

## Using Geographic Information Systems (GIS) to Display Spatial Patterns of Diabetes in Delaware

Saheedat Sulaimon, MPH;<sup>1</sup> Rashida Smith, BS;<sup>2</sup> Ariel Paz, MPH;<sup>3</sup> Madeline Brooks, MPH<sup>4</sup>

1. College of Population Health, Thomas Jefferson University
2. College of Population Health, Thomas Jefferson University
3. College of Population Health, Thomas Jefferson University
4. Research Associate, Value Institute, Christiana Care Health System

### Introduction

Diabetes, a chronic condition affecting how glucose is used for energy in the body, exacts a staggering toll on public health. More than 30 million people in the United States (U.S.) (9.4% of the population) have diabetes, a condition that has risen to the seventh leading cause of death in the U.S.<sup>1</sup> Diabetes often exacerbates existing health conditions and can lead to serious chronic health problems such as heart attack, stroke, blindness, kidney failure, and lower-extremity amputations.<sup>2</sup> In 2017, diagnosed diabetes resulted in costs of \$327 billion, \$90 billion of which was due to reduced productivity.<sup>3</sup> The burden of diabetes necessitates further efforts to study, treat, and prevent this disease at the national and local levels.

Critical to these efforts is an understanding of behavioral and social risk factors for diabetes. Among U.S. adult diabetics, 15.9% were current smokers, 87.5% were overweight or obese, and 40.8% were physically inactive (participating in less than ten minutes of moderate or vigorous activity per week).<sup>4</sup> Race and ethnicity also influence the risk for type 2 diabetes. African Americans, Hispanic/Latino Americans, and American Indians are at a higher risk for type 2 diabetes compared to their Caucasian counterparts.<sup>2</sup> Diabetes is also very prevalent among Medicare beneficiaries. More than a quarter (28%) of Medicare beneficiaries were diagnosed with diabetes in 2010, and it was ranked the fifth most common chronic condition among this group.<sup>5</sup>

Diabetes is of particular concern in the state of Delaware. In 2016, 10.6% of Delaware adults reported being diagnosed with type 1 or type 2 diabetes, higher than the national rate of 9.4%.<sup>4,6</sup> Sussex County had the highest prevalence of diabetes (13.1%) among Delaware's three counties.<sup>6</sup> Furthermore, diabetes was the eighth leading cause of death in the state in 2016.<sup>7</sup> Non-Hispanic black Delawareans are disproportionately affected by diabetes mortality, with rates twice as high as those of their white counterparts.<sup>8</sup> A qualitative research study of physicians in Delaware identified barriers to providing care for diabetic patients, including lack of population-based patient management, self-management education, and public health support.<sup>9</sup>

Despite the clear need for population-based management of diabetes, it remains challenging to incorporate evidence from research into clinical practice.<sup>10</sup> Geographic information systems (GIS), used to display and analyze spatial data, offer a powerful tool for public health planning. Previous studies have used GIS to identify geographic patterns in diabetes prevalence and mortality at the national level.<sup>11,12</sup> By studying the spatial distribution of diabetes and its risk factors, public health professionals can identify areas of high priority and develop population-based interventions. This study used GIS to investigate visual relationships of diabetes

prevalence and mortality rates among Delaware residents. The spatial data presented here can provide additional insight for statewide health programming.

Three maps were created to test five hypotheses informed by state and national trends. Map 1 tested the following hypotheses: (1) a majority of census tracts in Sussex County will have higher prevalence rates of diabetes than those in New Castle and Kent Counties, mirroring county-level trends and (2) census tracts with greater prevalence rates of diabetes will also have a higher percentage of adults who report having a primary care provider. Map 2 tested the following hypothesis: (3) the percentage of Medicare beneficiaries with diagnosed diabetes in each county will be comparable to national levels. Map 3 tested the following hypotheses: (4) age-adjusted diabetes mortality rates will be higher in Sussex County compared to New Castle and Kent Counties and (5) overall age-adjusted diabetes mortality rates across counties will be higher among non-Hispanic blacks than non-Hispanic whites.

## Methods

We obtained county and census tract shapefiles for the state of Delaware from FirstMap Delaware and the U.S. Census Bureau.<sup>13–15</sup> Delaware contains 215 census tracts, 214 of which contain people (one census tract contains only a landfill and a wastewater treatment plant). For the purposes of these analyses, there were considered to be 214 “true” census tracts in the state. ArcMap 10.3 was used to create choropleth maps of the prevalence rates of diabetes and percent of adults who reported having a PCP by Delaware census tract in 2013. In addition, county-level choropleth maps were created to map the percent of Medicare beneficiaries with diabetes, overall age-adjusted diabetes mortality rates, and age-adjusted diabetes mortality rates by race. All maps were set to Delaware’s State Plane coordinate system (NAD 1983 StatePlane Delaware FIPS 0700 (Meters)) and displayed at a scale of 1:750,000.

