillance — United States, 2011. https://www.cdc.gov/mmwr/preview/mmwrhtml/ss6104a1.htm. Accessed April 8, 2020.

21. Bautista CT, Wurapa EK, Sateren WB, Morris SM, Hollingsworth BP, Sanchez JL. Association of bacterial vaginosis with chlamydia and gonorrhea among women in the U.S. Army. *American Journal of Preventive Medicine*. 2017;52(5):632-639.

22. Marotta P. Assessing spatial relationships between race, inequality, crime, and gonorrhea and chlamydia in the United States. *J Urban Health*. 2017;94(5):683-698.

23. Crichton J, Hickman M, Campbell R, Batista-Ferrer H, Macleod J. Socioeconomic factors and other sources of variation in the prevalence of genital chlamydia infections: A systematic review and meta-analysis. *BMC Public Health.* 2015;15.

24. Kohler PK, Manhart LE, Lafferty WE. Abstinence-only and comprehensive sex education and the initiation of sexual activity and teen pregnancy. *J Adolesc Health*. 2008;42:344–351.

25. Annang L, Walsemann KM, Maitra D, Kerr JC. Does education matter? Examining racial differences in the association between education and STI diagnosis among black and white young adult females in the U.S.. *Public Health Rep.* 2010;125:110–121.

26. Fetner T, Dion M, Heath M, Andrejek N, Newell SL, Stick M. Condom use in penile-vaginal intercourse among Canadian adults: Results from the sex in Canada survey. *PLoS One*. 2020;15(2).

27. Yarbrough ML, Burnham C-AD. The ABCs of STIs: An Update on sexually transmitted infections. *Clin Chem*. 2016;62(6):811-823.

28. Hlatshwayo M, Reno HEL, Yarbrough ML. STI update: Testing, treatment, and emerging threats. CCJM. 2019;86(11):733-740.

29. Bom RJM, van der Linden K, Matser A, et al. The effects of free condom distribution on HIV and other sexually transmitted infections in men who have sex with men. *BMC Infect Dis*. 2019;19(1):222.

30. Petrova D, Garcia-Retamero R. Effective evidence-based programs for preventing sexually-transmitted infections: a meta-analysis. *Curr HIV Res*. 2015;13(5):432-438.

31. Owusu-Edusei KJ, Chesson HW, Gift TL, Tao G, Mahajan R, Ocfemia MCB, Kent CK. The estimated direct medical cost of selected sexually transmitted infections in the United States, 2008. *Sex Trans Dis.* 2013;40:197–201.

32. Williams AM, Kreisel K, Chesson HW. Impacts of federal prevention funding on reported gonorrhea and chlamydia rates. *American Journal of Preventive Medicine*. 2019;56(3):352-358.

33. CDC. Summary of Notifiable Diseases – United States, 2001. *MMWR.* 2003;50.

34. CDC. Summary of Notifiable Diseases – United States, 2002. *MMWR.* 2004;51.

35. CDC. Summary of Notifiable Diseases – United States, 2003. *MMWR.* 2005;52.

36. CDC. Summary of Notifiable Diseases – United States, 2004. *MMWR.* 2006;53.

37. CDC. Summary of Notifiable Diseases – United States, 2005. *MMWR.* 2007;54.

38. CDC. Summary of Notifiable Diseases – United States, 2006. *MMWR*. 2008;55.

39. CDC. Summary of Notifiable Diseases – United States, 2007. *MMWR.* 2009;56.

40. CDC. Summary of Notifiable Diseases – United States, 2008. *MMWR.* 2010;57.

41. CDC. Summary of Notifiable Diseases – United States, 2009. *MMWR.* 2011;58.

42. CDC. Summary of Notifiable Diseases – United States, 2010. *MMWR.* 2012;59.

43. CDC. Summary of Notifiable Diseases – United States, 2011. *MMWR.* 2013;60.

44. CDC. Summary of Notifiable Diseases – United States, 2012. *MMWR.* 2014;61.

45. CDC. Summary of Notifiable Diseases – United States, 2013. *MMWR.* 2015;62.

46. CDC. Summary of Notifiable Diseases – United States, 2014. *MMWR*. 2016;63.

47. CDC. Summary of Notifiable Diseases – United States, 2015. *MMWR*. 2017;64.

48. CDC. Summary of Notifiable Diseases – United States, 2016. *MMWR*. 2018;65.

49. CDC. Summary of Notifiable Diseases – United States, 2017. *MMWR*. 2019;66.

50. CDC. Summary of Notifiable Diseases – United States, 2018. *MMWR*. 2020;67.

51. CDC. Summary of Notifiable Diseases – United States, 2019. *MMWR*. 2021;68.

52. Sexually Transmitted Disease in Wisconsin, 2011, Reported Cases. https://www.dhs.wisconsin.gov/publications/p0/p00415-2011.pdf. Accessed April 21, 2020.

