Geographical Clustering of Sexually Transmitted Infections: A Closer Look at Rural County Incidence Rates

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Abstract

Sexually transmitted infections (STIs) are increasingly prevalent in rural communities and local health departments are and important resource for surveillance and treatment options. The purpose of this study was to analyze and map the distribution of sexually transmitted diseases (chlamydia, gonorrhea, hepatitis A, hepatitis B, hepatitis C, syphilis and HIV for Williams County, Ohio, to optimize intervention strategies in a rural area. The study population was constructed from de-identified reportable disease data from the Williams County Health Department in Montpelier, Ohio. Incidence rates from 2014 to May of 2017 were geographically mapped and "hot spots" based on zip code were identified. STIs were collectively clustered in several localized areas within the county. (**Add conclusive findings**). Additional intervention and prevention resources through the local health department aimed at demographic and geographic variables can be utilized based on findings.

Keywords: *Rural, Sexually transmitted infections, Sexually transmitted disease, Geographic information system, Public health*

Geographical Clustering of Sexually Transmitted Infections: A Closer Look at Rural County Incidence Rates

According to the Centers for Disease Control and Prevention (CDC), there is an estimated 20 million newly diagnosed sexually transmitted infections (STIs) each year with almost half of them among young people ages 15 to 24 (Aral, Fenton & Lipshutz, 2013). The cost of STIs to the United States health care system is estimated to be anywhere from $16 billion (Owusu-Edusei et al., 2013) to $17 billion in diagnosis, treatment, and care costs (Chesson, 2004). Therefore, STIs remain among the most prevalent and costly health conditions facing western industrialized countries and an opponent in the public health fight. Sexually transmitted disease and sexually transmitted infection are terms that are often used interchangeably (as in this paper), but many individuals do not experience any symptoms or have infection develop into disease). Infection without a presenting disease makes detection even more difficult for health officials. Since STIs often go unnoticed and untreated, they can spread easily through high-risk populations and may result in a diverse range of potential health consequences. These health consequences can range from mild acute illness to serious long-term complications such as cervical, liver and other cancers, along with reproductive health problems (Institute of Medicine, Committee on Prevention and Control of Sexually Transmitted Diseases, 1997). A high proportion of people who are infected but are asymptomatic and have low screening levels, are the ones fueling transmission rates (Spielberg et al., 2014). Untreated chlamydia or gonorrhea can lead to pelvic inflammatory disease, infertility, ectopic pregnancy, and chronic pelvic pain, while untreated trichomoniasis can increase a woman's risk of premature delivery, and all three mentioned infections can increase the risk of acquiring HIV (Spielberg et al., 2014). The risk of acquiring a STI depends on multiple factors including the sexual behavior of an individual, the behaviors of their sexual partner, but also the partner(s) of their partner(s), and so on. For this reason, we need to think in terms of populations, not just individuals as public health advocates (Aral, Fenton & Lipshutz, 2013).

Geographical space mapping is a significant public health tool that identifies populations at risk on this broader scale. To further study epidemics, spatial mapping of the clustering of Sexually transmitted diseases (STD) at a more local level may provide a better insight into certain epidemics and high-risk population behaviors. Though sexually transmitted infections (STIs) are thought to be an urban disease due to socioeconomic and ethnicity factors, rural communities may also see increases in prevalence.

Sexually Transmitted Disease Trends

In the United States, rates of sexually transmitted diseases (STDs) have decreased in areas, while increasing in others. With the Affordable Care Act, the availability of testing was thought to increase. However, even with the expansion of insurance coverage, consumer protections, and access to primary care/prevention services and treatment, there are still many Americans left uninsured (Hoover et al., 2015). The CDC estimated that in 2015, the overall rate of chlamydia nationally among women (645.5 cases per 100,000 females) was over two times the rate among men (305.2 cases per 100,000 males). During 2014 to 2015 the rate of reported gonorrhea increased 18.3% among men and 6.8% among women, with rates among both men and women increasing in every region of the United States. During 2014 to 2015, the syphilis rate increased both among men (18.1%) and women (27.3%) and rates increased among both sexes in every region of the country. The number of cases of hepatitis A has been variable over the five-year period from 2011 to 2015, with highs in 2013. Hepatitis B had a large increase in 2015 and acute hepatitis C had a 2.9-fold increase from 2010 to 2015.

According to Gottlieb et al. (2014) there was an estimated 499 million curable sexually transmitted infections (gonorrhea, chlamydia, syphilis, and trichomoniasis) occurring globally in 2008 with over 500 million people estimated to have a viral STI (e.g. herpes simplex virus type 2 human papillomavirus). Specifically, there has been a recent increase in sexually transmitted diseases across rural parts of Ohio, with 461 chlamydia infections per 100,000 people compared to 447 nationally and 144 gonorrhea cases per 100,000 people versus 106 nationally (Ison, 2015).

In the most recent Annual Communicable Disease Report for Williams County, Ohio, it was reported that the rate of chlamydia infection in Williams County has an overall increase since 2010. The most substantial increase occurred from 2010 to 2011; an increase in rates by 148% (Briggs, 2017).

Spatial Mapping in Public Health

Social determinants encompass where an individual resides and how they interact and grow within an environment. For example, geographical location of residency and health care availability are social determinants that may impact one's’ health. Since variation in social determinants occurs, the socioeconomic conditions of a particular area should be taken into account when researching STD prevention and intervention programs.

Variation in the burden of disease occurs in different communities and these marked variations can change over time and geographic location (Satterwhite et al., 2013). Additionally, there are varied disparities in the burden of STIs in different groups across and even within states (Chesson, Sternberg, Leichliter & Aral, 2010). Currently, the highest rates of sexually transmitted infections continue to be in metropolitan areas (Ison, 2015), but while these rates are mostly stable or have been steadily declining, many rural areas, such as those in Ohio, are seeing a steady increase (Ison, 2015). With the help of state guidelines, local health departments are one resource individuals may utilize for testing and information regarding STIs. Understanding where resources are located and how they are being utilized is imperative for understanding if there is more of a need in certain areas.

The field of geographic information systems (GIS) has become extremely useful in understanding the bigger picture of data, especially in the realm of public health (Musa et al., 2013). GIS puts focus on population health by identifying disease causes through surveillance techniques.

GIS mapping allows for a visual representation of high risk zip codes that could not otherwise be easily perceived with data graphs and tables and to help community stakeholders integrate local knowledge, and interpret data. There is little research currently done on the topic, due to the lack of community access to confidential health data. GIS is often used by epidemiologists to assess proximity, aggregation, and clustering, as well as to perform spatial smoothing, interpolation and spatial regression (Auchincloss, Gebreab, Mair & Diez-Roux, 2012). Transmission depends on sexual contact, sexual network patterns and the prevalence of the infection in a particular pool of potential sexual partners. An individual living in a rural community with a small pool of potential partners has an increased chance that one infected person may spread the infection to multiple individuals in the same sexual partner pool.

Researchers are targeting where there is a need for STD resources (due to high rates of infection) by mapping cluster-associated STD patterns. Ramjee and Wand (2014) used geographical clustering of high risk behaviors in South Africa to suggest that young women are particularly at high risk of both HIV and STI acquisition and that there are pockets/ “hotspots” in communities which demonstrate concentrated epidemics, while an observational study in

Guangdong Province, China, used spatial mapping too see geographical variations of syphilis (Wong et al., 2016). Identification of ‘‘hotspots’’ is critical for targeted biomedical behavioral and structural intervention to reduce the burden of HIV/STI in the community (Ramjee & Wand, 2014). For the current study, a disproportionate clustering of STD cases compared to other areas around Williams County, are predictive of a “hot spot”.

A study conducted in Wake County, North Carolina used similar methodology to analyze and map the distribution of four reportable sexually transmitted diseases, chlamydial infection/non-gonococcal urethritis, gonorrhea, primary and secondary syphilis (syphilis), and HIV infection. The study found there was spatial heterogeneity and suggests that STD specific prevention strategies should be targeted at core areas as opposed to uniformly across Wake County (Law et al., 2014). Core areas overlapped for all four STDs studied, with each STD having a clustered spatial distribution with one primary core area of infection (Law et al., 2014). Additionally, the lower incidence STDs exhibited larger spatial variability and smaller neighborhoods of influence than higher incidence STDs (Law et al., 2014). By identifying positive cases, additional testing could be conducted in high risk areas and positive tests were referred to the local health department. For risk analysis, visualization of health and census data can be obtained using the standard spatial mapping techniques. Spatial analysis identifying geographical clusters of STD prevalence will be utilized for the current study.

Rural Area Research and Local Health Departments

Rural local health departments have fewer resources to offer the community and, therefore, many local health departments use grant funding and local resourcing. Fewer resources can equate to less testing, less advertising, fewer operating hours, and fewer personnel working on site. The hypothesis that less STD prevention resources can lead to an increase in STD cases is known as “Brown’s Law” after Dr. William Brown, an STD preventionist within the CDC (Aral et al., 2013). Research suggests that rural locations experience higher than national averages for certain sexually transmitted infections such as chlamydia and hepatitis B (Roberts, Johnson, Brems & Warner, 2007). There are also differences in the prevalence of disease found in rural women, which have been attributed to individual-level (e.g., low income status, low education, marital status) and regional-level (e.g., lack of access to health care facilities and to affordable health coverage) (Tzilos, Hade, Ruffin, & Paskett, 2017). Higher rates of STDs in rural areas is therefore multifactorial.

Local health departments are important for screening and treating STDs in rural communities, but often lack the resources to do so effectively (Paschal, Oler-Manske & Hsiao, 2011). Public STD programs, including local health departments that provide STD services are an important venue for providing services to at risk populations that may not be well connected to health care (Cuffe, Esie, Leichliter, & Gift, 2017). Currently, most prevention and intervention efforts are focused at the regional and national levels. Conversely, factors that can influence the reach and effectiveness of STD prevention strategies are the size, organizational structure, and available resources of local health departments.

Geographic areas surrounding smaller or absent local health departments, such as the health department of Williams County, may lack the proper resources to reduce the number of STDs in a particular area. Often residents of rural communities have lower incomes and educational attainments, which puts these individuals at higher risk for poor health outcomes. Additionally, water quality, agricultural methods, forestry, or mining, or the overall landscape of an area can complicate the effect of place of residence (Hartley, 2004). Transportation issues or the burden of seeking care may prevent individuals in rural communities from receiving the same health care as their counterparts in more urbanized areas.

