Adherence to Diabetes Treatments in Rural and Urban Areas

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**Introduction:**

People in rural areas face barriers related to access to health care services and often have worse health outcomes (CDC, 2017). While only 15% of residents in the United States live in areas designated as rural, approximately 34% of Nebraska residents live in rural areas (RHIH, 2021). Additionally, based on the Rural-Urban Commuting Area Codes (RUCA) from the USDA Economic Research Service, over half of the Zip codes in Nebraska correspond with Rural Areas (298) or Small Towns (54). The remaining 230 Zip codes are divided between Micropolitan Areas (78), and Metropolitan Areas (152) (ERS, 2021). As a result, Nebraska has large numbers of people living in areas with low population densities that have the potential for people to have to drive long distances to access health care.

Distance from a clinic or hospital, lack of specialized care in the area, and demographic factors can make getting the right care difficult at times. Of adults seeking care, 21% experience a non-financial barrier, more than experienced financial burdens alone (18.5%). Multiple barriers were no uncommon either, two thirds of patients with financial barriers also experienced financial burdens as well (Kullgren, at al. 2012). According to data from the Health Resources and Service Administration (HRSA, 2021), there are 605 physician FTEs (full time equivalent) to cover rural Nebraska. Taking out the largest rural provider drops the total to 399 for the remaining rural areas. While the ratio of doctors to population in rural and urban areas is similar, 1,239 people/doctor and 1,390 people/doctor respectively, rural areas suffer in terms of physician density. Urban areas have 0.169 doctors per square mile, while rural areas only have .009 doctors per square mile. Certain counties are better off than others and there are certain areas within counties that are also better off. There can be different results when separating the population by zip code and classifying urban centers and small towns or by classifying counties as a whole with HRSA data.

Diabetes impacts more than 34 million Americans and 170,000 Nebraskans (CDC, 2020). More people than this are also diagnosed with prediabetes, a condition that if left unchecked can develop into diabetes. The main characteristic of prediabetes is that the blood sugar is elevated, as it is in diabetes, but not to the same degree. Proper management of diabetes, and prediabetes is an integral part of ensuring positive outcomes for a population. Diabetes care is estimated to cost 2.3 times as much as care for patients without diabetes (ADA, 2016). In addition to the financial benefits, proper treatment and management of diabetes could save hundreds of lives in Nebraska. When compared to all causes of death in Nebraska, diabetes was 7th in 2017 with 575 total deaths. This resulted in a death rate of 29.9 per 100,000 people, which placed Nebraska at 10th in the nation for deaths from diabetes. In a study by Curtis, et al., patients with increased adherence to glucose lowering agents, defined as the percentage of days with 80% coverage or higher, spent less time in the hospital, less time in the emergency room, and spent less on acute care and outpatient costs (Curtis, et al, 2017).

**Literature Review:**

The standard of care that diabetes treatment is measured against is the Healthcare Effectiveness Data and Information Set, of HEDIS (CMS, 2021). HEDIS sets the national set of standards for care designed to help both patients and payers understand what is required for certain diseases. The standard of care for diabetes in 2021 includes an HbA1c test and a retinal exam every year (BCBS Illinois, 2021). While certain scenarios may require more rigorous intervention, this represents the minimum standard that should be administered.

Rural and urban areas have different demographics and these factors and differences in availability of resources results can result in different opportunities (Arbuckle, et al, 2018). In a meeting with the Care Management team at Blue Cross/Blue Shield of Nebraska, diabetes care has been of increasing priority when it comes to improving outcomes (BCBSNE, 2021). There are mobile physicians that rotate through rural areas to ensure proper coverage of the populations that don’t always have access to more specialized services. While there are primary care physicians, these areas sometimes lack the specialists that urban areas have. Rather than a rural/urban split in adherence rates and outcomes, it is more likely that differences are split between education and demographics. These characteristics may be split between rural and urban areas, but they would only be coincidental at that point, rather than causal.

Adherence, at least when it comes to medication, is considered one of the most modifiable factors that can influence outcomes (Arbuckle, et al, 2018). While rural, urban, and suburban classifications may not directly influence medication adherence, other factors that are clustered differently in rural, urban, and suburban areas may have an impact (Arbuckle, et al, 2018). Arbuckle et al. measured adherence using the Morisky Medication Adherence Scale (MMAS-8) and grouped patients using RUCA codes. Scores on the MMAS-8 scale can range from zero to eight and patients scoring six or below were labeled ‘low adherers’, patients scoring six to eight as ‘medium adherers,’ and those that scored eight were ‘high adherers.’ There was not a statistically significant different between rural, urban, and suburban populations in terms of adherence. Each population wasn’t necessarily identical to the others, however, and each population was balanced by different combinations of age, sex, income, and other factors. Women and older patients generally had higher adherence and rural populations generally had higher concentrations of women and older patients, rural areas generally had lower incomes, which negatively impacted adherence.