53. Sexually Transmitted Disease in Wisconsin, 2012, Reported Cases. https://www.dhs.wisconsin.gov/publications/p0/p00415-2012.pdf. Accessed April 21, 2020.

54. Sexually Transmitted Disease in Wisconsin, 2013, Reported Cases. https://www.dhs.wisconsin.gov/publications/p0/p00415-2013.pdf. Accessed April 21, 2020.

55. Sexually Transmitted Disease in Wisconsin, 2014, Reported Cases. https://www.dhs.wisconsin.gov/publications/p00415-2014.pdf. Accessed April 21, 2020.

56. Sexually Transmitted Disease in Wisconsin, 2015, Reported Cases. https://www.dhs.wisconsin.gov/publications/p00415-2015.pdf. Accessed April 21, 2020.

57. Sexually Transmitted Disease in Wisconsin, 2016, Reported Cases. https://www.dhs.wisconsin.gov/publications/p00415-2016.pdf. Accessed April 21, 2020.

58. Sexually Transmitted Disease in Wisconsin, 2017, Reported Cases. https://www.dhs.wisconsin.gov/publications/p00415-2017.pdf. Accessed April 21, 2020.

59. Sexually Transmitted Disease in Wisconsin, 2018, Reported Cases. https://www.dhs.wisconsin.gov/publications/p00415-2018.pdf. Accessed April 21, 2020.

60. Sexually Transmitted Disease in Wisconsin, 2019, Reported Cases. https://www.dhs.wisconsin.gov/publications/p00415-2019.pdf. Accessed April 21, 2020.

61. Wisconsin sexually transmitted disease surveillance report, 2012 *La Crosse County.* https://www.dhs.wisconsin.gov/publications/p0/p00415a-b/p00415b-lacrosse-2012.pdf. Accessed April 21, 2020.

62. Wisconsin sexually transmitted disease surveillance report, 2013 *La Crosse County.* https://www.dhs.wisconsin.gov/publications/p0/p00415b-2013-lacrosse.pdf. Accessed April 21, 2020.

63. Wisconsin sexually transmitted disease surveillance report, 2014 *La Crosse County.* https://www.dhs.wisconsin.gov/publications/p00415b-2014-lacrosse.pdf. Accessed April 21, 2020.

64. Wisconsin sexually transmitted disease surveillance report, 2015 *La Crosse County.* https://www.dhs.wisconsin.gov/publications/p00415b-2015-lacrosse.pdf. Accessed April 21, 2020.

65. Wisconsin sexually transmitted disease surveillance report, 2016 *La Crosse County.* https://www.dhs.wisconsin.gov/publications/p00415b-2016-lacrosse.pdf. Accessed April 21, 2020.

66. Wisconsin sexually transmitted disease surveillance report, 2017 *La Crosse County.* https://www.dhs.wisconsin.gov/publications/p00415b-2017-la-crosse.pdf. Accessed April 21, 2020.

67. Wisconsin sexually transmitted disease surveillance report, 2018 *La Crosse County.* https://www.dhs.wisconsin.gov/publications/p00415b-2018-lacrosse.pdf. Accessed April 21, 2020.

68. Wisconsin sexually transmitted disease surveillance report, 2019 *La Crosse County.* https://www.dhs.wisconsin.gov/publications/p00415b-2019-lacrosse.pdf. Accessed April 21, 2020.

69. Kaufman HW, Gift TL, Kreisel K, Niles JK, Alagia DP. Chlamydia and gonorrhea: shifting age-based positivity among young females, 2010-2017. *Am J Prev Med.* 2020;59(5):697-703.

70. Centers for Disease Control and Prevention. Youth risk behavior survey, data summary & trends report 2007-2017. https://www.cdc.gov/healthyyouth/data/yrbs/pdf/trendsreport.pdf. Accessed October 20, 2022.

71. U.S. Census Bureau QuickFacts: La Crosse County, Wisconsin. www.census.gov. Accessed October 21, 2022.

72. Resident population in La Crosse County, WI. https://fred.stlouisfed.org/series/WILACR3POP. Accessed October 21, 2022.