Targeting At-Risk Populations

The current study aims to identify high STI incidence rate areas to better target intervention programs. Thomas & Tucker (1996) suggest that there are core groups of high-risk individuals that tend to spread infection and STDs can result directly or indirectly from this small subgroup of individuals. If this holds true, then spatial mapping of an area may be able to identify where these core groups are and prevention programs can be targeted in order to lower the community's STD rates

By identifying "hot spots", prevention and intervention programs can be targeted towards at-risk populations. This approach differs from the "universal" approach, which blankets an entire population for intervention and prevention strategies. The strength or weakness of using a targeting approach is linked to how well that program works in a population or the cost effectiveness of the program. Currently, there are no published studies comparing targeted versus universal interventions for STD prevention and intervention programs (Aral et al., 2013). Researchers, program implementers and policy-makers have not resolved whether or not targeted or universal approaches to STD prevention are more effective (Aral et al., 2013). In a smaller population, such as a low-population county, the targeting approach may hold advantages over the more general universal approach. One cited advantage being advanced efficiency, in which the most vulnerable and in-need groups are reached through prevention and intervention (World Health Organization, 2010). As discussed, rural areas have a different dynamic in the way intervention and prevention programs may be utilized. With limited resources as well, a more targeted approach may be beneficial for funneling available resources into the groups or areas in the population that are most in need.

A model for the current research study was adopted from a study on diabetes in which Curtis, Kothari, Paul, and Connors, (2013), mapped secondary datasets to efficiently help communities prevent and manage diabetes. The study by Curtis and colleagues (2013), mapped county-level diabetes-related rates and resources/use using publicly available data to identify Michigan counties with high diabetes prevalence and low or no medical and/or community resources. By using public data and mapping tools, researchers were able to identify diabetes health-service shortage areas that can be targeted public health programming. This type of study design is cheap, using county data, and with no threats to human subjects. The cross-sectional, ecological study design has some limitations, but is overall the best way to obtain GIS mapping. Limitations of false areas of high prevalence due to testing site availability may occur. Additionally, not all infections will be confirmed cases and the numbers will not be indicative of all true cases of STDs. Although there are some minor limitations, this same research design will be utilized for the mapping of STDs in the current study.

Study objective

The main objective of this study was to map the distribution of sexually transmitted diseases (chlamydia, gonorrhea, hepatitis A, hepatitis B, hepatitis C, syphilis and HIV) for Williams County, Ohio, to optimize intervention strategies in a rural area. De-identified reportable disease data from the Williams County Health Department in Montpelier, Ohio, was used to geographically map cases of sexually transmitted diseases. A secondary objective was to identify specific “hot spots” that could benefit from intervention resources.

Rationale

This type of spatial mapping has yet to be done in a rural county of the United States, therefore, the purpose was to determine if this type of analysis would be beneficial in identifying areas of need. Specifically, GIS mapping has been an innovative tool for public health research. If mapping can identify areas of need, local health departments can utilize similar strategies to target populations or areas for intervention programs and tailor their resources. There was no prior research found showing spatial recognition of STD clusters or “hot spots” in a rural midwestern United States community. While spatial mapping has focused more on larger areas in countries outside of the United States, little has shown the effectiveness in smaller census tract areas. GIS mapping is useful for easy interpretation within a community. Research should represent the disease burden when making maps, all while protecting data confidentiality and truth. The lack of resources in small, local health departments may be the driving force behind an increase in STD cases surrounding those areas. By targeting the high-risk populations, resources can be directed and “wasting” of resources kept at a minimum. Information from this research may be used to design and apply similar intervention and prevention programs in additional locations.

Ethics Statement

The study protocol was approved by the Grand Valley State University Institutional Review Board and a confidentiality contract has been signed between researcher/co-investigator and the Williams County Health Department. The Grand Valley State University Human Research Review Committee (HRRC) determined that this project did not meet the definition of covered human subjects research and was deemed exempt from approval by the HRRC.

Materials and Methods

STI cases were abstracted from 2014-2016 Morbidity and Mortality Weekly Reports, collected through the Ohio Disease Reporting System (ODRS). The ODRS provides real-time secured access for state and local public health practitioners to report infectious diseases. Local, state, and national agencies require that certain diseases be reported. Laboratories can also report infectious diseases to local public health via electronic lab reporting. Class A are reported to local public health immediately by phone. A list of all reportable diseases in the State of Ohio is available at http://www.odh.ohio.gov/reportablediseases. MMWR data on number of STI cases in Williams County is publicly available. Only de-identified information was used from an existing dataset from the Williams County Health Department. The Director of Nursing at the Williams County Health Department had access to all reportable disease reports and was responsible for abstracting datasets and query information prior to analysis. The number of STD cases reported to the Centers for Disease Control and Prevention (CDC) may be less than the actual number of cases occurring in the U.S. population due to incomplete records/reporting (CDC, 2017).

Yearly incidence rates were calculated using new case reports of each STI reported and demographic characteristics were determined using univariate analyses of sex, age, and race/ethnicity using Microsoft® Excel® 2016. The incidence rates of each STI per year was provided to the Bryan, Ohio city engineering department for mapping using geographic information system (GIS) software (ESRI) and maps generated to show “hot spot” areas by STI category.

The different STI cases were categorized and used as the dependent variable. The location or identified “hot spots” were the independent variable.

The population of Williams County, Ohio was 37,222 in 2014, 37,120 in 2015 and 37,017 in 2016 (U.S. Census Bureau, 2017). The 2014 population data by zip code is in Table 1 and was used for analyzing the population statistics. Exact population data for 2017 was not yet available and therefore, the adjusted incidence rates for 2017 were not calculated.

Risk ratios were calculated for each STI by zip code using SAS 9.4. Bryan, Ohio (43506) was used as the reference zip code due to the area having the highest population in the county and at least one case per each disease/year for comparison.

Results

The average county-level incidence rate of chlamydia increased by 117% (182.7 cases per 100,000 population in 2014 vs 397.1 cases per 100,000 population in 2016) during the study period from 2014 to 2016. The incidence rates per STI by year can be found in Table 2. STI cases occurred in predominately white individuals. The majority of these cases were women (74% in 2014, 94% in 2015, 78% in 2016 and 72% in 2017). Similar incident rate trends occurred with hepatitis C, with an even larger increase of 268% (48.4 cases per 100,000 population in 2014 to 178.3 cases per 100,000 population in 2016) from 2014 to 2016. The number of cases of hepatitis C in 2017 (as of May 5, 2017) was already 23 cases. Hepatitis C cases were slightly higher in number among the male population every year during this study period. Cases of HIV were very low, with only 3 cases reported in 2014, 0 in 2015, and 1 in 2016 and 2017. There were no syphilis cases recorded from 2014 to May 5, 2017.

Chlamydia and gonorrhea cases were primarily in the 18 to 28-year age group (90% in chlamydia and 100% in gonorrhea of those recorded from January 1, 2017 to May 5, 2017).

There were no reported cases of chlamydia or gonorrhea in the 40 to 50 age range for the study period.

Table 1

Population in Williams County, Ohio in 2014 by zip code.

Zip Code	**Metropolitan Area**	**Population**
43501	Alvordton, Ohio	788
43502	Archbold, Ohio	6,933
43505	Blakeslee, Ohio	96
43506	Bryan, Ohio	14,830
43517	Edgerton, Ohio	3,744
43518	Edon, Ohio	2,726
43557	Evansport/ Stryker, Ohio	3,393
43543	Holiday City/ Montpelier, Ohio	7,771
43554	Holiday City/Pioneer, Ohio	2,408
43531	Kunkle, Ohio	216
43570	West Unity, Ohio	3,106

Table 2

Incidence[1] of Reported Sexually Transmitted Infections in Williams County, Ohio by Year

	Incidence per Year			
Reportable Disease[2]	2014	2015	2016	2017
Chlamydia	68	98	147	40
Gonorrhea	7	8	6	6
Hepatitis A	1	2	3	0
Hepatitis B	1	2	5	0
Hepatitis C	18	43	66	23
Syphilis[3,4]	0	0	0	0
HIV[3]	3	0	1	1

Note. Table 1: Incidence of Sexually Transmitted Infections in Williams County, Ohio.
[1] Duplicate cases were removed prior to data analysis to restrict multiple positive results of the same illness occurring in the same individual.
[2] De-identified data used was obtained from the Morbidity and Mortality Weekly Report, collected from the Ohio Disease Reporting System as of May 5, 2017.
[3] HIV and Syphilis data collected from Toledo-Lucas County Health Department records.
[4] No cases of syphilis were recorded between years 2014 to May 5, 2017.

Table 3

Incidence[1] of Reported Sexually Transmitted Infections in Williams County, Ohio by Year per 100,000 Population

	Incidence per Year[5]			
Reportable Disease[2]	2014	2015	2016	2017[6]
Chlamydia	182.7	264	397.1	
Gonorrhea	18.8	21.6	16.2	
Hepatitis A	2.7	5.4	8.1	
Hepatitis B	2.7	5.4	13.5	
Hepatitis C	48.4	115.8	178.3	
Syphilis[3,4]	0	0	0	
HIV[3]	8.1	0	2.7	

Note. [1] Duplicate cases were removed prior to data analysis to restrict multiple positive results of the same illness occurring in the same individual.
[2] De-identified data used was obtained from the Morbidity and Mortality Weekly Report, collected from the Ohio Disease Reporting System as of May 5, 2017.
[3] HIV and Syphilis data collected from Toledo-Lucas County Health Department records.
[4] No cases of syphilis were recorded between years 2014 to May 5, 2017.
[5] Population data obtained from U.S. Census Bureau Statistics.
[6] Population data not available for 2017.