In addition to adherence fluctuating based on different demographic factors, adherence can fluctuate within a population with a single disease as well. In a systematic review conducted between January 2004 and July 2013, the authors found that there was a wide range in levels of adherence to treatment for Type 2 diabetes care (Krass, 2014). The worst adherence rate they observed was 38.5% and the highest was 93.1%. Since there were a variety of studies, there wasn’t one consistent method of measuring adherence, only rates to compare. Of the 27 studies they reviewed, only six of them reached more than 80% adherence. Adherence was defined internal to each study and the measures they used for adherence had to be verifiable to reduce any bias from self-reporting. They were able to find that depression and medication costs were two main factors in reducing adherence in the populations that had lower adherence rates. While there can be other factors involved that can contribute to the inability to pay and rates of depression, these are both starting points for interventions to increase adherence.

A patient’s culture and personal beliefs that can impact adherence as well (Shahin, 2019). The main focus of a systemic review from Shahin, et al. was on the adherence to diabetes treatments and hypertension, although some of the studies focused on other chronic conditions like COPD and asthma. This review began with patients who had already been diagnosed with a disease, therefore problems with adherence would stem from perceptions, beliefs, and behaviors for the patients, rather than access to care itself.

There are five main tenets of personal beliefs about diseases: identity, timeline, consequences, control, and causes (Shahin, et al, 2019). Identity refers to how patients feel about the label of the disease and the changes necessary for improvement and treatment. Timeline refers to how long patients think the disease and subsequent recovery will last. Consequences refer to how severe patients believe the disease will be and how much it will impact their lives. Control is how much a patient feels that the disease can be cured or managed. Causes refers to the patient’s perceptions of how they got the disease. Any one of these factors can lead to someone not adhering to a treatment plan. Patients ultimately wanted to feel like they had control over their disease and could have a positive impact on their health through their actions.

In addition to the personal beliefs that patients had about their diseases, cultural and behavioral differences also played a role in adherence (Shahin, et al., 2019). Acculturation, or the change to behaviors from the continuous contact of two distinct cultures, was shown to have a positive impact on outcomes. In cases where acculturation did not occur, patients were more likely to rely on existing cultural or religious cures. Health literacy was also found to be an important factor in adherence, either directly or indirectly. With high levels of health literacy, patients understood their disease and the medication plan they were on, which increased adherence. Despite this, there was still a negative relationship between threatening illness perceptions and adherence. This effect was more severe at lower levels of medical literacy. This chart put together by Shahin, et al (2019). describes the interaction between the different factors and their relation to each other and adherence.

Diagram

Description automatically generated

Between all the different factors that play into adherence, they can be split into two categories, modifiable and unmodifiable. Unmodifiable factors are things like age and ethnicity. Patient perceptions about themselves or the disease, beliefs about the medications and treatments, and personal and cultural beliefs are all modifiable, if the patient is willing. Communication and education are important factors in patients being able adjust their behaviors and increase adherence. Education can apply to the patients themselves, learning about the disease, treatment options, and the benefits to adherence, or the physicians, to gain a better understanding of reasons patients deviate from the recommended treatment and the cultural and personal reasons for their decisions. Since there won’t be a one-size-fits-all solution, both physicians and patients will need to make changes in order to improve outcomes.

**Research question:**

Do diabetes patients in rural areas meet yearly physician and vision appointment guidelines at the same rates as urban patients?

**Data:**

The data are from Blue Cross/Blue Shield of Nebraska. Diabetes patients are identified from members with a diagnosis code of ‘diabetes’ and not equal to ‘prediabetes’, ‘pre diabetes’, or ‘pre-diabetes’ between 2014 and 2019 inclusive. Patients are excluded if they are less than 21 years old at the time of diagnosis to make sure they have full autonomy throughout their treatment. Patients older than 75 by the end of the period will also be excluded as the CDC guideline is only designed to apply to patients between the ages of 18 and 75. Any member that terminates their contract with Blue Cross/Blue Shield during the observation period for any reason is also excluded. Members can terminate their contract for a variety of reasons including life events like marriage, birth of a child, and death, or changing jobs. This population was then compared to member tables, prescription tables, claims tables to build a dataset of members with a diabetes diagnosis and subsequent follow-up appointments in line with what someone with diabetes might make. In order to broaden the scope of what counts as a follow-up, appointments were included for a variety of symptoms for which diabetes is often a comorbidity. The intent of including symptoms beyond just normal checkups is to capture a more realistic look at what life with diabetes is like beyond just yearly blood tests. The additional diagnoses included were any type of diagnosis for joint pain, gout, and arthritis since diabetes can impact the musculoskeletal system (ADA, 2001). These correspond to ICD Codes M05 through M25. Any diagnosis code text for ‘nephropathy’ was also included. Comorbidity diagnoses were only relevant following a diagnosis of diabetes to measure follow-up appointments. Vision claims are measured in a similar way, with the ICD-10 Codes being limited to everything that starts with ‘H’ and excludes the word ‘ear’.