### Map 1: Prevalence of Diabetes and Percent of Adults Reporting to Have a Primary Care Physician (PCP) by Delaware Census Tract

**Data source.** A subset of the CDC’s 2013 Behavioral Risk Factor Surveillance System (BRFSS) was used in this study. BRFSS is an annual, health-related telephone survey conducted at the state level. This survey collects data from non-institutionalized adults in the U.S. regarding health conditions, risk behaviors, and use of preventive services.<sup>16</sup> Data were downloaded as a Microsoft Excel file from Policy Map.

**Sample.** Survey data collected from BRFSS apply to the non-institutionalized adult population, aged 18 years or older, who live in the U.S. These data were analyzed at the census tract level. The census tract-level data are estimated from a multilevel model with post-stratification based on metropolitan area status, race, age, and income characteristics. The multilevel model is based on state-level estimates, as well as state- and individual-level characteristics including age group, income level, racial/ethnic group, and metropolitan area status.<sup>17</sup>

**Measures.** To collect data for the BRFSS, home telephone numbers were obtained through random-digit dialing, and the survey was available in both English and Spanish. In the BRFSS Section 7.12, Column 109 (Chronic Health Conditions), respondents who responded “Yes” to the question “Has a doctor ever told you that you have diabetes?” were considered to have diabetes. Women who only had diabetes during pregnancy and individuals who reported having prediabetes or borderline diabetes were not included.<sup>18</sup> Because BRFSS does not distinguish

between type 1 and type 2 diabetes, the data included a combined count. Prior to the geographic analysis, the tabular data were organized in a Microsoft Excel spreadsheet with the following column headings: (1) census tract, (2) estimated number of adults ever diagnosed with diabetes in 2013, (3) estimated adult population aged 18 and older in each census tract between 2012 and 2016, and (4) prevalence rate of diabetes in each census tract. Column three, the estimated adult population by census tract, was obtained from the 2012-2016 U.S. Census Bureau's American Community Survey (ACS).<sup>14</sup> The prevalence rate of diabetes in each census tract was calculated as follows:

$$\frac{\text{census tracts total \# of cases of diabetes in 2013}}{\text{census tracts adult population (2012-2016)}} \times 1,000.$$

In BRFSS Section 3.2, Column 88 (Health Care Access), respondents who responded “Yes, only one” and “More than one” to the question “Do you have one person you think of as your personal doctor or health care provider?” were included. These data were downloaded as the estimated percent of adults per census tract reporting to have a PCP.<sup>18,19</sup>

**Geo-based analysis.** Once data tables were imported to ArcMap, prevalence rates and percentages for outcomes of interest were joined to the census tract shapefile based on their 11-digit Federal Information Processing Standards (FIPS) codes. Prevalence rates and percentages were classified into quintiles.

## Map 2: Percent of Medicare Beneficiaries with Diagnosed Diabetes by County

**Data source.** We obtained 2015 data on the percent of Medicare beneficiaries with diagnosed diabetes by county in Delaware from CMS and Policy Map.<sup>20</sup>

**Sample.** Medicare beneficiaries are considered to have a chronic condition if there is a CMS claim indicating that the beneficiary received a service or treatment for the specific condition.<sup>5</sup> The sample only includes individuals who are enrolled in Medicare Part A (hospital insurance) and Part B (medical insurance). Medicare Part A and Part B cover individuals, ages 65 and over, who are receiving Social Security, people who have received disability benefits for at least two years, people who have amyotrophic lateral sclerosis (Lou Gehrig's disease) and receive disability benefits, as well as people who have end-stage renal disease (permanent kidney failure) and receive maintenance dialysis or a kidney transplant.<sup>5</sup> Information for Medicare beneficiaries who have died during the study year is also included in the dataset.

**Measures.** Diabetes data were collected through CMS administrative enrollment and claims data for Medicare beneficiaries. Individuals who have diabetes were identified based on CMS claims for services or treatment for diabetes.<sup>5</sup>

**Geo-based analysis.** Data on the percent of Medicare beneficiaries with diagnosed diabetes were downloaded and cleaned for import into ArcMap. Medicare data were joined with county shapefiles based on county FIPS codes. The percentage of Medicare beneficiaries with diabetes was classified into three classes using manual intervals.

## Map 3: Diabetes Mortality by Delaware County

**Data source.** We obtained diabetes mortality data from 2014—the most recent year available—from Delaware Open Data which contains data collected by the DHSS, DPH, and Delaware Health Statistics Center.<sup>21</sup> The U.S. Census Bureau's American FactFinder website was used to

obtain county adult populations for Delaware using Census 2010 population data as well as U.S. adult populations using Census 2000 population data.<sup>22-27</sup>

**Sample.** The sample consisted of individuals who died of diabetes in Delaware in 2014. The sample size was inclusive of all counties, genders, races, and educational levels.<sup>21</sup> All deaths occurred in adults aged 18 or older. Deaths by age group, inclusive of the 18 and older population, were used for age-adjusted mortality rates.

