12-2023

Geospatial Distribution of Pharmacist Diabetes Management within a Patient Centered Medical Home Model in Omaha, Nebraska

Anthony Donovan
University of Nebraska Medical Center

Geospatial Distribution of Pharmacist Diabetes Management within a Patient Centered Medical Home Model in Omaha, Nebraska

Anthony Donovan, PharmD

University of Nebraska Medical Center College of Public Heath

Master of Public Health - Epidemiology Concentration

Committee Members:

Chair – Nicole Kolm-Valdivia

Members – Edward Peters, Kaitlyn Crosby

Abstract

Patients with uncontrolled diabetes, defined as a hemoglobin A1c value greater than 9%, are at an increased risk of diabetes progression. Primary care is often the first point of contact where patients with uncontrolled diabetes are identified and treated. Pharmacists are utilized in diabetes medication management of patients with uncontrolled diabetes as one component of primary care multidisciplinary models of care. This descriptive project describes the geospatial distribution of patients with uncontrolled diabetes from a single institution in the Omaha, Nebraska area who were exposed to pharmacists within a Patient Centered Medical Home (PCMH) model of care compared to those who were not. The data source included an automated electronic health record query of patients with hemoglobin A1c laboratory values greater than 9% between 2017 and 2021. The primary findings of this project were mapped using ArcGIS by zip code to show the proportion of patients with pharmacist involvement over the total number of identified patients with uncontrolled diabetes. Descriptive statistics to describe the patient characteristics is also presented as well as a log-binominal model predicting the outcome of the exposure to a PCMH pharmacist. Patient exposed to a PCMH pharmacist were statistically younger on index date (mean age 55.4 vs 57.1, p-value <0.001), had a higher proportion of female sex (54.0% vs 48.3%, p-value <0.001), had a higher proportion of Black or African American race (30.2% vs 19.1%, p-value <0.001), and had a lower proportion of no diabetes medications in the baseline period (11.1% vs 14.0%, p-value 0.008). The crude proportion of patients with uncontrolled diabetes who saw a pharmacist was 26.1% from the single institution in Omaha, Nebraska. North, northeast, and southeast Omaha had relatively numerically higher proportions of patients who were exposed to a PCMH pharmacist while areas with numerically lower proportions of patients were distributed around south Omaha and western Omaha.

Chapter 1 – Introduction

Uncontrolled diabetes is a significant public health concern due to the contributions of highly elevated blood sugars to negative health outcomes. Addressing uncontrolled diabetes at the individual patient-level decreases risk of disease progression and downstream complications. Additionally, at the population-level, however, health systems and independent provider groups are further motivated to have robust programs to address uncontrolled diabetes due to quality-of-care targets and value-based arrangements with payers and other managed care entities. Given the individual and population impact of addressing uncontrolled diabetes, innovative services and models of care have been implemented, including accountable care organizations (ACO)[1] and value-based care (VBC)[2] for example. One such model is the utilization of ambulatory care pharmacists on multidisciplinary team models of care.

Ambulatory care pharmacists are pharmacists who perform patient care other than dispensing of medications through a variety of services in outpatient settings.[3] Ambulatory care pharmacists at Nebraska Medicine are valuable care team members that routinely provide medication management services, including diabetes medication management. Patients often become involved with ambulatory care pharmacists at Nebraska Medicine due to uncontrolled diabetes who persistently do not meet their therapeutic goals. As such, ambulatory care pharmacists have been utilized to improve individual patient outcomes related to uncontrolled diabetes at Nebraska Medicine. At the population level, however, there is little data known presenting the magnitude of and where these patients who are treated by pharmacists within Omaha, Nebraska.

The aim of this project is to describe the geospatial distribution by zip codes of patients with uncontrolled diabetes who are exposed to ambulatory care pharmacists at Nebraska Medicine in Omaha, Nebraska. The results of this project may justify the current program's layout or help guide institutional decision makers to reallocate resources that would address unmet needs in the community. The opportunity for additional services provided to those at risk of complications from uncontrolled

diabetes may lead to better quality of care at Nebraska Medicine and a more efficient use of resources. The results of this project may also contribute to a body of knowledge justifying the use of ambulatory care pharmacists as team members on public health and population health management initiatives that utilize geospatial analyses for health services delivery and research.

