Diabetes Hospitalization in Minnesota

2006-2014

DEPARTMENT OF HEALTH

Diabetes Hospitalization in Minnesota, 2006-2014

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Background

The number of adults who have diabetes – type 1 or type 2 – in Minnesota is at an all-time high.[1] National numbers suggest the number of new cases that develop each year may be slowing down, but we don't have all of the information to say for sure.[2] More than one of every five dollars spent on health care in the U.S. is to care for people who have diabetes and, in 2012 in Minnesota, at least $2.3 billion was spent on medical care for diabetes and related complications.[3]

Good News for Diabetes

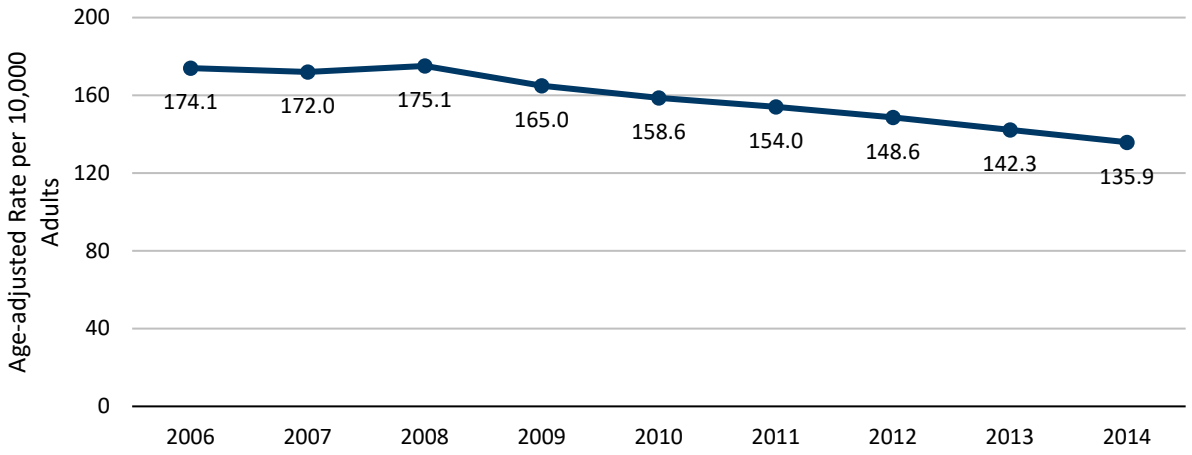
While these numbers still convey concern about diabetes in Minnesota, this report focuses on one of the bright spots – hospitalization rates for diabetes in Minnesota have been going down.

The diabetes hospitalization rate is an important number to keep track of for many reasons:

- First, people who have diabetes tend to have other conditions and they are often more likely to be hospitalized. Diabetes can lead (directly or indirectly) to the development of many other health problems, including but not limited to, heart problems, stroke, nerve damage, arthritis and kidney problems. People who already have other chronic health problems who go on to develop diabetes may find those conditions more difficult to manage if they have diabetes. These two facts may help to explain why people who have diabetes are at greater risk of being hospitalized.
- Second, when people who have diabetes are hospitalized, they are often hospitalized for longer periods of time. People who have diabetes tend to stay in the hospital for more days than people who do not have diabetes, even when the reason for hospitalization is not related to diabetes.[3] This may be because having diabetes makes it more complicated to treat other conditions at the same time, and that people with diabetes may have more severe conditions.
- Third, hospitalizations are a big part of the costs of diabetes. Hospitalization costs among patients with diabetes is the largest piece of health care costs linked to diabetes. Inpatient hospitalizations, or admissions to the hospital, make up more than 40% of the health care costs related to diabetes.[3] Being hospitalized more often, for longer periods of time, and for more serious reasons than people without diabetes may explain why costs can be so high.

Minnesota Diabetes-Related Hospitalizations Declined

Figure 1. Age-Adjusted Rate of Adult Diabetes-Related Hospitalizations (type 1 and type 2) per 10,000 Minnesota adults, 2006-2014



*Data Sources: Minnesota – Minnesota Hospitalization Data, **MDH and Minnesota Hospital Association***

People who have diabetes can be hospitalized for many reasons that are related to diabetes, so it is important to examine the total rate of hospitalization for diabetes-related causes. Figure 1 shows that Minnesota's rate of diabetes-related hospitalization declined significantly from 2008 to 2014 (p=<0.01). These numbers include adults who have type 1 and type 2 diabetes.