**Measures.** Outcome data were collected from death certificates of individuals who died from diabetes in 2014 in Delaware. The Office of Vital Statistics, under the DPH and the DHSS, is responsible for collecting and storing death certificate information for the state of Delaware.<sup>21</sup>

**Statistical analysis.** Since each row of data represents one death attributed to diabetes, filter functions were first used to sort diabetes-attributable deaths by county and age group. County mortality data population counts were used to determine the age-adjusted diabetes cause-specific mortality rates per county. The following cause-specific mortality equation was used:

$$\frac{\text{county's total \# of deaths due to diabetes in 2014 per age group}}{\text{county population by age group in 2010}} \times 100,000.$$

Race-specific diabetes mortality rates by county were also calculated:

$$\frac{\text{county's total \# of (black or white) deaths due to diabetes in 2014}}{\text{county (black or white) population by age group in 2010}} \times 100,000.$$

**Geo-based analysis.** Diabetes mortality data were cleaned and converted to an Excel spreadsheet. The Excel spreadsheet included the following column headings for each of Delaware's three counties: county name, FIPS county code, number of deaths due to diabetes in 2014 per age group, county population by age group in 2010, and diabetes mortality rate. Death rates were stratified by age groups and age-adjusted using the U.S. population in 2000 as a reference population. The basemap shapefile for Delaware and diabetes mortality data table were imported to ArcMap 10.3. Overall and race-specific diabetes mortality rates were manually classified into three classes (see Table 1).

Table 1. Age-Adjusted Diabetes Mortality Rates, per 100,000 People, by Delaware County: Overall, Black, and White Populations, Year 2014

County Name	Overall Age-Adjusted Diabetes Mortality Rate, per 100,000, in 2014	Age-Adjusted Diabetes Mortality Rate, per 100,000, Black Population, in 2014	Age-Adjusted Diabetes Mortality Rate, per 100,000, White Population in 2014
New Castle	26.53	82.39	46.14
Kent	25.87	64.11	52.72

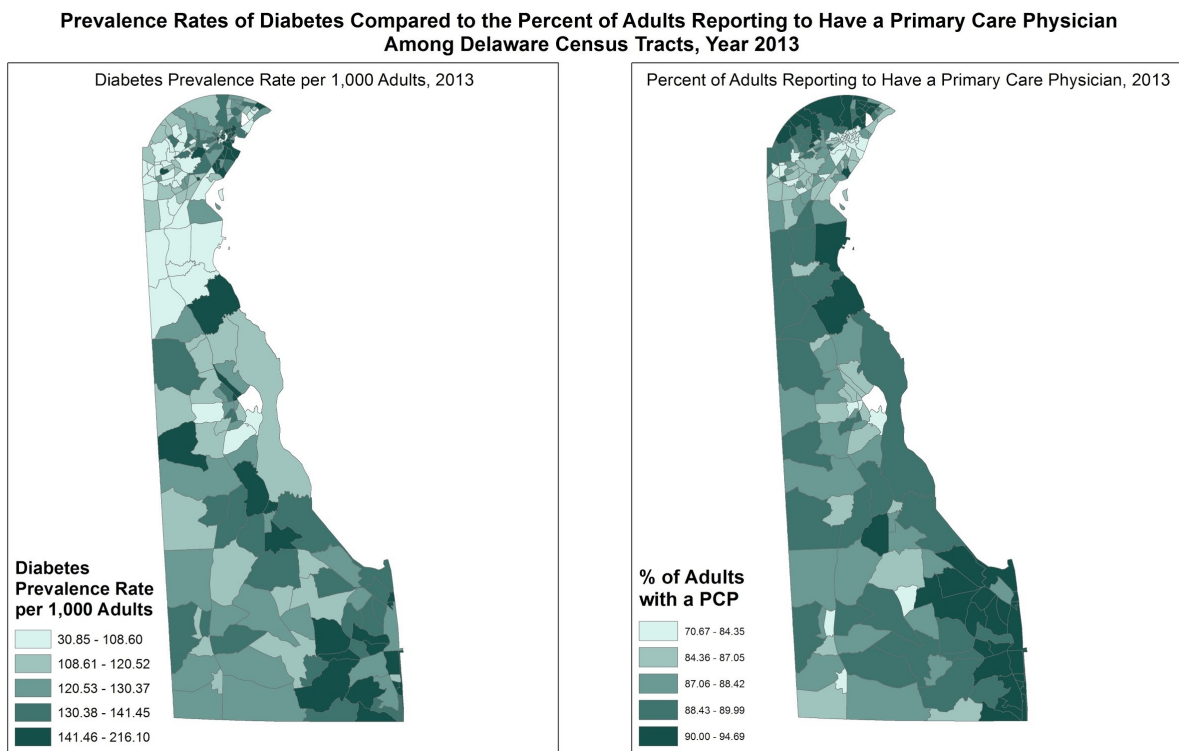
Sussex	30.75	93.73	55.98
--------	-------	-------	-------

## Results

### Map 1: Prevalence of Diabetes and the Percent of Adults Reporting to Have a Primary Care Physician (PCP) by Delaware Census Tract

Sussex County had the highest overall prevalence of diabetes with 133.37 cases per 1,000 adults, followed by Kent County (122.14 per 1,000) and New Castle County (118.10 per 1,000). Of the 214 census tracts with diabetes prevalence data, 120 had a diabetes prevalence rate greater than the statewide rate of 122.39 cases per 1,000 adults in 2013 (see Figure 1). Those census tracts in the highest quintile of diabetes prevalence rates had rates exceeding 141 cases per 1,000 adults ( $n = 42$  census tracts). Additionally, 24 out of the 42 census tracts in the highest quintile of diabetes prevalence rates were located in New Castle County, the northernmost county in the state.