Table 4

Descriptive Characteristics No. (%)

Reportable Disease[1,2]	2014		2015		2016		2017	
Sex	M	F	M	F	M	F	M	F
Chlamydia	18(26)	50(74)	23(23)	73(94)	32(22)	115(78)	11(28)	29(72)
Gonorrhea	0 (0)	7(100)	3(38)	5 (62)	4(67)	2(33)	4(67)	2(33)
Hepatitis C	10(56)	8(44)	24(56)	19(44)	39(59)	27(40)	14(61)	8(35)
Race								
Chlamydia								
White	45 (67)		95 (97)		133 (90)		32 (80)	
Black	0 (0)		3 (3)		1 (0.68)		1 (2.5)	
Other	1 (1)		0 (0)		0 (0)		1 (2.5)	
Unknown	22 (32)		0 (0)		13 (9)		6 (15)	
Gonorrhea								
White	6 (86)		8 (100)		5 (83)		6 (100)	
Black	1 (14)		0 (0)		0 (0)		0 (0)	
Other	0 (0)		0 (0)		0 (0)		0 (0)	
Unknown	0 (0)		0 (0)		1 (17)		0 (0)	
Hepatitis C								
White	12 (67)		36 (84)		58 (88)		17 (74)	
Black	0 (0)		3 (7)		3 (4)		4 (18)	
Other	0 (0)		0 (0)		0 (0)		1 (4)	
Unknown	6 (33)		4 (9)		5 (8)		1 (4)	
Age								
Chlamydia								
18 to 28	65 (96)		84 (86)		131 (89)		36 (90)	
29 to 39	2 (3)		10 (10)		15 (10)		3 (7.5)	
40 to 50	1 (1)		3 (3)		1 (0.6)		1 (2.5)	
51 to 61	0 (0)		0 (0)		0 (0)		0 (0)	
61 & older	0 (0)		1 (1)		0 (0)		0 (0)	
Gonorrhea								
18 to 28	4 (57)		6 (75)		3 (50)		6 (100)	
29 to 39	2 (29)		1 (12.5)		1 (17)		0 (0)	
40 to 50	1 (14)		1 (12.5)		0 (0)		0 (0)	
51 to 61	0 (0)		0 (0)		0 (0)		0 (0)	
61 & older	0 (0)		0 (0)		2 (33)		0 (0)	
Hepatitis C								
18 to 28	5 (28)		11 (26)		19 (28)		5 (22)	
29 to 39	3 (17)		14 (33)		12 (18)		6 (26)	
40 to 50	5 (28)		6 (14)		11 (17)		4 (17)	
51 to 61	3 (17)		9 (21)		18 (27)		5 (22)	
61 & older	2 (11)		3 (7)		6 (10)		3 (13)	

Note.[1] Due to low case numbers, the demographic information of Hepatitis A & B and HIV has been excluded to prevent possible case identification. No cases of Syphilis were recorded.

[2] Cases were not analyzed by dichotomous variables to prevent possible case identification.

Table 5

Incidence Rate per 100,000 population by Zip Code in Williams County, Ohio

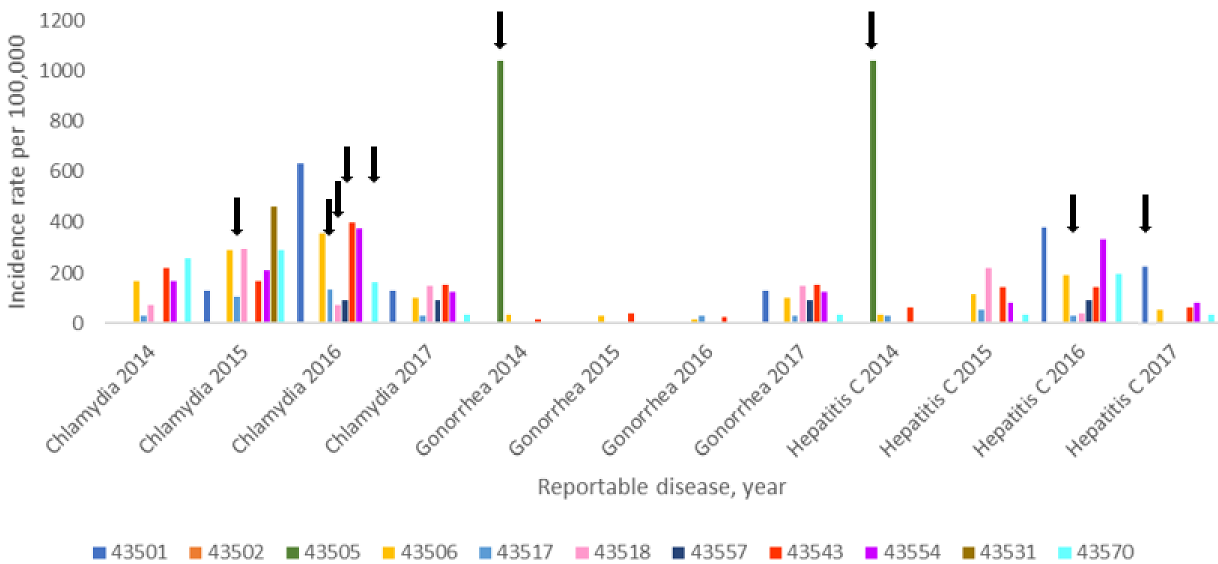
Reportable disease	43501	43502	43505	43506	43517	43518	43557	43543	43554	43531	43570
Chlamydia 2014	0	0	0	168.6	26.7	73.4	0	218.8	166.1	0	257.6
Gonorrhea 2014	0	0	1041.7*	33.7	0	0	0	12.9	0	0	0
Hepatitis C 2014	0	0	1041.7*	33.7	26.7	0	0	64.3	0	0	0
Chlamydia 2015	127	0	0	290	106.8*	293.5	0	167.3	207.6	463	289.8
Gonorrhea 2015	0	0	0	27	0	0	0	38.6	0	0	0
Hepatitis C 2015	0	0	0	114.6	53.4	220.1	0	141.6	83.1	0	32.2
Chlamydia 2016	634.5	0	0	357.4	133.5*	73.4*	88.4*	399	373.8	0	161*
Gonorrhea 2016	0	0	0	13.5	26.7	0	0	25.7	0	0	32.2
Hepatitis C 2016	380.7	0	0	188.8	26.7*	36.7	88.4	141.6	332.2	0	193.2
Chlamydia 2017	127	0	0	101.1	26.7	146.7	88.4	154.4	124.6	0	32.2
Gonorrhea 2017	0	0	0	27	0	0	0	0	0	0	0
Hepatitis C 2017	253.8*	0	0	54	0	0	0	64.3	83.1	0	32.2

Note. *p >0.05

Table 5 highlights the areas in which there was a significant difference in incidence rate in comparision to the reference zip code (43506). Blakeslee, Ohio (43505) had a significant increase of gonorrhea and hepatitis C in 2014. In 2016, there were 4 areas (43517, 43518, 43557 and 43570) that had a significant decrease in number of chlamydia cases. Additionally, 43501 saw a significant increase in hepatitis C cases in the beginning of 2017. To better illustrate the information in *Table 5,* Figure 1 gives the same information, including arrows to show significant differences in incidence rates.

Figure 1

Incidence Rate per 100,000 population by Zip Code in Williams County, Ohio (2014-May, 2017)

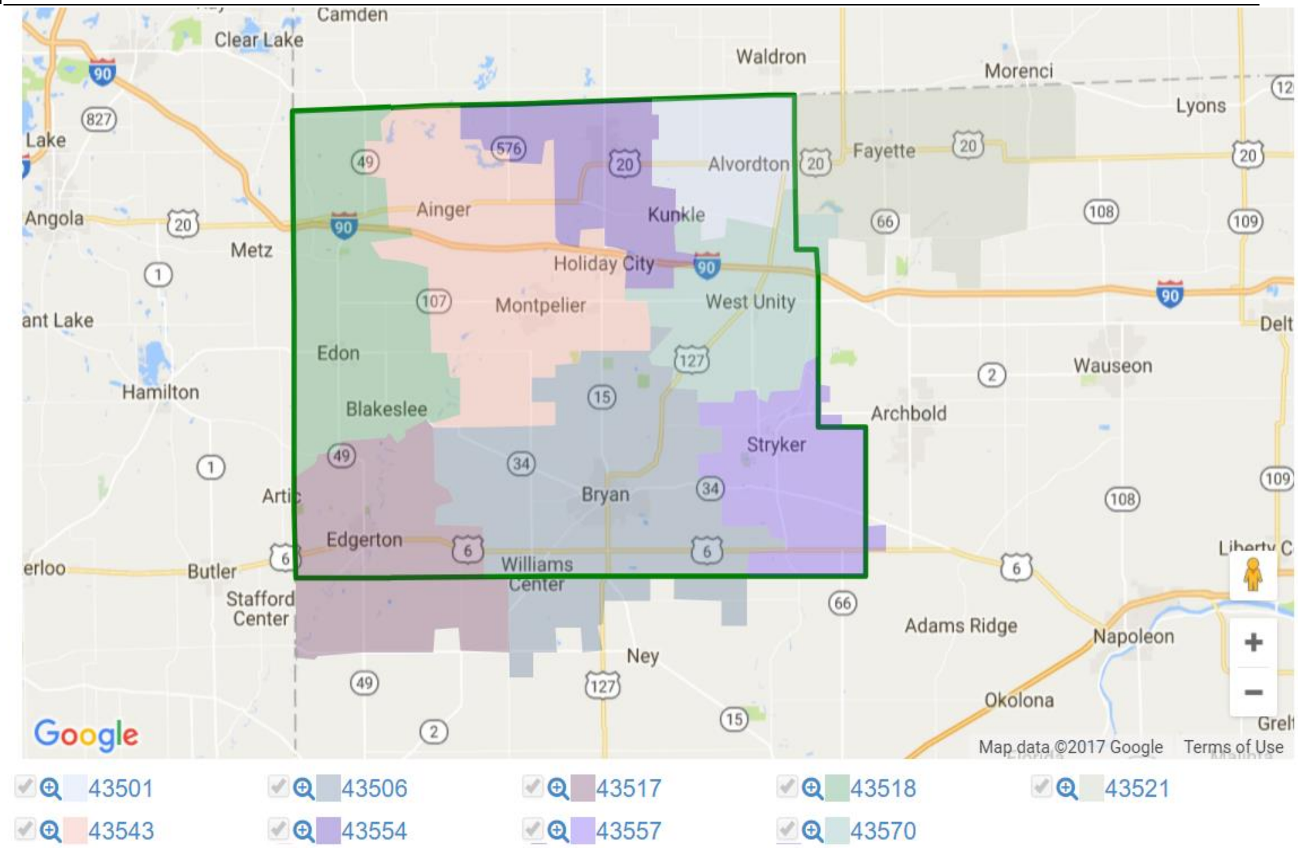


Note. Significant incident rates (p> 0.05) are marked on Figure 1 by black arrows.