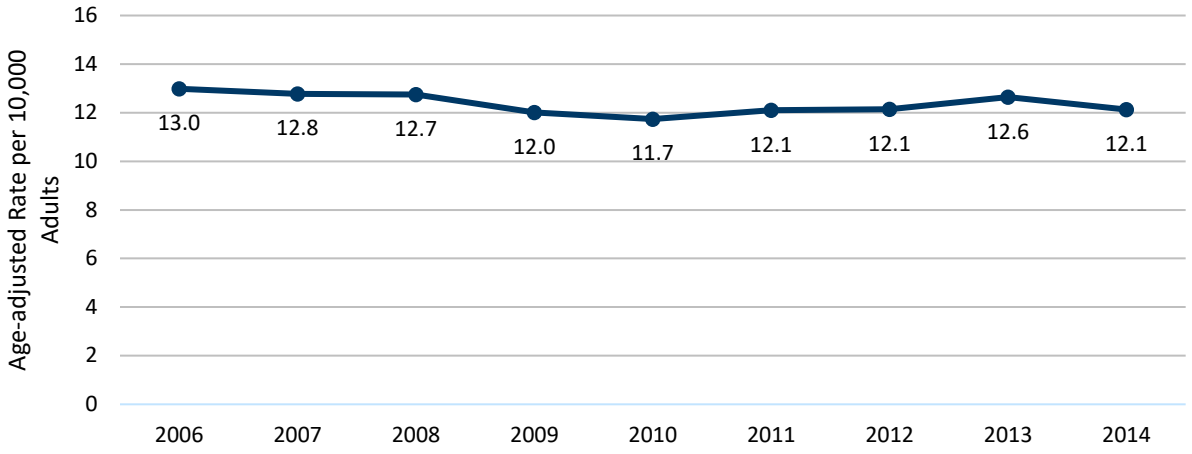
A national analysis of data from 1990 to 2010 showed that the rates of diabetes complications including heart attack, stroke, lower limb (foot and leg) amputations and kidney failure went down for people who have diabetes.[4] Most of the improvement happened between 1995 and 2005.[4] What did this mean? Each year, there were about 10 fewer hospitalizations for heart attacks for every 1,000 U.S. adults who have diabetes and six fewer strokes for every 1,000 U.S. adults who have diabetes. When the researchers looked at hospitalization rates in the same way this report does – looking at rates of diabetes-related hospitalizations based on the number of U.S. adults and not just adults with diabetes – they saw some rates drop a smaller amount and others did not drop at all.[4] That is because the total number of people who have diabetes in the general population increased over this same time period, mostly driven by increases in type 2 diabetes.[5] In the national analysis, the researchers also removed people recently diagnosed with diabetes from the data. Newly diagnosed people might be healthier and less likely to be hospitalized. It is possible that these more recently diagnosed people could be driving the lowered rates. In the reanalysis that did not include newly diagnosed diabetes cases, the hospitalization rate did not go down as much, but it still decreased. This means that

increases in diagnosis and the inclusion of "presumably healthier people" did not cause all of the decrease in hospitalization rates.

Similar to the national analysis focused on specific conditions, we saw a decrease in the rate of hospitalizations per person who have diabetes. These analyses used state survey data between 2010 and 2014 to estimate the number of people who have diabetes (Data not shown). However, we also saw a decrease in the rate among **all adults**. The number of adults who have diabetes increased nationally and in Minnesota, although at a slower rate in the State. In Minnesota, the number of adults who have diabetes doubled in the 1990s and 2000s, while in the US, the number tripled. Having fewer people who developed diabetes may help to explain some of why our state hospitalization rates went down, and the pattern was less clear for the national analysis examining specific hospitalizations. Since we still saw a significant reduction in rates per person who has diabetes, smaller increases in the number of people who have diabetes isn't the whole story. **However, it is still important to mention that efforts to prevent diabetes at the population-level and among people at greatest risk for developing diabetes are critical for the downward trend to continue.**

Reasons for hospitalization can fall into two categories: 1) hospitalizations for blood sugar that is either extremely high or extremely low (such as ketoacidosis or coma); and 2) hospitalizations for long-term effects of repeatedly high blood sugars like eye, kidney and cardiovascular disease. We looked to see if the same downward trend held for hospitalizations where extremely high or extremely low blood sugars was the main and immediate reason.

Figure 2. Age-Adjusted Rate of Adult Hospitalizations for Diabetes (type 1 and type 2) as the Main Cause per 10,000 Minnesota adults, 2006-2014



*Data Sources: Minnesota – Minnesota Hospitalization Data, **MDH and Minnesota Hospital Association***

Hospitalization rates for diabetes as the main reason for hospitalization were stable over the time period and did not show any significant difference. They did not show the same pattern of decline that the overall diabetes-related hospitalization rate did. This means that the decrease we saw in the first figure is being driven by fewer hospitalizations resulting from the long-term

effects of blood sugars that are not well-controlled. Long-term improvements in care for people who have diabetes can impact these hospitalizations.

The changing rates of diabetes-related hospitalizations in Minnesota

Lower overall rates of diabetes-related hospitalizations might result from improvements in the care of people who have diabetes. That includes the care people receive from their health care provider, care and support they receive from their community, and care that people who have diabetes give themselves.

Care received from health care providers

Minnesota passed a state Health Reform Law in 2008, two years before the nation passed the Affordable Care Act. Minnesota Health Reform resulted in a number of efforts to improve the quality of care so that health care is 1) better; 2) costs less; and 3) the health of communities improves.

The health reform legislation activated many important changes and it has helped Minnesota be one of the "first states out of the gate" in making these reforms. One important change is an increased focus on patient-centered, team-based care. That means that care is organized around an individual's needs, and the person's doctor, nurse practitioner or physician's assistant is part of a team of health care professionals who help him or her to address their health needs more completely and efficiently. These team members include health professionals like nurses, care coordinators, dieticians, pharmacists and community health workers. Patients may have increased access to their health care provider through these additional team members.

Another important change is tracking patient outcomes and holding health care professionals and clinics responsible for the outcomes. There are five diabetes goals, known as the D5, that all patients who have diabetes work to achieve. These goals include achieving good blood sugar, cholesterol, and blood pressure levels; not smoking; and being treated with aspirin if heart disease is also present. Clinics are required to track these goals through the patient's primary health care provider (doctor, nurse practitioner, or physician assistant) and report on them for all of their diabetes patients. Tracking and improving these important patient outcomes in the primary care clinic can help avoid many diabetes-related hospitalizations.

The goal of state reforms was to drive clinics to improve the care for patients who have diabetes, resulting in fewer complications that lead to hospitalization. Many national efforts to address clinical care, including general efforts to prevent people from going back into the hospital shortly after they are first hospitalized, could also be contributing to Minnesota's downward trend.