Figure 1. Prevalence Rates of Diabetes per 1,000 Adults Compared to the Percent of Adults Reporting to Have a Primary Care Physician Among Delaware Census Tracts, Year 2013



Source: Data obtained from the Centers for Disease Control and Prevention's Behavioral Risk Factor Surveillance System (2013), U.S. Census Bureau (2017), and U.S. Bureau of the Census' American Community Survey (2012-2016).

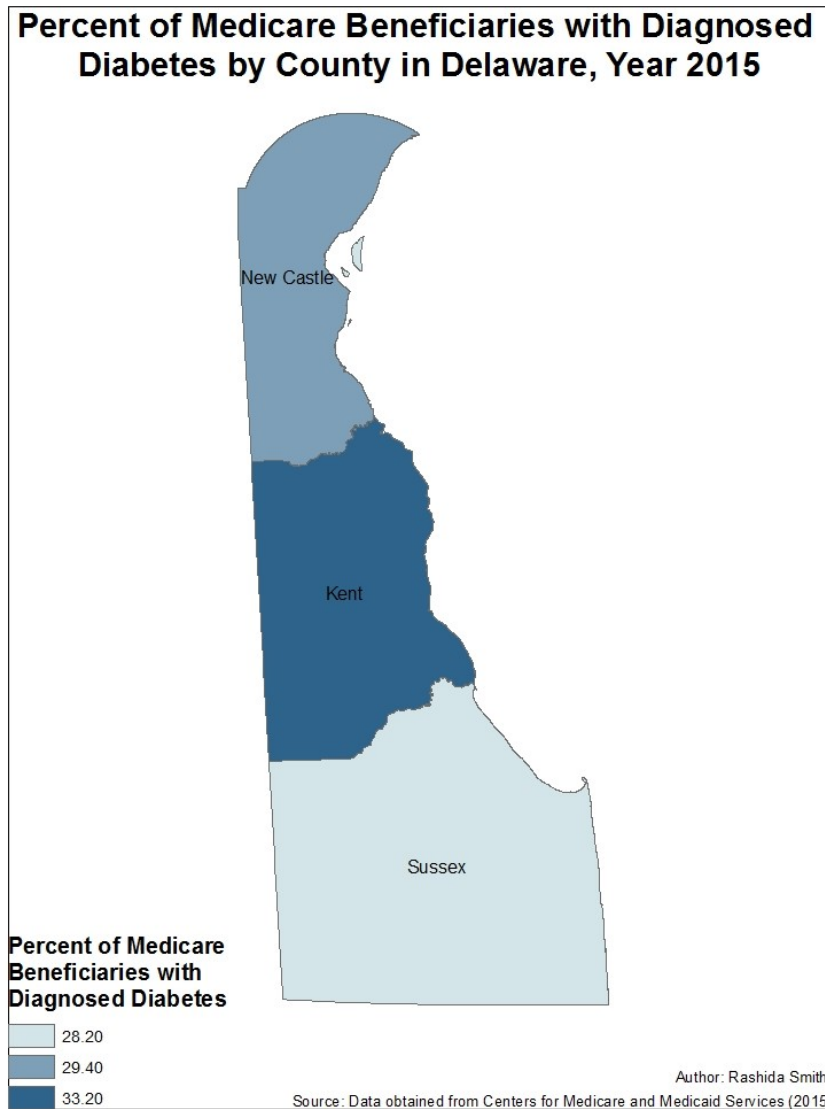
In all census tracts in Delaware (excluding those where data were not available), more than 70% of adults reported having a PCP. Specifically, in 80% ( $n = 172$ ) of census tracts, more than 84% of adults reported having a PCP. New Castle County had the greatest number of census tracts ( $n = 34$ ) in the lowest quintile of percentage of adults with a PCP. Sussex County had the greatest number of census tracts ( $n = 23$ ) in the highest quintile of percentage of adults with a PCP.

New Castle County had the most census tracts in both the highest quintile of diabetes prevalence rates and the lowest quintile of self-reported PCP access; however, all census tracts in New Castle County had PCP access rates of 70% or greater. While Sussex County had the most census tracts ( $n = 23$ ) in the highest quintile of PCP access (access rates exceeding 90%), all of these census tracts had diabetes prevalence rates exceeding 114 cases per 1,000 adults. It is challenging to visually ascertain relationships between PCP access and associated rates of diabetes diagnosis or prevention.