Each member was anonymized with member ID’s to protect the member identity and the analysis was done on data aggregated to zip code or county levels to make sure no personally identifiable information or protected health information is accessible in any way.

A person’s diagnosis date is represented by their first claim with a diagnosis of diabetes in the dataset. That established them as part of the population and everything after that is counted as a treatment. Follow-up tests following the diagnosis are counted against the standard of care. Each patient will also have their zip code included to be able to aggregate the data when it comes to that stage.

Location data to map the individuals in the population came from the USDA Rural-Urban Commuting Area (RUCA) codes to designate the area someone lives in as metropolitan, micropolitan, small town, or rural as well as where people in that location commute. County level classifications are also included based on the data from the Health Resources and Services Administration which classifies entire counties as rural or urban. Zip code and county level mapping was included to aid in understanding the data. Based on the articles from Shahin, et al. and Arbuckle, et al., demographics can differ within populations. In addition to understanding if there is a difference in rural and urban adherence, finding outliers within those two groups and understanding what makes them outliers can help to guide future discussions on adherence.

**Method:**

Once the population was narrowed down to the appropriate population, they were compared to the standard of care. Each individual was be measured to the degree in which they adhere to the standard of care over the observation period. Each period was measured on its own to not allow for double counting in one period to make up for skipping another.

Each individual patient had a base record with their diagnosis date and the subsequent appointments for both follow-ups and vision appointments are put into separate tables. Each year following a diagnosis was recorded as an opportunity for a follow-up, labeled as a ‘maintenance opportunity.’ Each year with a follow-up appointment successfully made, any year with a record using the selected diagnosis codes, was recorded as a ‘treatment visit.’ Without knowing what actually went on in each visit, it’s impossible to know if diabetes was discussed at all or not, however, given that these visits take place post diagnosis and there are many comorbidities, it is something that the physician should be attending to as a maintenance activity. Separate counts were created for vision and medical follow-ups with separate analyses for one appointment per year and two appointments per year since there are different recommendations for different types of diabetes. No distinction was made for types of diabetes in terms of measuring their adherence.

Each patient’s adherence was calculated from the equation below in three forms, one appointment per year, two appointments per year, and vision only.

[Years with appointment(s) post diagnosis/Total Years post diagnosis] = Adherence

With each patient’s adherence calculated, it was summarized by zip code and RUCA code level using the RUCA database. RUCA codes summarize to 11 levels, one through ten and 99. In order to separate the rural and urban areas, all patients with a zip code corresponding to a seven or higher (7, 8, 9, 10, 99) were labeled as rural. Patients with Zip codes one through six were labeled urban. While this isn’t an exact measure, it does account for urban centers being relatively close to rural areas and providing health services compared to a rural area without a larger urban area nearby.

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| 1  Metropolitan area core: primary flow within an urbanized area (UA) |
| 2   Metropolitan area high commuting: primary flow 30% or more to a UA |
| 3  Metropolitan area low commuting: primary flow 10% to 30% to a UA |
| 4 Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC) |
| 5 Micropolitan high commuting: primary flow 30% or more to a large UC |
| 6 Micropolitan low commuting: primary flow 10% to 30% to a large UC |
| 7 Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC) |
| 8 Small town high commuting: primary flow 30% or more to a small UC |
| 9 Small town low commuting: primary flow 10% to 30% to a small UC |
| 10  Rural areas: primary flow to a tract outside a UA or UC |
| 99 Not coded: Census tract has zero population and no rural-urban identifier information |

After grouping patients into the two groups with their average adherence rates, a t-test using R was used to determine if the difference between the two rates was statistically significant.

**Results:**

When held to a standard of one visit per year, rural residents had an adherence of 75.63%, meaning that over the time period of 2014-2019, rural residents had an appointment with a physician following a diagnosis of diabetes for every one year post diagnosis 75.63% of the time. Urban residents met the same criteria at a rate of 76.46%. The difference between these two was statistically significant at the level of 95% [.0044, .0122]. There were 33,486 patients in the rural group that met all criteria to be included in the population and 119,564 patients in the urban group.

If patients were held to the standard of two appointments per year the adherence rates dropped for both groups. The rural group dropped to 64.14% and the urban group dropped to 67.51%. The results of the t-test to determine if the difference was statistically significant was similar, with the 95% confidence interval resulting in [.0294, .0381].

The vision groups had much lower rates of adherence than either physician visit group, but still had a significant difference. The rural adherence was 10.98% and the urban adherence was 11.58%. The 95% confidence interval for the difference in vision adherence rates was [.0033, .0086].