The team-based care model, tracking patient outcomes, and improving care for people who have diabetes and other chronic conditions are all key aspects of the Patient-Centered Medical Home also known as Health Care Homes in Minnesota. A recent Health Care Homes, Five Year Program Evaluation report showed the model achieved about $1 billion in savings per million

people served through public programs per year. It also showed better health outcomes for people with diabetes as well as people with other conditions like depression and vascular disease.

Care and support from communities

Minnesota also developed the Statewide Health Improvement Partnership (SHIP) as another result of the Health Reform legislation. SHIP works to create healthier communities by addressing the risk factors that can lead to developing chronic diseases like diabetes. SHIP works with schools, communities, workplaces and health care providers to improve access to healthy food, make opportunities for active living more available, and promote tobacco-free living. By making it easier for all Minnesotans to eat healthy, engage in physical activity, and not use commercial tobacco products or be exposed to secondhand smoke, SHIP is making Minnesota communities healthier for people living with diabetes.

Self-care

Appropriate self-management may also prevent complications that can lead to hospitalization. Minnesota has had one of the highest percentages of people who have diabetes who have received some type of education (any number of hours or format) related to diabetes management.(data not shown) Diabetes education can occur in clinical or community settings.

There are specially designed, accredited programs for people who have diabetes called diabetes self-management education/training (DSME/T) classes taught by highly trained health professionals in clinic settings. These classes teach self-care strategies like how to eat healthier, be more physically active, monitor blood sugar levels, set goals for health and take medications appropriately. Participating in these classes is an important way that people can learn how to successfully manage diabetes. Ideally, DSME/T classes are paired with ongoing support for people who have diabetes. As described in Behavioral Programs for Type 2 Diabetes Mellitus: A Current State of the Evidence, DSME/T programs paired with ongoing support that engage patients for more than 11 hours led to changes in blood sugar control that were clinically-important.

Community-based support can include support groups, and research-based or evidence-based programs. These programs have structured curriculum to put into practice what patients have learned from health professionals. Some examples for people with diabetes are Living Well with Chronic Disease and Living Well with Diabetes.

While self-care is an extremely important part of managing diabetes, and likely contributes to reduction in hospitalizations, more progress needs to happen. Less than one in five Minnesota adults who have diabetes participates in a formal diabetes self-management education (DSME/T) program in any year (Data not shown). While there are improvements that need to be made in coverage for DSME/T to make it more accessible (Improving Payment Accuracy for Services: Diabetes Self-Management Training), education is a covered benefit for Minnesotans who have diabetes, whether they are covered by Medicaid, Medicare or private insurance. Benefits are available the first year of a person's diagnosis and every year afterward.

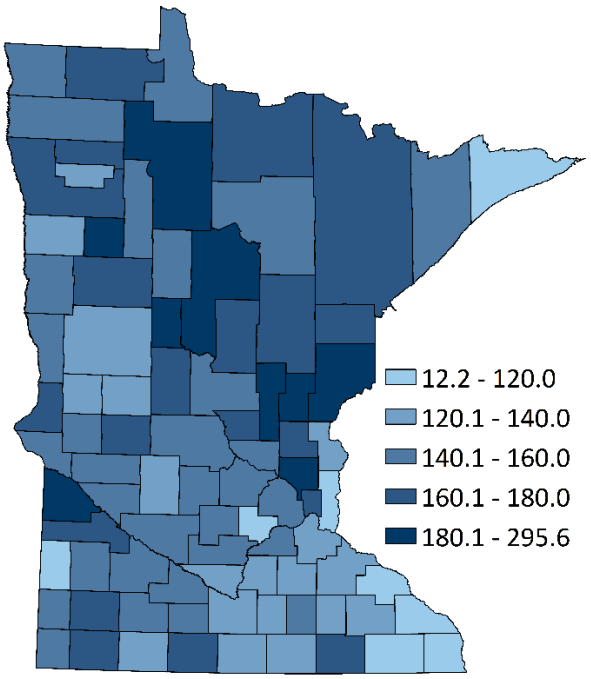
Some Minnesotans are Hospitalized for Diabetes More than Others

Although Minnesota has seen improvement in the rate of diabetes-related hospitalization, it is not all good news. Rates of hospitalization are very different depending on where in Minnesota people live, which tells us that there is still work to do in many parts of the state. Several factors may help explain why some places have higher rates of hospitalization than others.

- **Population characteristics differ by county and certain groups of people have higher rates of diabetes.** For example, diabetes is more common as people age, so a county with an older population would be expected to have more people who have diabetes. This could result in higher hospitalization rates than in a county with a younger population.

- **Availability of health resources is not consistent across the state.** People who have diabetes and live in areas with many options for primary care or self-management education may be able to better control their diabetes and prevent complications that would result in hospitalization.

Map 1. Age-Adjusted Rates of Adult Diabetes-Related Hospitalizations per 10,000 Minnesota Adults by County, 2010-2014



Data Source: Minnesota Hospitalization Data, ***MDH and Minnesota Hospital Association***