Overall, 43506 (Bryan, Ohio) and 43543 (Montpelier, Ohio) saw the highest incidence rates between 2014 and 2017 for chlamydia, hepatitis C and gonorrhea. *Figure 2* is a map of Williams County that lays out the zip codes for reference to maps in Appendix A.

Figure 2

Zip Code Map of Williams County, Ohio



Note. Retrieved from http://www.zipdatamaps.com/williams-oh-county-zipcodes

Discussion

This study illustrates the utility of accessing available secondary communicable disease data combined with GIS mapping software to examine hot spots and target resource need.

The increased rates of chlamydia and gonorrhea from 2014 to 2016 may be due to changes in diagnostic, screening, and reporting practices (CDC, 2016). Additionally, the sensitivity of testing has improved**,** which may also attribute to the increase of positive test results during the study period (CDC, 2017). The age range of 18 to 28 year-olds saw higher rates of chlamydia and gonorrhea, which is not surprising given the notion this group is more sexual active. The incidence rates of hepatitis C were more spread out across age groups, which may be due to a combination of factors**.** Baby boomers (born between 1945 and 1965) and intravenous drug users are at higher risk of hepatitis C. Baby boomers are at increased risk due to unsafe/uncontrolled healthcare practices that occurred before healthcare control measures became mandatory. Also, prior to 1992, blood products had no mandatory screening processes (Ward, 2013).

Currently, the Williams County Health Department is comprised of a nursing unit, women, infant and children (WIC) program and environmental health. This organization size is similar for the surrounding local health departments. Larger health departments may see more programs and units. Shorter work-week hours and less clinic availability are often results of this type of small department. Resources are provided via a clinic on the third Wednesday of every month (Montpelier, Ohio) or the second and fourth Thursday of every month (Bryan, Ohio) only. Everyday clinics are not available. Resources include pap tests, STI testing and treatment and dispersion of a variety of birth control methods (the pill, the Depo-Provera shot, the Mirena IUD, the Ortho Evra patch, and condoms). Since there are resources available in the zip codes with the highest incidence rates of STIs overall, 43506 and 43543, it is imperative that resources and prevention techniques are implemented in the smaller areas that are seeing increased incidence rates as well (e.g. 43501, 43505).

Strengths and Limitations

This study was the first of its' kind to use GIS software to map rural county STI incidence rates. Previous studies focused on multi-county analysis, while this study focused on one for future intervention purposes. The study was low cost and could be utilized in low-resource areas in local health departments. GIS software may be available to some local health departments or in collaboration with city or state engineers.

While the study had some strengths, results should be interpreted with caution. Data was collected using a secondary dataset. Data entered into the Ohio Disease Reporting System may not be all-inclusive or complete. However, the STI data used in this study is mandated to be reported by physicians to give a good representation of case numbers. The researcher used date of result as primary year for analysis. Due to inadequate reporting techniques and Morbidity and Mortality Weekly Report weeks not matching to annual calendar, the year associated with each case may be differ in this report. Incidence rates were conducted using population data from United States Census data. The entire population was considered equally at risk for acquiring the disease; no age-adjusted rates were calculated. For IRB approval purposes, cases under the age of 18 were not utilized for this study. This excluded approximately 25.9% of all cases of Gonorrhea and 16% of all cases of Chlamydia from the study.

Conclusion

This study successfully identified areas in Williams County, Ohio where incidence rates were higher in some areas of the county than others. A year-by-year comparison allowed for the researcher to see changes in STI high-incidence areas. The study did not consider behavioral factors which may increase a person's risk of infection. Further study could look at behavioral patterns, such as, intravenous drug users, sexual partner connections, human trafficking, and STI prevention usage. The purpose of this study was to initially map the areas of higher incidence of STIs to then be able to look at the behavioral patterns of particular areas for intervention and prevention purposes. If mapping of incidence rates could be made easy for public health officials at the local health department level, then prevention techniques could be implemented in order to reduce incidence rates. GIS mapping gives a good visual representation of the data, which can be beneficial to those trying to interpret findings. This study was able to map incidence rates from a rural county and paves the way for research on other rural areas that often get overshadowed by urbanized-area research.

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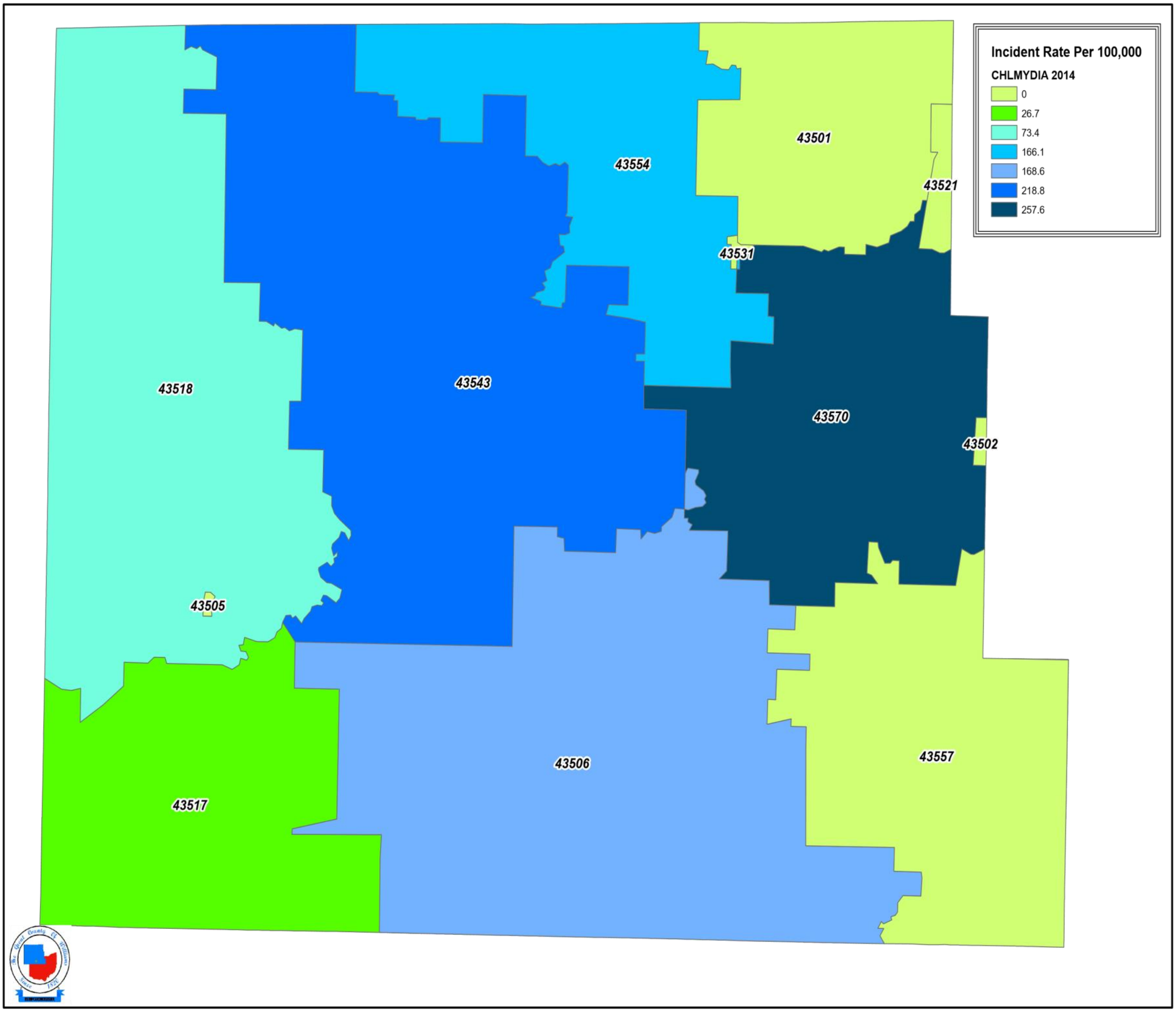
Appendix A