**Limitations:**

Since the only data I have collected for the analysis is from Blue Cross/Blue Shield of Nebraska, it limits the scope of this study. Blue Cross/Blue Shield covers over 700,000 people in Nebraska. That accounts for less than half of the total insured population of Nebraska, 1.9 million people with 178,000 uninsured (Enroll Nebraska, 2019). My dataset represents only a subset of the collection of people in the state with insurance. When filtering for diabetes patients, the only people I am including to measure adherence are people diagnosed within a small timespan. For a chronic illness like diabetes, this is a relatively short time to be living with the disease. These people may have different adherence rates than people who have more experience managing a disease, either higher due to it being new and they feel like they have more control, or lower due to less experience with their treatment plans.

Similarly, the only people that would have diabetes records in this database are people that have had physician appointments of some sort and been diagnosed with the disease. Any follow up treatments would also have to be run through some sort of health care facility and billed through insurance to show up in my data. Any preventative behavioral measures such as diet and exercise would not show up at all, even though for less severe forms of diabetes they can be effective treatment options. It also depends on the doctor deciding what the treatment plan is for each individual. While monitoring activities like regular blood tests should still take place, it is ultimately up to the doctor and the patient to decide what is best given the circumstances. Any new things that can’t be coded as a test, treatment, or prescription won’t be identified. Preventative measures like exercise and diet, which fall more under prevention than treatment, may reduce how much insulin someone needs or how often they get an A1C test, which could cause them to look non-compliant when they are really just managing their treatment.

Another limitation is that rural can be defined in a number of different ways. Different government agencies have different criteria for defining rural areas. There are zip codes that are classified at ‘rural’ in the USDA RUCA database, but are located in Urban counties. Certain areas can be considered Rural for Nebraska, and may be rural, but are located near another city across state lines that would ordinarily change its classification. Since people routinely cross zip code and county lines to receive health care there are some limitations around how certain areas are classified. It isn’t possible to know the exact circumstances of each individual and their distance from each treatment in each case to really understand what kind of access to care they have.

Including the year of 2020 in the dataset would have also posed a challenge due to COVID-19. Any changes in behavior and treatments for the year may have showed up in the data and make certain areas or populations appear less compliant than they otherwise would have been. For this reason, 2020 and 2021 were excluded. While Covid-19 started in 2019, its affects were not being felt around the United States enough to impact behavior to a significant degree in the final week of the year.

For the vision component, Blue Cross/Blue Shield of Nebraska does not record all vision claims that members might have. While Blue Cross has records for vision diagnosis for members, these aren’t necessarily indicative of every visit to an eye care provider. Comparing the vision adherence to the medical adherence rates would not be a fair comparison as there are other vision insurance companies that a patient with diabetes records could have, either through their employer or otherwise. Comparing rural to urban within vision would be ok as long as there isn’t a cultural or behavioral difference between rural and urban residents in the kind of insurance they have for vision care.

**Discussion:**

While the differences between rural and urban adherence rates statewide only amounted to small but significant differences, there is still evidence of rural residents getting less care than urban residents in terms of vision care and medical care. Rural counties had a much greater range of adherence rates than urban counties. Using the same cutoff of seven on the RUCA codes, patients grouped into counties with an average of their RUCA codes by patients resulted in 69 predominantly rural counties or areas and 25 predominantly urban counties. The rural counties had a maximum adherence of 100%, achieved by several counties with a very small patient population. Excluding those, there were still several counties that managed to achieve adherence rates at or above the state average. The lowest rate was 11%, achieved by a county with seven recorded patients in the records. The primarily urban counties had a range of 58% to 78%. A line of best fit set to a scatter plot of county populations and adherence rates shows a slight positive relationship between population and adherence after removing the four most populous counties as outliers.

Population itself isn’t enough to be predictor of adherence, but the variability of the adherence rates in rural counties is something that could use future interventions. The worst performing 26 counties for adherence were all rural. While a single intervention or strategy may not be a cost-effective option for all patients or providers, awareness of the disparities between them and the rest of the state could be the first step in improving adherence.

**Conclusion:**

There isn’t enough evidence here to say that there is a dramatic lack of care in rural areas or that urban residents are able to get substantially better care than rural residents more often. Comparing the entire state of Nebraska in two categories was too simplistic and groups a lot of different parts of the state together, despite differences. New interventions in diabetes in Nebraska should be targeted to the areas that need them, whether by county or by city. By looking at counties or regions, interventions can be tailored to what is specifically needed rather than one option for opposite corners of the state both happen to be rural. As none of the worst performing locations are large populations centers, any solutions wouldn’t have the benefit of economies of scale to help their cost effectiveness, as it would in larger cities. Smaller interventions lead at the provider or county public health level may be more helpful and cost effective than a large, state-lead effort.

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