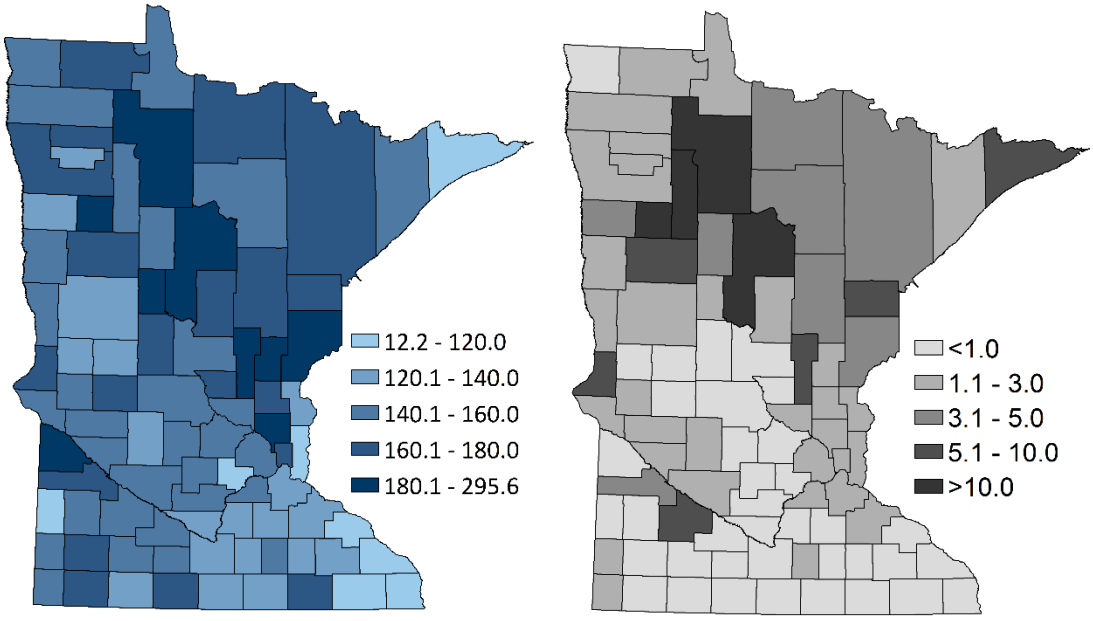
Map 1 shows differences in the age-adjusted rate of diabetes-related hospitalizations by county in Minnesota. Age-adjustment is a mathematical method that tries to remove most of the differences in age between populations – in this case, counties – that we want to compare. The idea is that differences seen in an age-adjusted hospitalization rates are mostly due to factors other than age.

In general, the highest rates of diabetes-related hospitalization are in counties in North-central Minnesota. Most counties with the lowest rates of diabetes-related hospitalization are in Southeast Minnesota, but these may be underestimated due to missing data on hospitalizations in this region (see Appendix 1). To see a map where counties are identified that have rates statistically different from the state average, please see Appendix 3.

Identifying characteristics that are associated with higher hospitalization rates can help us decide which populations may benefit from interventions to prevent diabetes complications that lead to hospitalization (See Maps 1-6). These analyses examine data at the county-level and are a first-pass at trying to describe patterns that exist statewide and should generate ideas for other analyses and conversations to more fully understand hospitalization trends in a particular county. Find a discussion of the selection of characteristics the strengths and limitations of the analysis in Appendix 5.

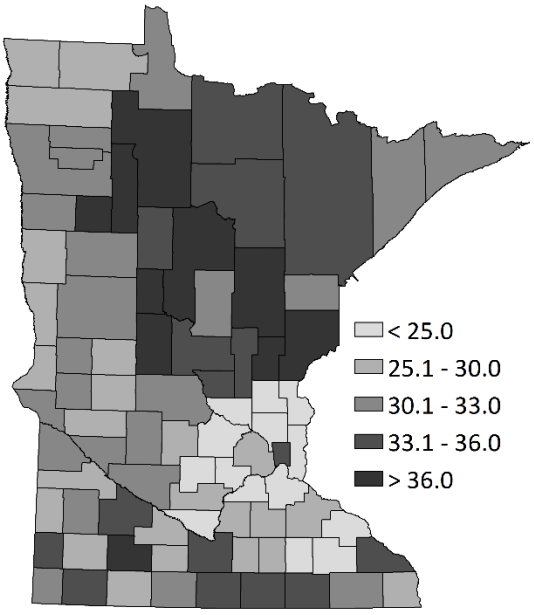
Demographic Factors

Maps 2-4. Selected Demographic Factors by County, 2010-2014

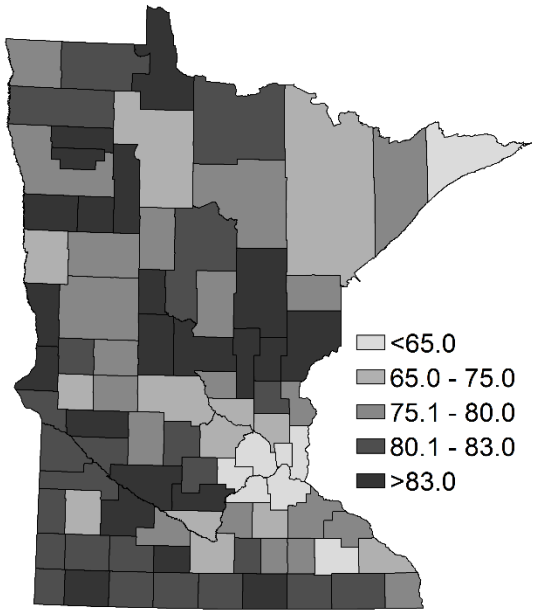


1. *Diabetes-related hospitalization rate*

2. Percent American Indian



3. Percent low-income



4. Percent with less than college degree

Data Source: American Community Survey, U.S. Census Bureau

Race and Ethnicity

Higher rates of diabetes among American Indians could be one factor driving differences in diabetes-related hospitalization rates by county. Nationally, American Indians have the highest rate of diagnosed diabetes (15.1% compared to 7.4% for non-Hispanic whites).[6] Map 2 shows the percentage of the population who are American Indian in each county. Counties with larger Native populations tend to have higher rates of diabetes-related hospitalization, which may point to this population containing more people who have diabetes.

We did not see this association among other racial or ethnic groups in the state; however, this may be because our analysis focused on county-level rates across the entire state (See Appendix 2 for methodology for all factors and Appendix 4 for results.). Differences by race might be more apparent if we were to look at rates in smaller geographic areas in the Twin Cities where the majority of non-white and Hispanic residents live or to conduct analyses looking at individual level data.