### **Map 2: Percent of Medicare Beneficiaries with Diagnosed Diabetes by County**

The percent of Medicare beneficiaries with diagnosed diabetes in Delaware in 2015 was mapped by county (see Figure 2). Kent County had the largest percent of Medicare beneficiaries with diagnosed diabetes (33.2%) compared to New Castle and Sussex Counties (29.4% and 28.2%, respectively), and therefore skewed the statewide prevalence of the disease. Values for New Castle and Sussex Counties were below the overall state value of 29.7%.

Figure 2. Percent of Medicare Beneficiaries with Diagnosed Diabetes, Year 2015

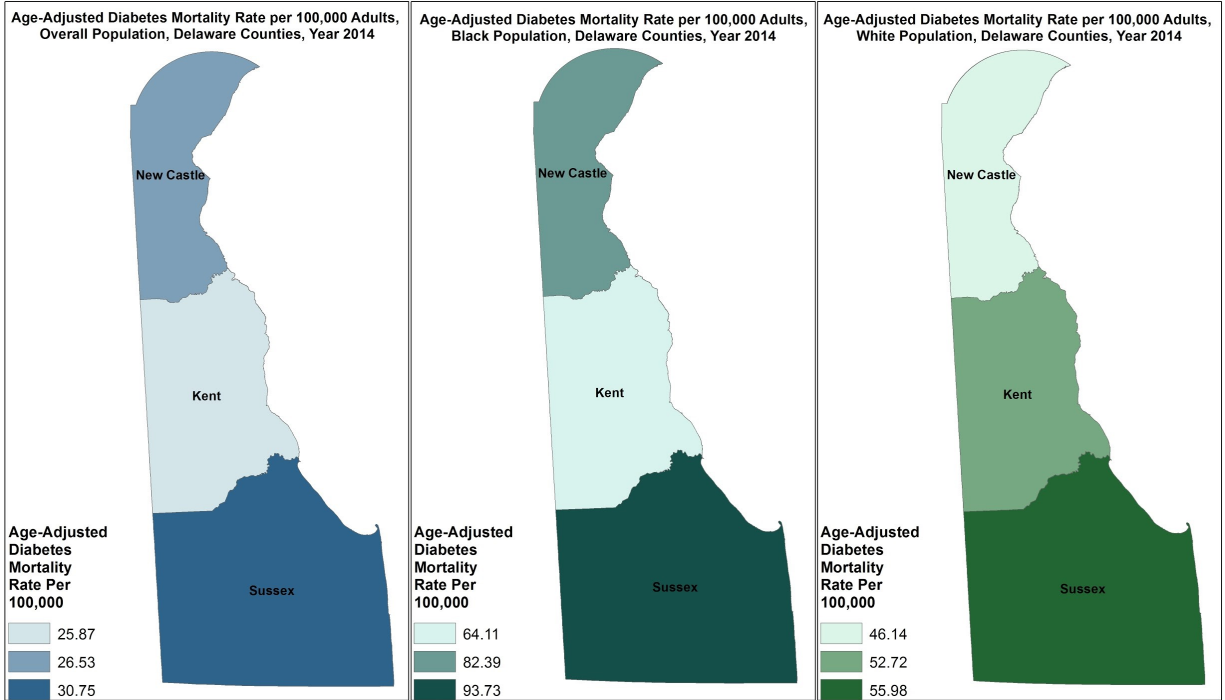


### Map 3: Diabetes Mortality by Delaware County

Age-adjusted diabetes mortality rates were mapped by Delaware County for the overall adult population and the black and white populations (see Figure 3). The overall age-adjusted adult diabetes mortality rate was highest in Sussex County with 30.75 diabetes deaths per 100,000 people, compared to New Castle and Kent which had similar cause-specific mortality rates (26.53 and 25.87, respectively). Diabetes mortality rates for the black population were highest in Sussex County with 93.73 diabetes deaths per 100,000 people, compared to New Castle and Kent Counties (82.39 and 64.11, respectively). Diabetes mortality rates for the white population were also highest in Sussex County, with 55.98 diabetes deaths per 100,000 people, compared to New Castle and Kent Counties (46.14 and 52.72, respectively).

Figure 3. Diabetes Mortality Rates per 100,000 Adults, by Delaware County: Overall, Black, and White Populations, Year 2014

**Age-Adjusted Diabetes Mortality Rates per 100,000 Adults by Delaware County:  
Overall, Black, and White Populations, Year 2014**



Source: Data obtained from the Delaware Department of Health and Social Services, Delaware Division of Public Health, and Delaware Health Statistics Center (2014) and American FactFinder (2010) Author: Saheedat Sulaimon

In addition to producing maps to assess visual patterns, a descriptive statistics summary table was created to reveal additional patterns that may not be evident from the spatial analysis. Comparing individual counties, the age-adjusted diabetes mortality rate per 100,000 people is consistently higher for the black population in Delaware counties, compared to the white population. Diabetes mortality rates for the white population are more reflective of the overall diabetes mortality rates for Delaware counties. Because the white population represents two-thirds of Delaware's population (68.9%), trends in diabetes mortality for the white population are more likely to be similar to the trends for the entire state.<sup>27</sup> However, because the black population comprises only 21.4% of the state population, diabetes mortality trends for the entire state may not be reflective of trends in the black population.<sup>27</sup>

## Discussion

Given the increasing interest in visually displaying the burden of chronic disease across the nation, GIS was used to analyze patterns of diabetes prevalence and mortality in Delaware. Specifically, we explored the relationships between: (1) prevalence of diabetes by census tract; (2) percentage of Medicare beneficiaries with diabetes by county; and (3) diabetes mortality by county.