Chapter 2 – Background and Literature Review

Diabetes mellitus is a chronic condition characterized by elevated blood glucose caused by various pathophysiology.[4] The crude adult prevalence of diagnosed diabetes in the United States in 2021 was 14.7%[5] while in the Omaha, Nebraska metro area in 2021, 12.4% of adults reported having diabetes.[6] Diabetes-related complications impact nearly all organ systems and commonly include microvascular complications, such as neuropathy and retinopathy, and macrovascular complications such as atherosclerotic cardiovascular disease (ASCVD) and the many subsequent complications from ASCVD such as heart attacks and strokes, among others.[4] The progression of diabetes is insidious and often patients do not present with symptoms until extensive disease is present. While blood glucose monitoring is often used for screening, the clinical biomarker that is most used to diagnose and quantify the extent of elevated blood sugars before or during treatment is percent hemoglobin A1c (hA1c).

Results of hA1c testing represent the average amount of blood glucose exposure to proteins located on red blood cells over the prior three months based on the turnover half-life of red blood cells. Values below 5.7 are considered normal blood glucose status where 5.7 to 6.5 is defined as prediabetes. hA1c results greater than 6.5 are used to diagnose diabetes and excessively increased hA1c values are a risk factor for worse diabetes complications and outcomes over time.[7] Patients with uncontrolled diabetes are defined as having hA1c values greater than 9%.

This cutoff is not arbitrarily chosen by clinical guidelines or decisions makers, however. Intensive treatment, defined as treating patients to an hA1c goal of less 7%, has been shown in landmark trials to significantly prevent progression of diabetes complications compared to less intensive treatment with higher HA1c goals, although at the expense of higher adverse events such as low blood sugars which can be dangerous.[8] Consequently, the extent and duration of elevated hA1c is associated with diabetes complications and mortality as well. Laiteerapong et al. demonstrated a legacy effect of time of

treatment initiation being associated with less diabetes complications and mortality. Additionally, the risk of diabetes complications and mortality increased with higher mean hA1c values when comparing mean hA1c values >8% compared to <6.5%.[9] The treatment paradigm for diabetes management thus targets the prompt identification of elevated blood glucose leading to patient-specific treatments to immediately result in the lowering of hA1c in combination with patient-specific safety factors such as preventing low blood sugars. Diabetes management is multimodal, requiring patients to change behaviors such as diet, exercise, but pharmacologic therapy can be extensive with highly elevated blood sugars.[10,11]

Based on the guideline directed paradigm, improving identification and reduction of highly elevated hA1c is also utilized by payers and value-based arrangements through quality and health system performance metrics. For example, the National Committee for Quality Assurance (NCQA) lists several diabetes related Healthcare Effectiveness Data and Information Set (HEDIS) measures.[12] This includes Glycemic Status Assessment for Patients with Diabetes, where patients will fail the measure if their most recent hA1c is greater than 9% or if the hA1c was not performed when indicated.[12] Thus beyond individual patient outcomes, population health management is an important component of health system strategies. Consequentially, failing these measures also leads to negative impacts on reimbursement from payers and losing shared saving from risk-sharing contracts.[13] Additionally, addressing social determinants of health (SDOH) and other non-clinical factors that contribute to patient risk is becoming relevant for how different quality measures and value-based arrangements are evaluated.[14] These non-clinical factors may include information related to location information, where patients live, work, and play.[15] With health systems and other independent provider groups being motivated by individual patient outcomes, population health management, and risky value-based arrangements, innovative health care delivery models have been implemented and expanded upon.