Poverty

Income levels may also influence rates of diabetes-related hospitalization, particularly as people with lower incomes may have fewer resources to manage their diabetes and have higher rates of diabetes overall. Map 3 shows the percent of the population living below 200% of the Federal Poverty Limit (FPL). FPL is a measure of income that takes family size into account and assesses whether or not a family has enough income to meet the basic needs of life. According to many definitions, people living below 200% of FPL are considered to be either in poverty (0-99% FPL) or low-income (100 - 199% FPL), but we will refer to the whole group as having low incomes.

Higher diabetes-related hospitalization rates were associated with higher percentages of people who have low incomes. In Minnesota, people who have low incomes are two-and-a-half

times more likely to report having diabetes as those with higher incomes[7], so we would expect counties with more low-income adults to have more people who have diabetes.

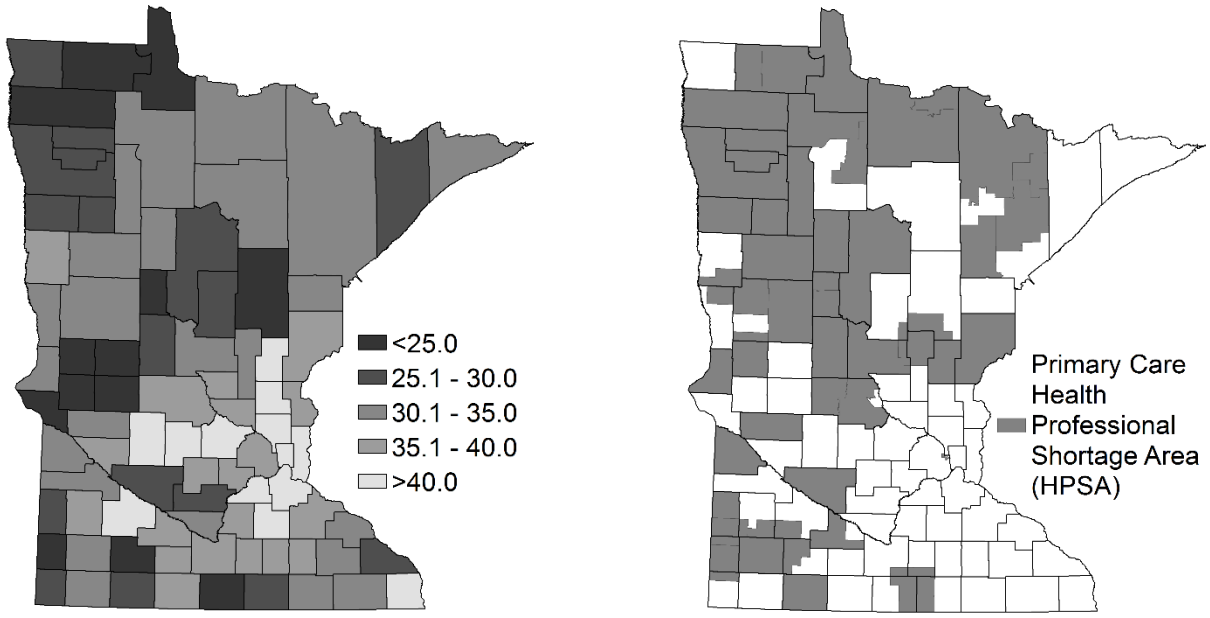
Education

Higher diabetes-related hospitalization rates were also associated with lower rates of educational achievement. In this report, we used the percentage of the adult population who completed less than a bachelor's or 4-year college degree as a marker for educational attainment, shown in map 4. People who have lower levels of education frequently have lower incomes and higher rates of unemployment, which are also associated with higher rates of diabetes.[6,8]

People who have lower levels of education may also have lower levels of health literacy. Health literacy describes how well a person can find, understand and use basic health information.[9] People who have low health literacy may have difficulty reading and understanding food labels to choose healthier food or following directions on how to take medications, which could lead to poor management of diabetes that may ultimately require hospitalization.

Quality of Care and Healthcare Access

Maps 5-6. Selected Quality of Care and Healthcare Access by County



5. Optimal Diabetes Care Rate[10] *6. Primary Care HPSAs*

Data Sources: Minnesota Community Measurement (2010); Health Resources and Services Administration (1978-2014)

Clinically-Measured Diabetes Care Goals

Quality of overall care (from health care providers, community and the person who has diabetes) available to people who have diabetes could also be a contributing factor to diabetes-related hospitalization in Minnesota. We have county-level data from 2010 that shows the

percent of patients who have diabetes who achieve all five of the Optimal Diabetes Care or D5 measures that all patients who have diabetes work to achieve. Ideally, we would have data for all five years, from 2010 through 2014, but this is a good starting point, especially since it lines up with the beginning of the time period that we are studying for hospitalization rates. The D5 goals have been largely the same between 2010 and 2014:

- Hemoglobin A1c less than 8,
- Blood pressure less than 140/90 mmHg,
- LDL-C less than 100 mg/dl (this measure has changed from 2010 to now),
- Taking a daily aspirin as recommended for patients with Ischemic Vascular Disease and
- Being tobacco-free.

Patients who are not meeting the Optimal Diabetes Care goals may have a higher risk for complications, which could lead to hospitalization as shown in a study examining 2009 data.[11] The D5 measure represents the combined work of provider, patient and communities toward achieving the goals for living well with diabetes and reducing complications. Lower rates of reaching the Optimal Diabetes Care goals were associated with higher rates of diabetes-hospitalization among Minnesota counties and were borderline statistically-significant.