### Map 1: Prevalence of Diabetes and the Percent of Adults Reporting to Have a Primary Care Physician (PCP) by Delaware Census Tract

Previous research has shown that having multiple providers of care rather than one designated PCP may have negative impacts on the health of individuals.<sup>28</sup> A limited patient-physician connection leads to low adherence to guideline-consistent services by physicians, and continuity of care has been associated with improved diabetes prevention and management.<sup>29,30</sup>



Our analysis of the prevalence of diabetes and the percent of adults reporting to have a PCP among census tracts in Delaware shows that New Castle County had the greatest number of census tracts in the highest quintile of diabetes prevalence rates, contradicting our hypothesis that we would see higher diabetes prevalence rates in Sussex County census tracts. Additionally, at least 70% of adults in all census tracts in the state reported to have a PCP in 2013. The high percentage of individuals who reported having a PCP corresponds to the literature on the importance of having a consistent PCP.<sup>28</sup> Because New Castle County appeared to have lower PCP access but higher diabetes prevalence in some census tracts, these data may be interpreted such that lower access to PCPs may result in lack of preventive care and screening that contributes to higher rates of diabetes. Prior research has shown that patients with diabetes who identified a regular PCP were more likely to receive most recommended elements of diabetes care and to have better control of this chronic condition.<sup>30</sup>

## **Map 2: Percent of Medicare Beneficiaries with Diagnosed Diabetes by County**

Visual analysis of this map shows that Kent County has the largest percentage of Medicare beneficiaries with diagnosed diabetes, whereas New Castle and Sussex Counties have similar values. The percentages for Medicare beneficiaries with diagnosed diabetes for each county are as follows: New Castle County, 29.4%, Sussex County, 28.2%, and Kent County 33.2%. These percentages closely mirror those at the national level. Diabetes is a highly ranked chronic condition among the Medicare beneficiary population with 28% of Medicare beneficiaries diagnosed with diabetes in 2010.<sup>5</sup> The high prevalence of diabetes among Medicare beneficiaries confirms the need for more targeted interventions in this population.

## **Map 3: Diabetes Mortality by Delaware County**

Diabetes mortality rates were highest in Sussex County for the overall population and the black and white populations. Comparing individual counties, the diabetes mortality rate per 100,000 people is consistently higher for the black population in Delaware counties, in comparison to the white population.

According to the Delaware Health Statistics Center, the five-year diabetes mortality rate for 2006-2010 was 20.6 deaths per 100,000 people. The report also stated that black Delawareans had a higher diabetes mortality rate compared to their white counterparts (Delaware DPH, 2014). Similarly, the findings in our study reflect these historical trends in that disparities in diabetes mortality rates persist between racial and ethnic groups. Lower levels of education and access to care may explain in part why disparities among racial and ethnic groups have continued to persist for decades.<sup>8</sup>

Diabetes mortality trends for the overall population are more reflective of diabetes mortality trends for the white population because Delaware's three county populations are predominantly white. For this reason, it is important to look beyond overall trends when assessing where to direct diabetes mortality prevention efforts. Overall diabetes mortality trends may not accurately reflect the health of sub-populations.

In order to change the trajectory of diabetes mortality rates among Delawareans, addressing disparities should be at the forefront of chronic disease management. Doing so can more appropriately influence county initiatives and better inform intervention and prevention programs for those populations at increased risk for diabetes mortality.

## Comparative Analysis

Our visual analysis of diabetes prevalence in Delaware identified geographic and demographic disparities in this condition. In comparing diabetes prevalence to diabetes mortality across counties, clear associations were not seen. Sussex County had the highest diabetes prevalence (133.37 cases per 1,000 adults) of the three counties in Delaware, yet New Castle County had a greater number of census tracts with prevalence rates exceeding 141 cases per 1,000 adults, as compared to Kent and Sussex Counties. In contrast, diabetes mortality rates do not mirror these patterns at the census tract level in that Sussex County had higher overall and race-specific diabetes mortality rates in comparison to Kent and New Castle Counties.

To continue our visual analysis, we looked at diabetes in the state's Medicare population. There did not appear to be a close relationship between diabetes prevalence and mortality among counties' Medicare beneficiaries. Despite Sussex County having the highest diabetes mortality rate, it has the lowest percentage of Medicare beneficiaries diagnosed with diabetes. Similarly, because the percentage of Medicare beneficiaries diagnosed with this disease was relatively low in New Castle County, it remains unclear whether receiving Medicare impacts an individual's diagnosis and management of diabetes. There are likely several confounding variables not examined here that influence the relationship between diabetes diagnoses, prevalence, and mortality in the Medicare population.