Figure A1

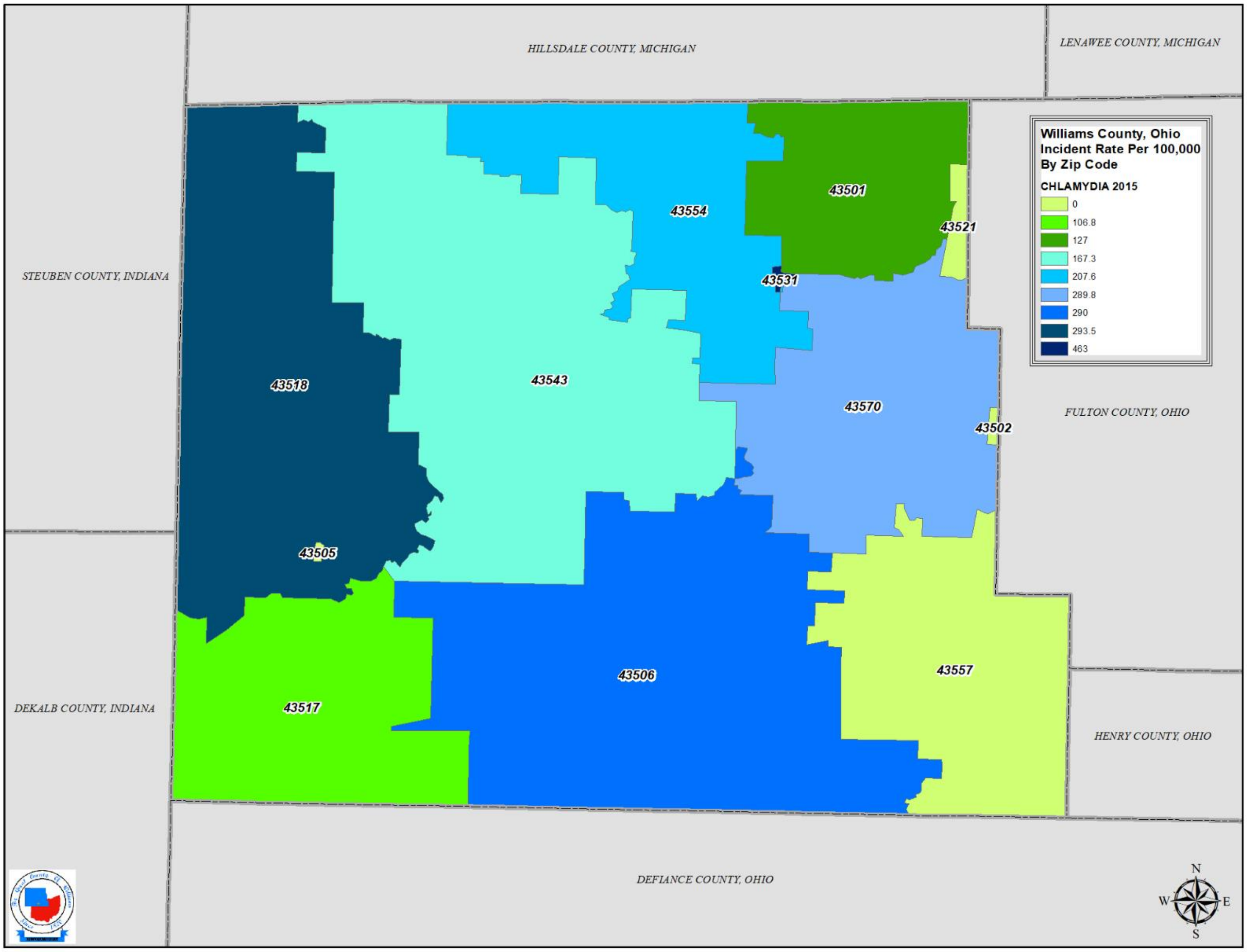
Chlamydia 2014



Note. Highest incidence rate per 100,000 population in 43570 (West Unity, Ohio)

Figure A2

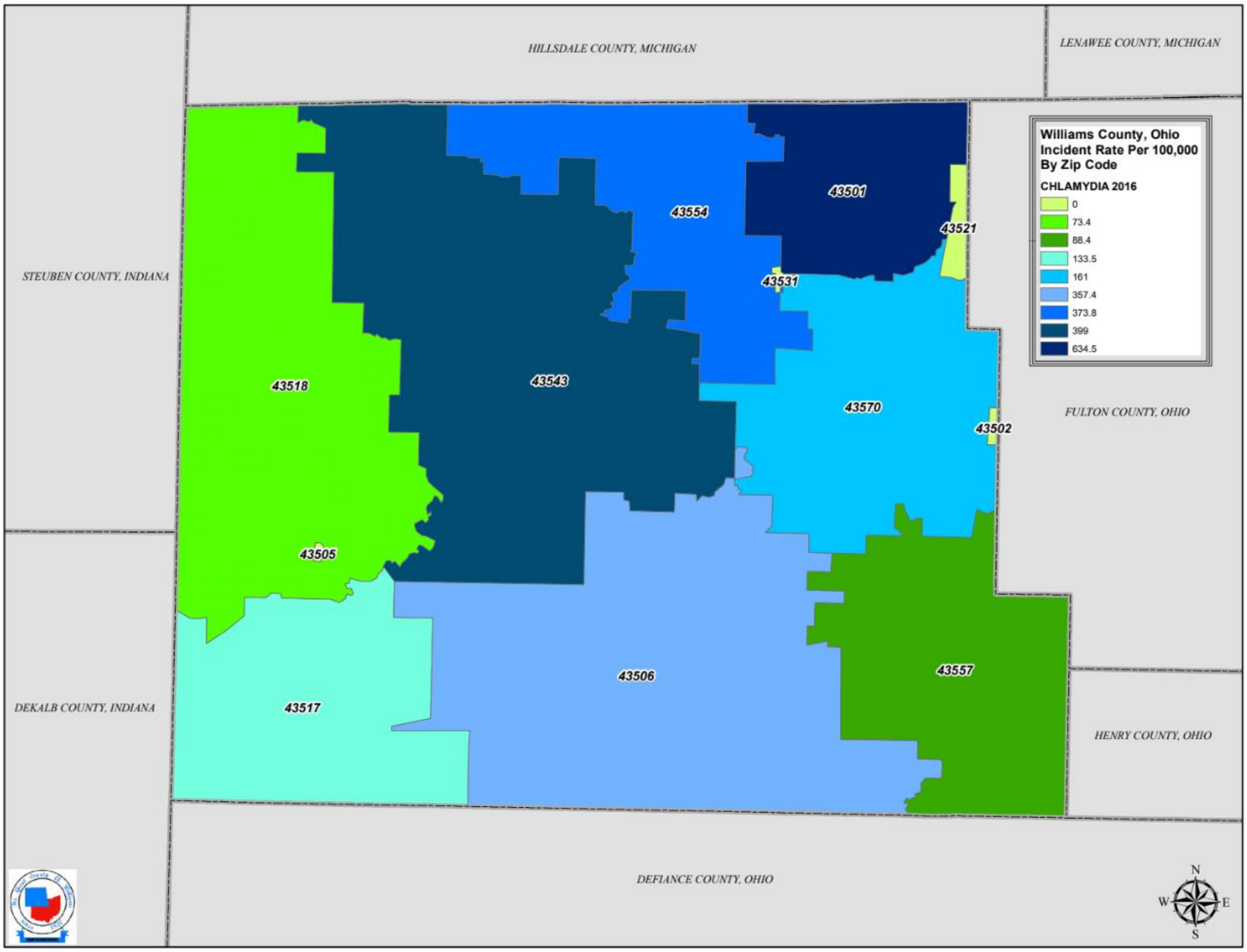
Chlamydia 2015



Note. Highest incidence rate per 100,000 population in 43531 (Kunkle, Ohio) and 43518 (Edon, Ohio)

Figure A3

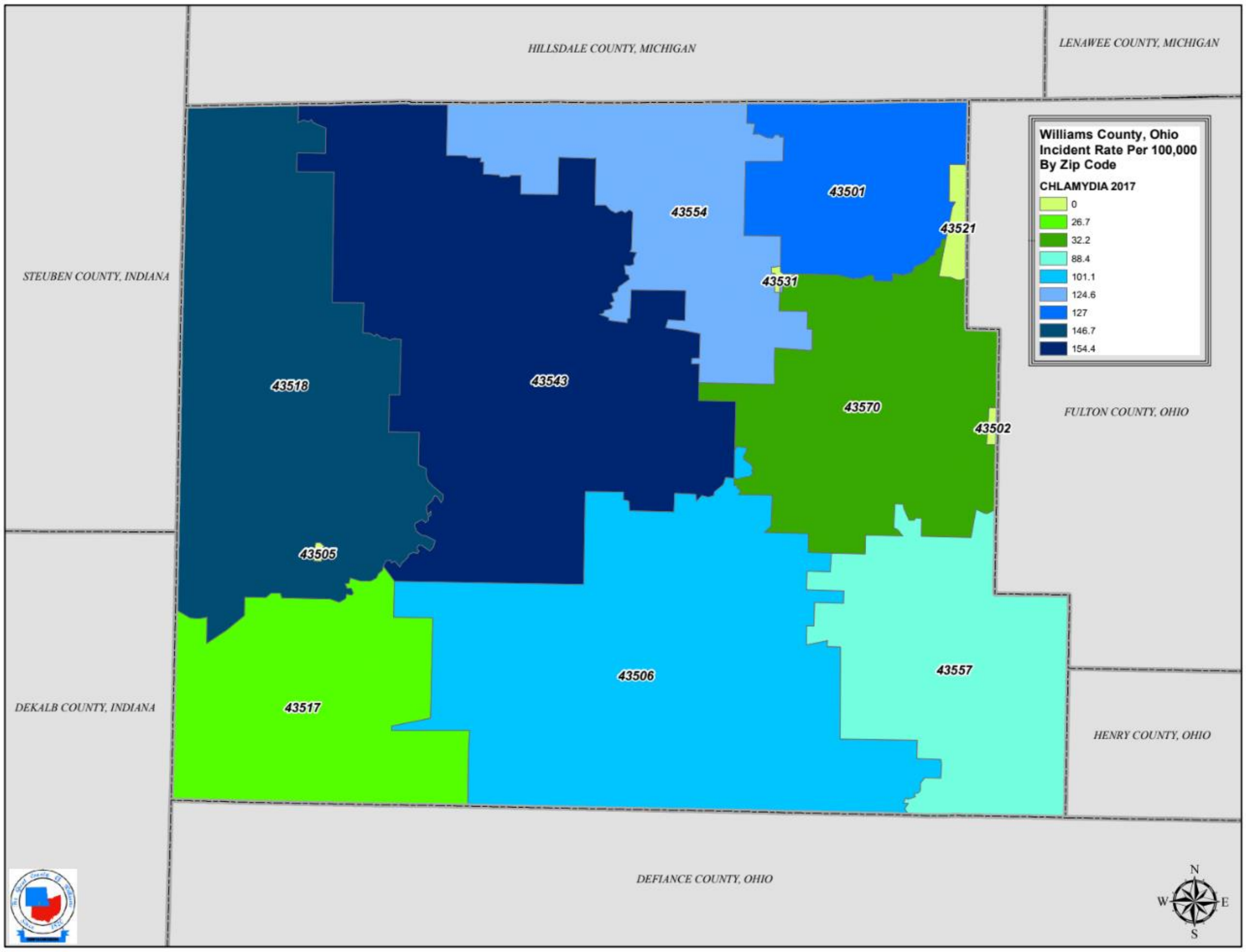
Chlamydia 2016



Note. Highest incidence rate per 100,000 population in 43501 (Alvordton, Ohio)