Health Care Access

Access to care for people who have diabetes may also contribute to diabetes-related hospitalization rates. Primary Care Health Professional Shortage Areas (HPSAs) are areas where the number of primary care physicians is too few to serve the population in need.[12] Primary Care HPSA regions are presented in map 6. HPSAs may include everyone living in a geographic area where there are too few physicians, or it could reflect a population group within an area that has barriers to seeing primary care doctors.

A Medicaid population that is in an area with few providers who accept Medicaid payment is one example of a population group who has barriers to seeing health care providers. These regions may also have limited availability of additional health resources commonly offered in primary care settings, like Diabetes Self-Management Education/Training (DSME/T) classes. Limited access to primary care health professionals was also associated with higher rates of diabetes hospitalization.

In summary, we observed higher hospitalization rates in counties that had higher poverty rates, higher percentage American Indian population, lower educational attainment, lower achievement of Optimal Diabetes Care goals and areas where there are not enough primary care providers. Further examination of this data, coupled with additional information from the local community, can help to identify potential interventions that could reduce hospitalization rates.

Conclusions

In the last decade, Minnesota has had success in reducing the rate of diabetes-related hospitalizations. However, there are still large differences in rates depending on where people

live within the state. Counties with populations that have higher percentages of American Indians, people who have low-incomes, and those who have lower educational attainment tend to have higher rates of diabetes-related hospitalizations. We also saw higher hospitalization rates in counties where performance on the D5 measures of quality of diabetes care was lower and access to primary care was limited.

Although we saw associations between high rates of diabetes-related hospitalization and various demographic factors, and measures of access to health care and quality of care, it is not possible to say with certainty whether these are the driving forces behind Minnesota's diabetes-related hospitalization rates. It is likely that a combination of these and other factors not explored in this report, such as changes in hospital discharge practices and the size of the population who have diabetes, are influencing differences in rates across the state. Many of the characteristics associated with high hospitalization rates are also associated with each other, like income, race and education.[5]

This information can help us identify the specific areas of the state where diabetes related hospitalizations are higher so that we can focus attention on the communities that need it most. Working with community members, community organizations, local health care providers, local public health, government and business leaders can help us identify possible causes for worse health outcomes and build strategies to address those causes.

Strategies addressing possible causes

These shared strategies can lead to important solutions and improvements in communities in need. These may include:

In health care

- Increasing health care access by addressing provider shortages and related infrastructure problems.
- Expanding use of team-based care, which may include the use of new providers in areas with need. For example, some rural areas have used community paramedics to address previously unmet needs.[13]
- Refining clinically-measured care goals to meet the needs of diverse communities and to better stimulate improvements in care.[14,15]

In communities

- Increasing access to and promotion of DSME/T classes and ongoing support for managing their diabetes.
  - Reducing or eliminating the co-pays for diabetes education
  - Allowing individuals to self-refer into programs
  - Increasing access to culturally-tailored DSME/T classes
  - Using telemedicine or other alternative delivery methods for DSME/T
  - Ensuring reimbursement for new modes of delivery for DSME/T
  - Increasing the number of Living Well with Chronic Disease and Living Well with Diabetes classes that can help to support people with diabetes

- Changing the environments where we live work, and play expands opportunities for active living, healthy eating and tobacco-free living. These changes benefit people who have diabetes and contribute to lowering the risk of developing diabetes among those who do not have it.

Addressing other factors that might relate to increased diabetes-related hospitalizations, including poverty, educational access, food availability, transportation, health care coverage, and high rates of type 2 diabetes development are also critically important to improving diabetes outcomes.[5]

Taking action

Stakeholders all across the state have a role to play in implementing these strategies. It will take the efforts of all to keep these improvements going and, especially, to reduce high hospitalization rates in affected communities. We all need to commit to strategies that will make a difference and that address the many factors that can all influence rates.

For MDH that means continued emphasis on the importance of team-based care in clinic settings, strengthening linkages between clinics and community resources, and promoting tracking of patient outcomes. This needs to occur through the Health Care Home certification and recertification processes as well as many other parts of the Health Department including the Minnesota Statewide Quality Reporting System and our Health Promotion and Chronic Disease Division. In addition, to improve self-care we need to inform patients and providers about the value of DSME/T and community-based support and education groups for people with diabetes and prediabetes. We also continue to build the infrastructure to support referrals and adequate payment, the ingredients needed for program sustainability. To ensure lasting success, the Statewide Health Improvement Partnership promotes policy and system changes that make it easier to eat healthy, to be physically active, and to live tobacco-free. Finally, we will continue to promote policies that ensure broad access to health care coverage, living wages, and other social determinants that can shape the overall health of people living with diseases like diabetes or who may be at risk for developing these conditions.

Appendix 1 –Minnesota Hospitalization Rate Calculations

Hospitalization rates for Minnesota are calculated by MDH using data from multiple sources, but mostly from the Minnesota Hospital Association (MHA).

In general, hospitals located in Minnesota report information on hospitalizations to the Minnesota Hospital Association. In turn, the Minnesota Department of Health gets information from the Minnesota Hospital Association about each hospitalization event; this information does not include patient names. In fact, it includes an ID number for the hospitalization event and not for a particular person. The Minnesota Department of Health combines this with similar information about Minnesota residents who were hospitalized in North Dakota, South Dakota and Iowa, which can be common in many communities near the state line. We do not have mechanisms in place to share data with Wisconsin.

ICD-9 diagnosis codes were used to identify diabetes hospitalizations. These included all codes in the range of 250.00 – 250.93. Primary hospitalizations were determined by looking for one of these codes as the first-listed diagnosis. All-cause hospitalizations were based on diagnoses identified as one of the first seven listed diagnoses.