## Strengths and Limitations

It is necessary to discuss our findings in the context of several strengths and limitations. The most recent available data were used to produce the three maps, providing us with the most current state of diabetes in Delaware. Additionally, looking at different measures of diabetes (prevalence, mortality, and Medicare beneficiaries) paints a more complete picture of this chronic disease. These maps can help display trends that may not be readily apparent in tabular data form.

It is important to note limitations that may impact the interpretation of our findings. One limitation is that some data are available only at the county level, obscuring variance within counties. This made it challenging to fully ascertain relationships between variables of interest across relatively large geographic units. Additionally, since data were collected from multiple sources and different calendar years, future map-based analyses would benefit from use of temporally consistent data covering a longer time period.

## Implications and Future Directions

Diabetes prevalence, mortality, and costs have far-reaching implications for the healthcare system and public health. Substantial healthcare costs and suboptimal health outcomes confirm the need to transform the delivery of diabetes care. Redesign of primary care services could help a greater number of patients meet recommended targets for preventive interventions. This can ultimately improve the health of the population by reducing not only the impact of diabetes but also associated physician burnout.<sup>31</sup> Furthermore, our findings may be used to inform policy making, targeted interventions, and future research initiatives at the census tract, county, and state levels.

Future studies should use more granular units of analysis (e.g. zip code-level data) to better explore the relationships between the mapped variables. Additionally, potential confounding

factors should be identified and comparatively mapped in order to expose a clearer link between outcomes of interest.

## Conclusion

Despite how much money the U.S. healthcare system spends on diabetes, individuals with diabetes are not reaching target levels of optimal care that clinical experts recommend. In order to help communities in Delaware effectively prevent and manage diabetes, county and census tract-level diabetes data were mapped to identify areas with high diabetes prevalence and mortality. Given that this chronic disease poses large economic, social, and physical burdens to both individual residents and the state as a whole, it is critical to identify specific geographic areas most affected by diabetes. Analyzing these data can help to highlight health disparities and expose other risk factors that are unevenly distributed across communities.

There is value in mapping these data for public health planning. Maps can be used to quickly visualize and communicate geographic disparities in diabetes.<sup>32</sup> The rise of diabetes continues to widen health inequities and present economic and social threats to society and health systems.<sup>31</sup> Incorporating geography into diabetes prevention and management can help us to better understand root causes and tailor interventions for unique populations.<sup>32</sup>

## References

1. Centers for Disease Control and Prevention. (2017). About diabetes. Retrieved from <https://www.cdc.gov/diabetes/basics/diabetes.html>
2. Centers for Disease Control and Prevention. (2018). About prediabetes & type 2 diabetes. Retrieved from <https://www.cdc.gov/diabetes/prevention/prediabetes-type2/index.html>
3. American Diabetes Association. (2018, May). Economic costs of diabetes in the U.S. in 2017. *Diabetes Care*, 41(5), 917–928. [PubMed https://doi.org/10.2337/dci18-0007](https://doi.org/10.2337/dci18-0007)
4. Centers for Disease Control and Prevention. (2017). National diabetes statistics report, 2017. Retrieved from <https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf>
5. Centers for Medicare and Medicaid Services. (2012). Chronic conditions among Medicare beneficiaries. Retrieved from <https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/chronic-conditions/downloads/2012chartbook.pdf>
6. Delaware Health and Social Services, Division of Public Health. (2016). Behavioral Risk Factor Survey (BRFS). Retrieved from <http://www.dhss.delaware.gov/dph/dpc/diabetes02.html>
7. National Center for Health Statistics. (2016). Stats of the State of Delaware. Retrieved from <https://www.cdc.gov/nchs/pressroom/states/delaware/delaware.htm>
8. Delaware Division of Public Health. (2014). The Burden of Diabetes in Delaware 2014 Update. Retrieved from [https://www.dhss.delaware.gov/dhss/dph/dpc/files/de\\_diabetes\\_burden\\_2014update.pdf](https://www.dhss.delaware.gov/dhss/dph/dpc/files/de_diabetes_burden_2014update.pdf)
9. Elliott, D. J., Robinson, E. J., Sanford, M., Herrman, J. W., & Riesenber, L. A. (2011, July-August). Systemic barriers to diabetes management in primary care: A qualitative analysis