Figure A4

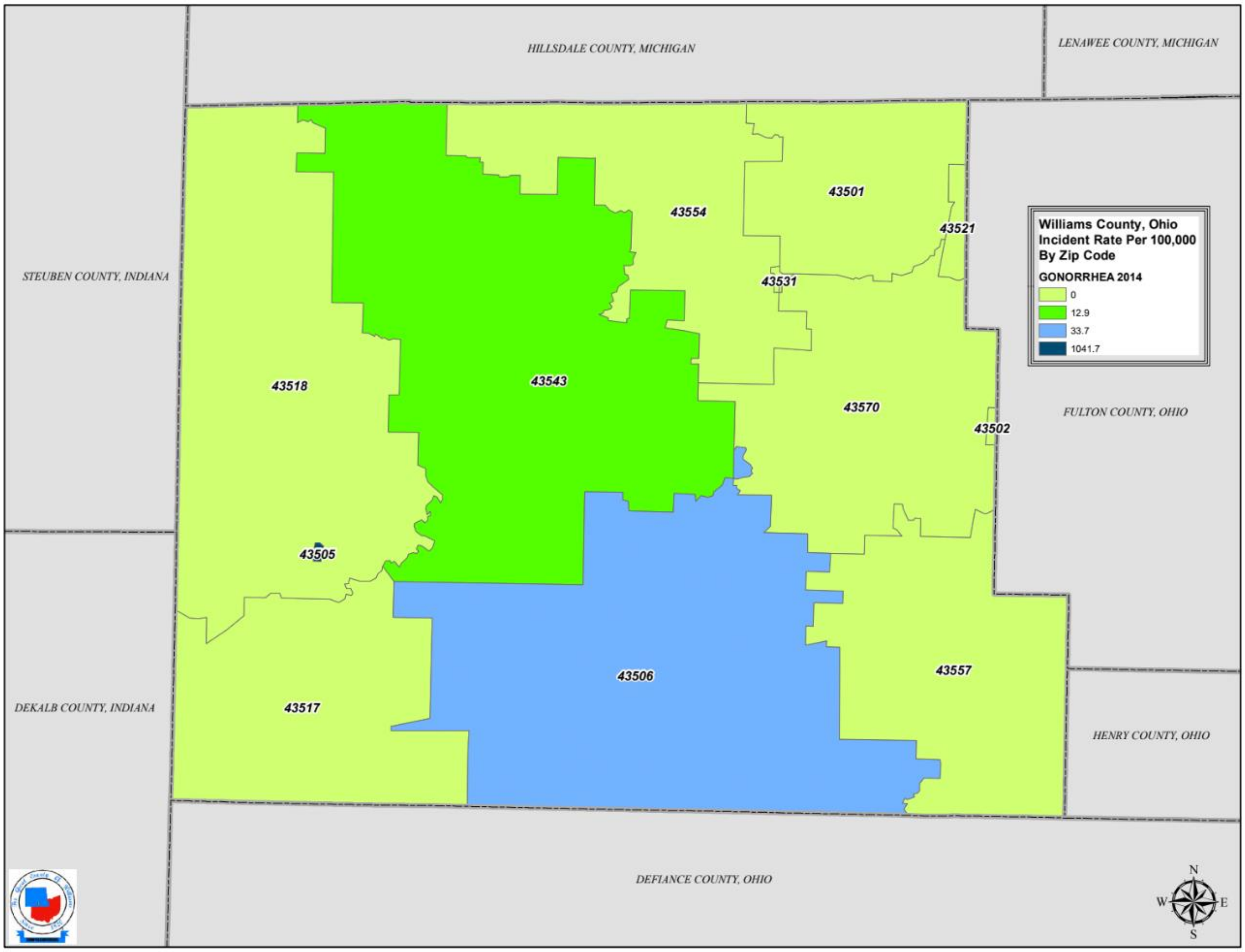
Chlamydia 2017



Note. Highest incidence rate per 100,000 population in 43543 (Montpelier, Ohio)

Figure A5

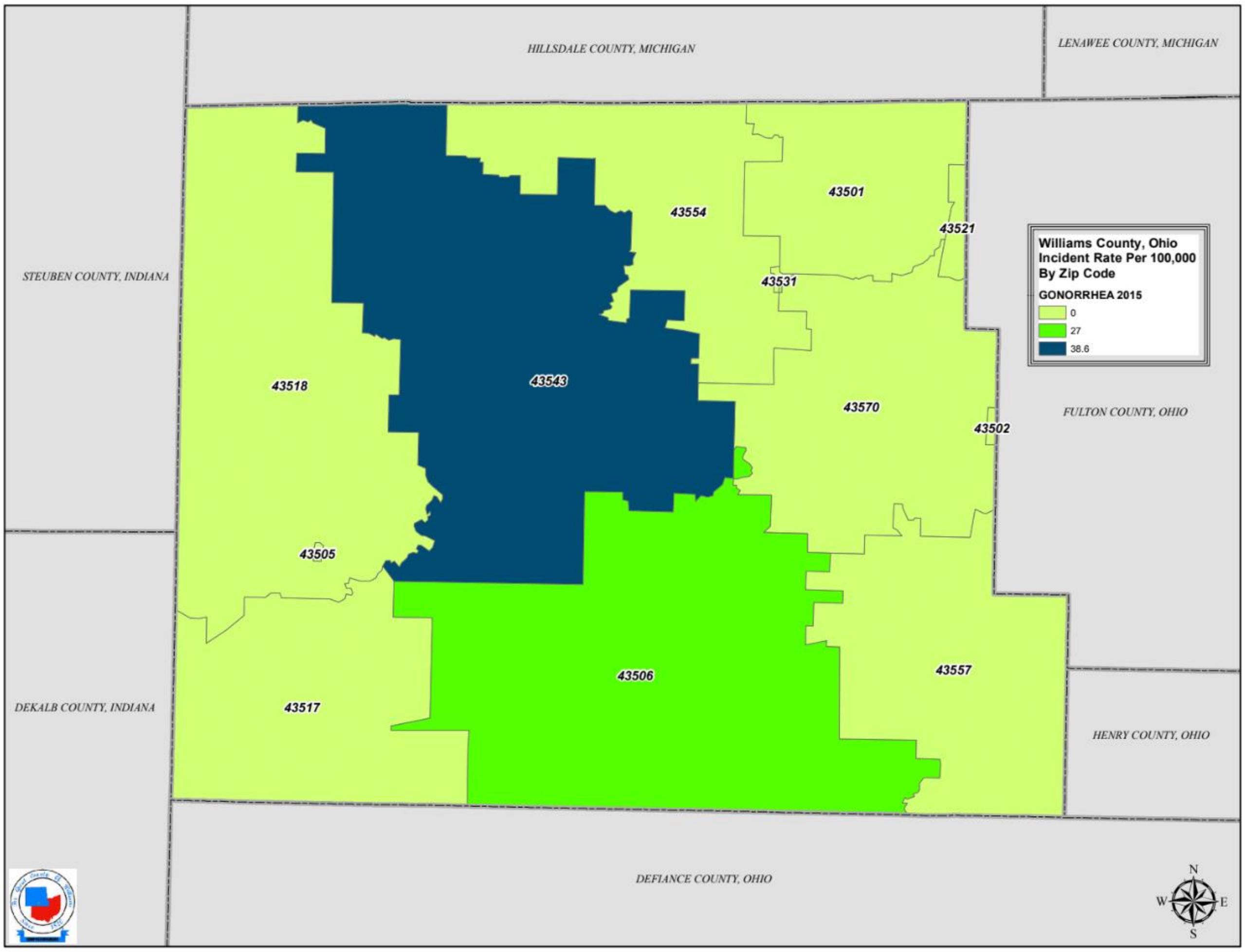
Gonorrhea 2014



Note. Highest incidence rate per 100,000 population in 43505 (Blakeslee, Ohio)

Figure A6

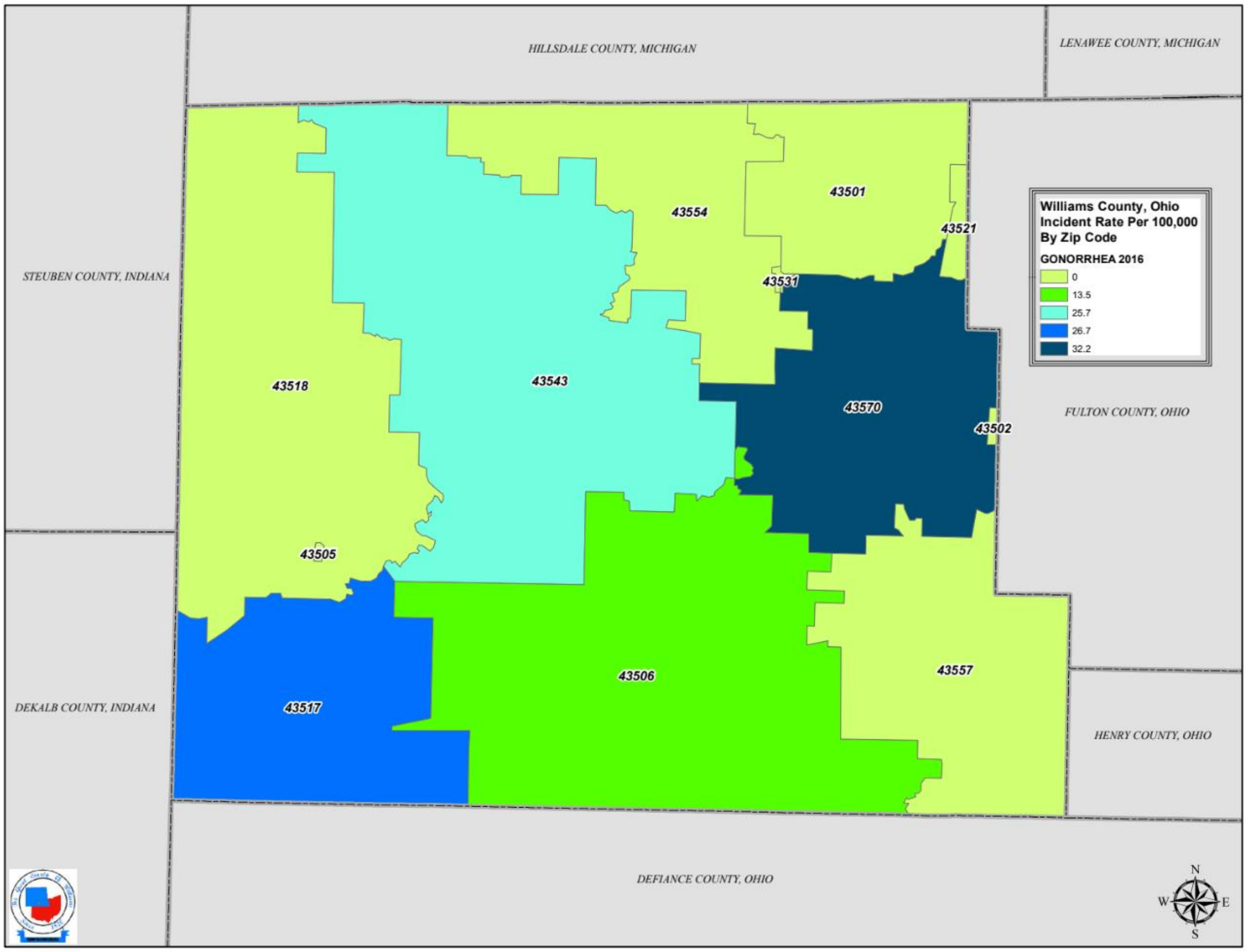
Gonorrhea 2015



Note. Highest incidence rate per 100,000 population in 43543 (Montpelier, Ohio)