Rates were adjusted to the 2000 U.S. standard population using four age groups (0–44, 45–64, 65–74, 75+).

Methods for calculating age-adjusted all-cause hospitalizations were consistent with methodology described by the Centers for Disease Control and Prevention (CDC).

Patient residence is available in hospitalization data only at the zip code level. To calculate county-level hospitalization rates, a zip code-based population-weighted attribution method was used. Hospitalizations were calculated at the zip code level and attributed to counties based on the percent of the population of the zip code within each county. For example, if 40% of the population of a zip code resided in County A and 60% resided in County B, then 40% of the total number of diabetes-related hospitalizations from that zip code were attributed to County A and 60% were attributed to County B.

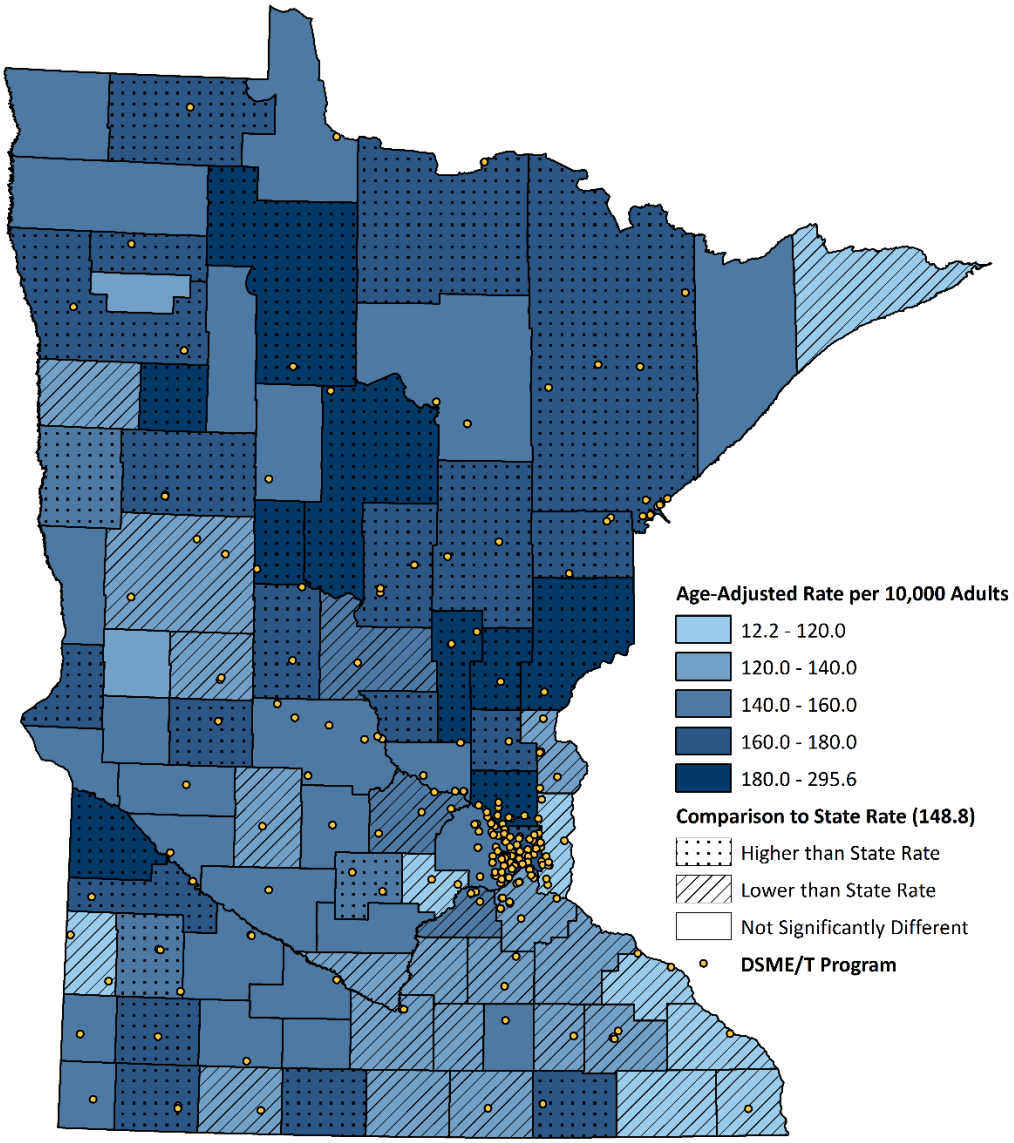
Appendix 2 – Methods for Assessing Correlations between Demographic and Health Care Factors and Hospitalization Rates

Correlation shows how strongly two variables are associated, but cannot determine whether one of these variables caused the other. In this analysis, we looked at county-level variables to assess whether a characteristic of a county was correlated with the hospitalization rate of that county. This kind of analysis is a great first step towards understanding what could be driving differences. The analysis does not use data at the level of the person – for example, looking to see if a person's income level is associated with their likelihood of being hospitalized. It instead looks at rates for groups of people living in a county and matches them with county-level variables. Future work, if the data are available, should look at individual level data and how characteristics of the communities in which people live (like counties) also affect the associations.

The correlation coefficient tells us whether the association is positive or negative. A positive correlation in this analysis means that higher rates of hospitalizations occur among in counties in which the variable we are studying is more common e.g. a higher percentage of American Indians is correlated with higher hospitalization rates). Negative correlations mean that higher rates of hospitalizations occur in counties in which the variable we are studying is less common (e.g. where a smaller percentage of people meet the Optimal Diabetes Care measure, hospitalization rates are higher).