- of Delaware physicians. *Am J Med Qual*, 26(4), 284–290. [PubMed](#)  
<https://doi.org/10.1177/1062860610383332>
10. Ammerman, A., Smith, T. W., & Calancie, L. (2014). Practice-based evidence in public health: Improving reach, relevance, and results. *Annual Review of Public Health*, 35(1), 47–63. [PubMed](#) <https://doi.org/10.1146/annurev-publhealth-032013-182458>
  11. Barker, L. E., Kirtland, K. A., Gregg, E. W., Geiss, L. S., & Thompson, T. J. (2011, April). Geographic distribution of diagnosed diabetes in the U.S.: A diabetes belt. *American Journal of Preventive Medicine*, 40(4), 434–439. [PubMed](#)  
<https://doi.org/10.1016/j.amepre.2010.12.019>
  12. Dwyer-Lindgren, L., Bertozzi-Villa, A., Stubbs, R. W., Morozoff, C., Kutz, M. J., Huynh, C., . . . Murray, C. J. L. (2016, December 13). US county-level trends in mortality rates for major causes of death, 1980-2014. *JAMA*, 316(22), 2385–2401. [PubMed](#)  
<https://doi.org/10.1001/jama.2016.13645>
  13. FirstMap Delaware. (2003). Delaware Boundaries County State. Retrieved from <https://firstmap.delaware.gov>
  14. U.S. Census Bureau. (2016). American Factfinder, 2012-2016 American Community Survey 5-Year Estimates, Table DP05. Retrieved from <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk>
  15. U.S. Census Bureau. TIGER/Line Shapefiles. (2017). Census Tracts: Delaware. Retrieved from <https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2017&layergroup=Census+Tracts>
  16. Centers for Disease Control and Prevention. (2014). Behavioral Risk Factor Surveillance System. Retrieved from <https://www.cdc.gov/brfss/about/index.htm>
  17. Policy Map. (2017). Data Sources. Retrieved from <https://www.policymap.com/data/our-data-directory/>
  18. Centers for Disease Control and Prevention. (2013). BRFSS 2013 Survey Data and Documentation. Retrieved from [https://www.cdc.gov/brfss/annual\\_data/annual\\_2013.html](https://www.cdc.gov/brfss/annual_data/annual_2013.html)
  19. Centers for Disease Control Behavioral Risk Factor Surveillance System. (2013). Percent of adults ever diagnosed with diabetes in 2013. Policy Map. Retrieved from <https://www.policymap.com/maps>
  20. Centers for Medicare and Medicaid Services. (2015). Estimated percent of all people who are medicare fee-for-service beneficiaries in 2015. Policy Map. Retrieved from <https://www.policymap.com/maps>
  21. Delaware Open Data. (2014). Delaware Deaths [Data file]. Retrieved from <https://data.delaware.gov/browse>
  22. U.S. Census Bureau. (2000). American factfinder, table DP-1. Retrieved from <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml>
  23. U.S. Census Bureau. (2000). American factfinder, table P012A. Retrieved from <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml>

24. U.S. Census Bureau. (2000). American factfinder, table P012B. Retrieved from <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml>
25. U.S. Census Bureau. (2010). 2010 American Community Survey 1-Year Estimates, Table B01001A. Retrieved from <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml>
26. U.S. Census Bureau. (2010). 2010 American Community Survey 1-Year Estimates, Table B01001B. Retrieved from <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml>
27. U.S. Census Bureau. (2010). 2010 Demographic Profile Data, Table DP-1. Retrieved from [https://factfinder.census.gov/faces/nav/jsf/pages/community\\_facts.xhtml](https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml)
28. Morrison, F., Shubina, M., Goldberg, S. I., & Turchin, A. (2013, May). Performance of primary care physicians and other providers on key process measures in the treatment of diabetes. *Diabetes Care*, 36(5), 1147–1152. [PubMed https://doi.org/10.2337/dc12-1382](https://doi.org/10.2337/dc12-1382)
29. Atlas, S. J., Grant, R. W., Ferris, T. G., Chang, Y., & Barry, M. J. (2009, March 3). Patient-physician connectedness and quality of primary care. *Annals of Internal Medicine*, 150(5), 325–335. [PubMed https://doi.org/10.7326/0003-4819-150-5-200903030-00008](https://doi.org/10.7326/0003-4819-150-5-200903030-00008)
30. O'Connor, P. J., Desai, J., Rush, W. A., Cherney, L. M., Solberg, L. I., & Bishop, D. B. (1998, October). Is having a regular provider of diabetes care related to intensity of care and glycemic control? *The Journal of Family Practice*, 47(4), 290–297. [PubMed https://doi.org/10.1177/003335491312800311](https://doi.org/10.1177/003335491312800311)
31. National Institute of Diabetes and Digestive and Kidney Diseases. (2017). Current burden of diabetes in the U.S. Retrieved from <https://www.niddk.nih.gov/health-information/communication-programs/ndep/health-professionals/practice-transformation-physicians-health-care-teams/why-transform/current-burden-diabetes-us>
32. Curtis, A. B., Kothari, C., Paul, R., & Connors, E. (2013). Using GIS and secondary data to target diabetes-related public health efforts. *Public Health Reports (Washington, D.C.: 1974)*, 128(3), 212–220. doi:<https://doi.org/10.1177/003335491312800311>

---

Copyright (c) 2019 Delaware Academy of Medicine / Delaware Public Health Association.

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<https://creativecommons.org/licenses/by-nc-nd/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.