Figure A7

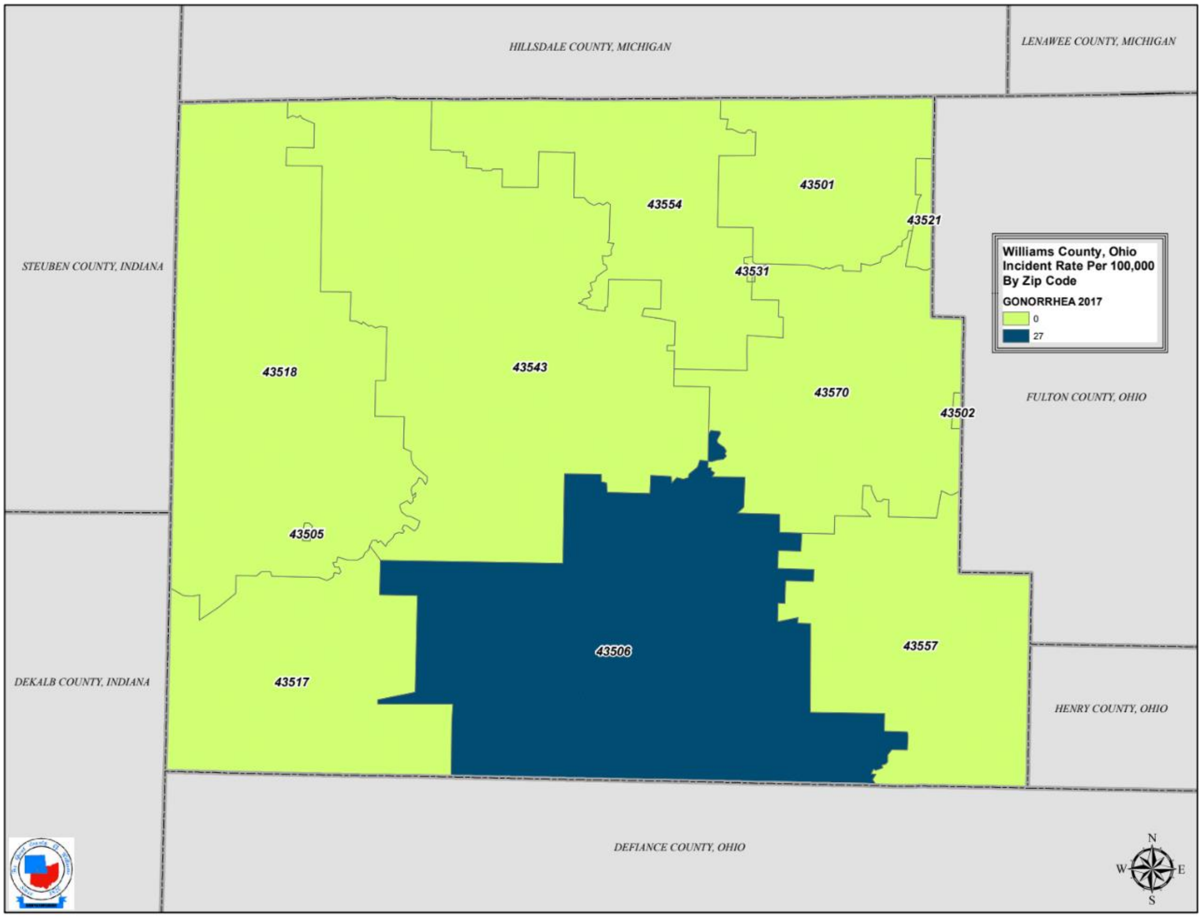
Gonorrhea 2016



Note. Highest incidence rate per 100,000 population in 43570 (West Unity, Ohio)

Figure A8

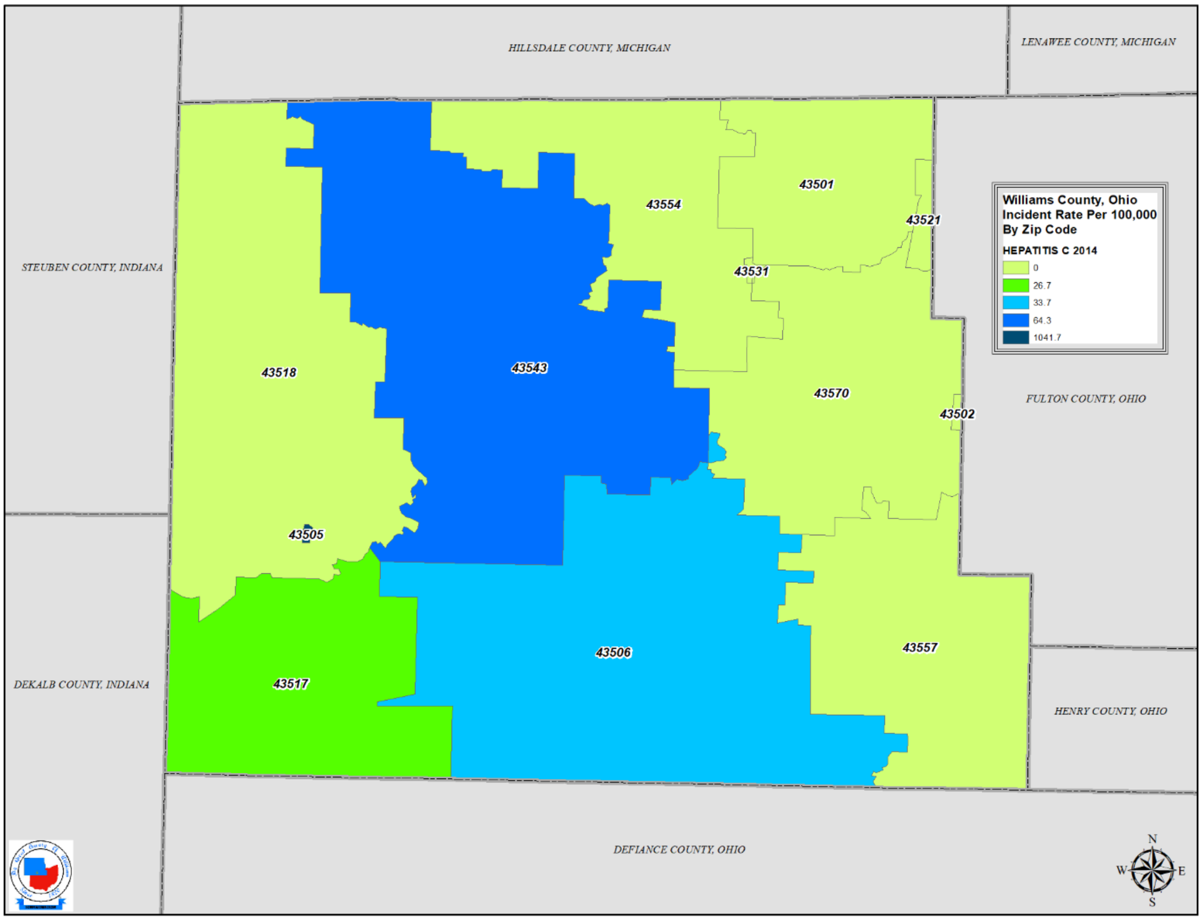
Gonorrhea 2017



Note. Highest incidence rate per 100,000 population in 43506 (Bryan, Ohio)