From the correlation coefficient (r), we can calculate the r^2 or the percentage of the variation in the diabetes-related hospitalization rate can be "explained" by the association with the variable that we are studying. We us the word "explained" to mean that the variation tracks with the variable. In truth, there could be a second variable that is also associated with the variable that we are studying and our outcome. It may be that the second variable is really the root cause or that it is linked to other factors that are the root causes. To understand the complex web of relationships, a person needs to look at all of the variables together. We looked at them one at a time and can say that a variable is associated with the outcome, not that it is necessarily a cause of the outcome.

Appendix 3 – Map of Age-Adjusted Rates of Adult Diabetes-Related Hospitalizations per 10,000 Minnesota adults by County, 2010-2014 with statistical-significance



Data Source: Minnesota Hospitalization Data, ***MDH and Minnesota Hospital Association.***

DSME/T Programs as of September 2016.

Appendix 4 – Correlations between Demographic and Health Care Factors and Hospitalization Rates

Factor	Data Source	r^2 or percent variance explained	P-value
% Native-American	American Community Survey	34.8% (+)	<0.01
% Under 200% FPL	American Community Survey	24.9% (+)	<0.01
% Less than Bachelor's Degree	American Community Survey	9.5% (+)	<0.01
Optimal Diabetes Care Rate	Minnesota Community Measurement	4.3% (-)	0.05
Health Profession Shortage Area	Health Resources and Services Administration	10.0 (+)	0.01

Appendix 5 – Interpretation of Correlations between County-Level Data and Hospitalization Rates

The county-level maps presented in this report do not explore all characteristics that may be associated with hospitalization rates, but they do examine key population characteristics and health care resources that may be associated with hospitalization rates based on previous research. To assess population characteristics, we selected a small number of variables available at the county-level from the American Community Survey. The variables selected had to be easy to understand as a county-level summary measure and represent distinct concepts, even if they may be correlated with other variables. To assess health care resources, we chose D5 data, which are a part of tracking health goals as described in the conclusions of the state-level analysis, and data describing areas that have limited access to health care.

There are a couple of things to consider while examining the data. First, these maps look at each characteristic one by one and it is important to note that the characteristics examined may be linked. Second, the data are also summed up at the county level, meaning that the correlation between the county-level poverty rate and the county-level hospitalization rate is what is being assessed; this is not necessarily the same, nor will it give the same answer as looking at individual poverty and individual probability of being hospitalized in a given year. However, in the absence of individual-level data, ecological type analyses like this county-level analysis have been very important tools for making the case for deeper analysis and discovery of root causes of problems in communities. They also can be important in their own right for pointing out the contribution of community factors to health and lead to the development of models that assess individual-level and community-level factors contributing to adverse health events.

In this report, correlations between each county-level characteristic and county-level hospitalization rates are presented. By examining the patterns and addressing populations with characteristics associated with higher hospitalization rates, we may be able to reduce hospitalizations in the counties with the highest hospitalization rates and continue the statewide downward trend.

[1] Centers for Disease Control and Prevention. Diabetes Atlas. http://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html

[2] Geiss, LS. Et al. "Prevalence and incidence trends for diagnosed diabetes among adults aged 20 to 79 years, United States, 1980-2012." *JAMA.* 312(12):1218-26.

[3] "Economic Costs of Diabetes in the U.S. in 2012". American Diabetes Association. 2013 http://care.diabetesjournals.org/content/diacare/early/2013/03/05/dc12-2625.full.pdf

[4] Gregg, EW. Et al. "Changes in Diabetes-Related Complications in the United States, 1990-2010". *New England Journal of Medicine.* 370(16):1514-23.

[5] Gregg, EW. Et al. "The Changing Face of Diabetes Complications. *Lancet Diabetes Endocrinology.* 4:537-47.

[6] Centers for Disease Control and Prevention. National Diabetes Statistics Report, 2017. Atlanta, GA: Centers for Disease Control and Prevention, U.S. Dept of Health and Human Services; 2017. https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf

[7] "Income, Employment and Diabetes in Minnesota". Minnesota Department of Health, Diabetes Unit. 2016. http://www.health.state.mn.us/divs/healthimprovement/content/documents/DiabetesIncome_2016_03_08.pdf

[8] Earnings and Unemployment Rates by Educational Attainment, 2015. Bureau of Labor Statistics. http://www.bls.gov/emp/ep_chart_001.htm

[9] For a more formal definition of Health Literacy, please see the Quick Guide to Health literacy at: https://health.gov/communication/literacy/quickguide/factsbasic.htm

[10] County-Level Optimal Diabetes Care Rates for 2010. From the Minnesota Health Atlas Project, Decade of Discovery, Mayo Clinic based on Analyses from Minnesota Community Measurement.

[11] Takahashi et al. Health Outcomes in Diabetics Measured with Minnesota Community Measurement Quality Metrics. *Diabetes Metab Syndr Obes.*2014. 8:1-8.

[12] Health Resources and Services Administration. Shortage Designation: Health Professional Shortage Areas & Medically Underserved Areas/Populations. https://bhw.hrsa.gov/shortage-designation

[13] Helseth, C. Community Paramedics Widen Medical Services in Rural Areas, 2010. The Rural Monitor. The Rural Health Information Hub. https://www.ruralhealthinfo.org/rural-monitor/paramedics-widen-medical-services/

[14] Performance Measurement for Rural Low-Volume Providers: Environmental Scan and Analysis. National Quality Forum. Jan 15, 2015. www.qualityforum.org/Projects/n-r/**Rural_Health**/Environmental_Scan.aspx

[15] "State-Based Risk Adjustment System Assessment and Feasibility Study." Minnesota Department of Health, Health Economics Program. 2016. http://www.health.state.mn.us/divs/hpsc/hep/publications/legislative/raLegislativeRpt2016.pdf