Figure A9

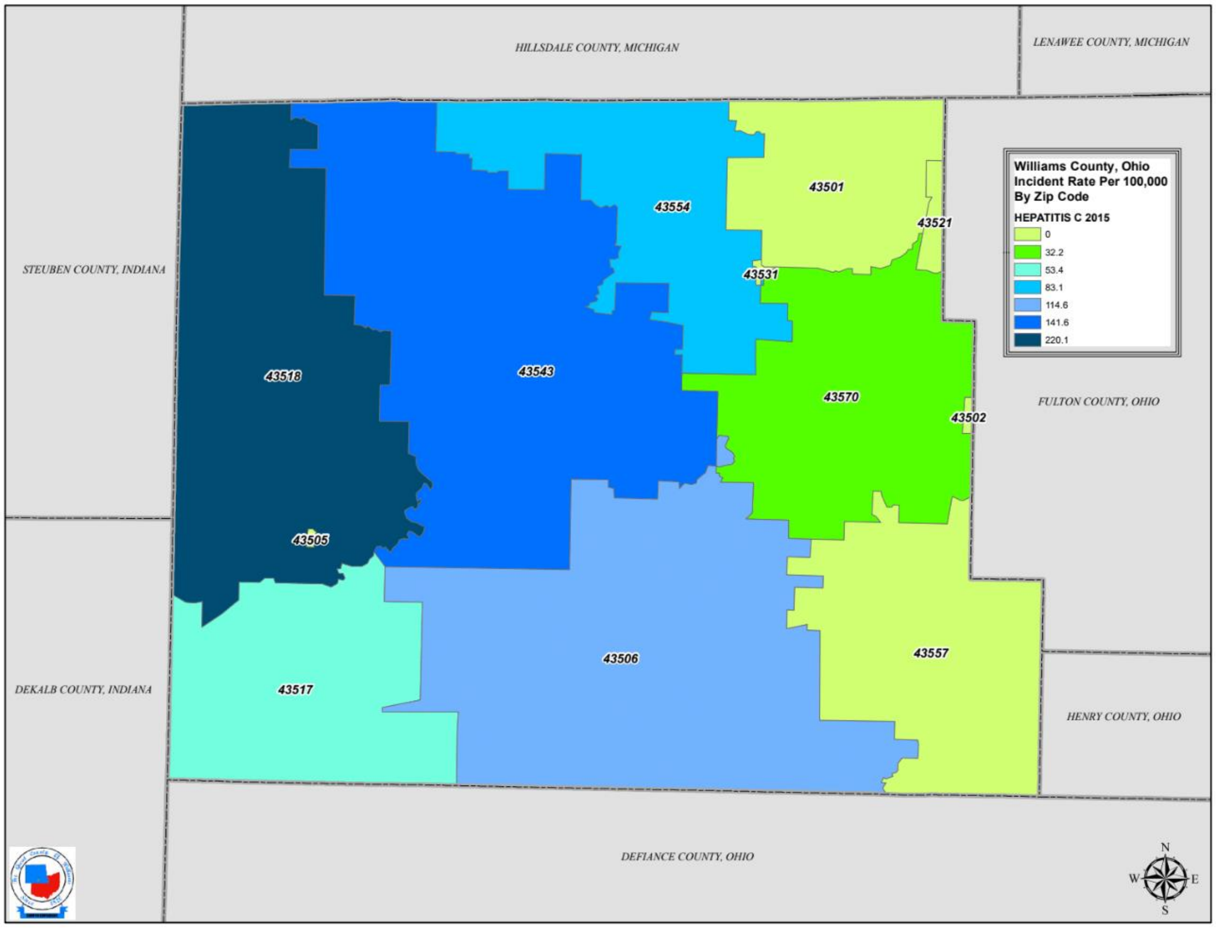
Hepatitis C 2014



Note. Highest incidence rate per 100,000 population in 43505 (Blakeslee, Ohio)

Figure A10

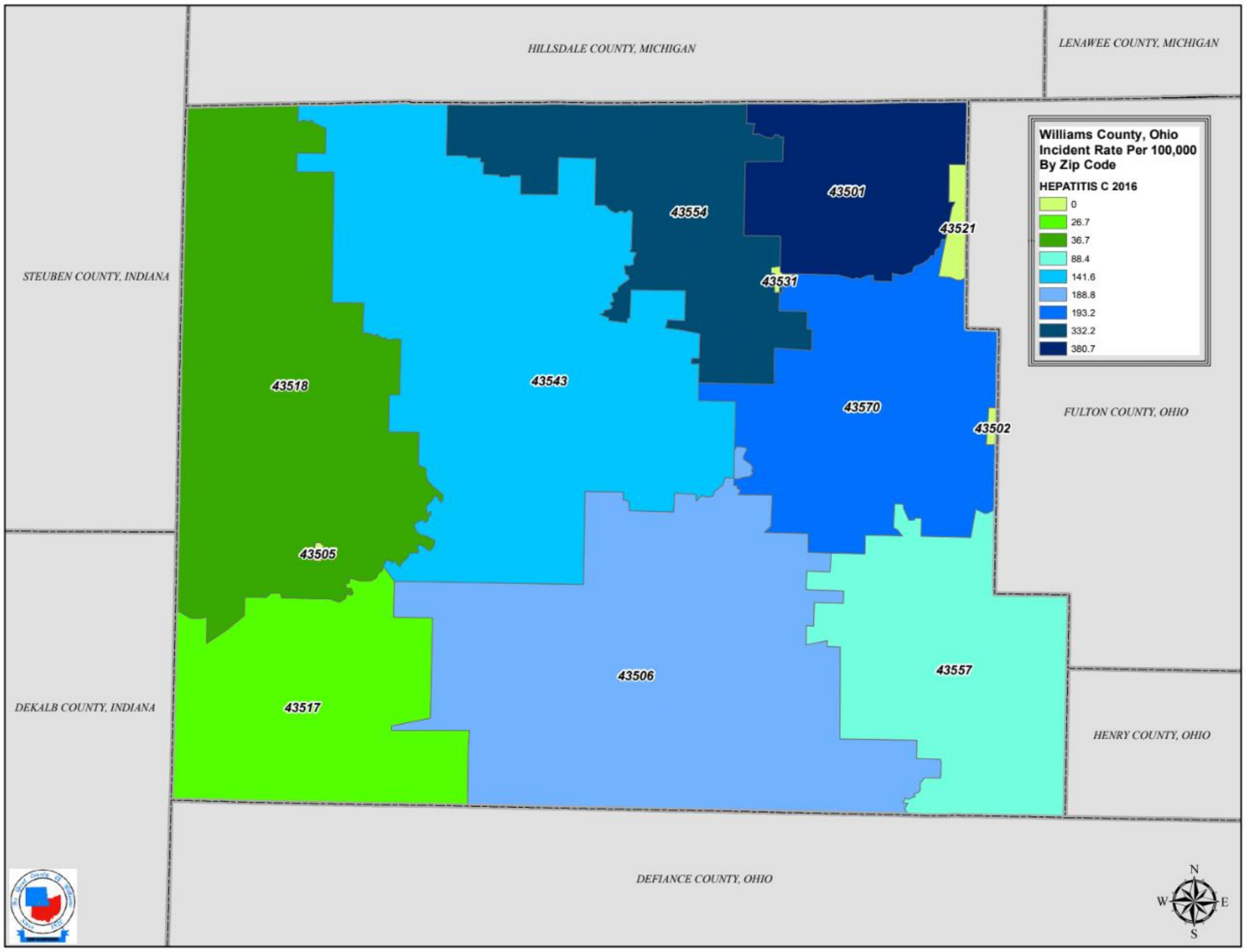
Hepatitis C 2015



Note. Highest incidence rate per 100,000 population in 43518 (Edon, Ohio)

Figure A11

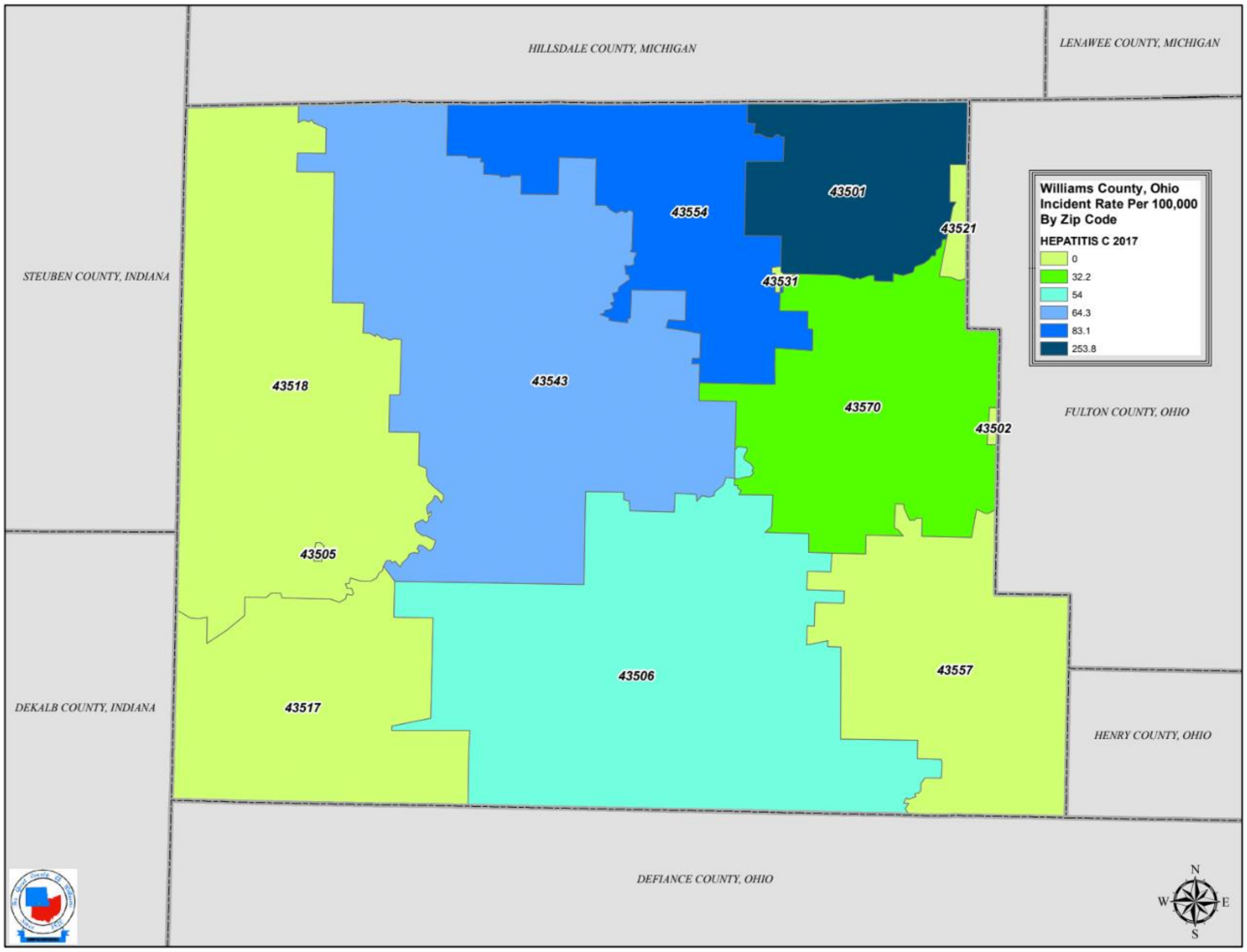
Hepatitis C 2016



Note. Highest incidence rate per 100,000 population in 43501 (Alvordton, Ohio)

Figure A12

Hepatitis C, 2017



Note. Highest incidence rate per 100,000 population in 43501 (Alvordton, Ohio)