One such model of care is the Patient Centered Medical Home (PCMH) that is defined, and participating programs are accredited, by the NCQA.[16] The primary features of the PCMH model are multidisciplinary care where patients are empowered to promote healthier lives due to connectedness and seamless patient centered health care delivery. With a primary care physician as the hub, PCMH models of care utilize other providers and non-providers to deliver patient care without patients having to seek care outside of their medical home.[16] Institutions that utilize PCMH models are ubiquitous in today's delivery of healthcare anywhere preventative primary care and chronic disease management is emphasized. Benefits in health outcomes have been demonstrated within PCMH models but these results are heterogenous by components offered and contributions to outcomes[17] while also showing an increased cost in the delivery of care.[18] While the PCMH model of care is likely to continue to be supported, components within the PCMH model of care should continue to be evaluated and improved upon, such as the composition of care team members and the most effective scope of each care team member's responsibilities.

As the medication experts, ambulatory care pharmacists offer unique skillsets within PCMH models to assist providers and other multidisciplinary team members. In addition to assistance, ambulatory care pharmacists can have aspects of medication management related services delegated from other care team members to promote more effective teams, potentially opening provider time to higher acuity needs. Inclusion of ambulatory care pharmacists is often well accepted by team members,[19] and positive short term patient health outcomes have been reported.[20] Comprehensive evaluation of pharmacist-led disease state management is a broad topic with often heterogenous and mixed results when it comes to cost effectiveness and long term outcomes, however.[21] Focusing on ambulatory care pharmacist management of patients with diabetes, literature is supportive of effective medication management leading to positive health outcomes[22,23], value-based care metrics,[24] and

guideline recommended prescribing[25] but similarly, robustly demonstrating long term and cost effectiveness outcomes are desirable.

Within the ambulatory care pharmacist program at Nebraska Medicine, similar findings have been demonstrated from internal reporting but also from academic research. One study demonstrated statistically significant improvement of composite and individual quality metrics related to diabetes care when patients had a pharmacist on their care team compared to usual care within the Nebraska Medicine PCMH clinic patient population.[26] Another study demonstrated significant improvement of guideline concordant prescribing of diabetes medications that are recommended for patients with diabetes and ASCVD who saw a pharmacist compared to usual care.[27] From a manuscript currently being submitted, a study evaluating patients with diabetes and chronic kidney disease (CKD) also demonstrated a statistically significant improvement in the prescribing of diabetes medication with CKD benefits in patients who saw an ambulatory care pharmacist compared to usual care. Altogether these academic studies have focused on population level results, evaluations exploring epidemiological factors at the patient, clinic, or geospatial level have not been pursued. Thus, information describing who ambulatory care pharmacists are seeing and where the patients are located may provide insights into opportunities at Nebraska Medicine and within the Omaha, Nebraska community. One approach to address this information is the use of geographic information systems.

Using geographic information systems (GIS) to evaluate pharmacy health services is encountered in the literature, however, there are notable gaps in the literature among different types of pharmacy related variables and outcomes evaluated using GIS. In a scoping review by Dias Fernandes et al, many pharmacy-related GIS publications evaluated availability of medicines or community pharmacy settings as well as the relative availability of pharmacies by area and patient factors.[28] In contrast, this project used GIS to evaluate ambulatory care pharmacist services, where pharmacists completely operate

outside of a dispensing role. To my knowledge, there are no published materials on ambulatory care pharmacist services managing diabetes and an analysis of geospatial distributions within a community.

Following the specific aim of this project, other descriptive studies have used geospatial findings to support decision making. Past literature evaluating "pharmacy deserts" use the absence of dispensing community pharmacies in given areas and patient socioeconomic related factors,[29] to guide resources and inform community stakeholders and policy makers. An intervention to shift resources, in contrast, to address geographic-based needs can be exemplified by Dodson et al. where high prevalence areas of opioid overdoses were overlaid and mapped to locations of pharmacies where availability of naloxone could be made more accessible.[30] Relevant to an ambulatory pharmacist chronic disease management, in a population based spatial analysis, the proportion of avoidable emergency department visits that could have alternatively been managed by a pharmacist for ambulatory disease states, such as diabetes, were visualized and quintiles of rates of avoidable emergency department visits were compared to quintiles of median family income to compare utilization and where resources could be equitably utilized.[31]

Thus, a geospatial analysis of patients with uncontrolled diabetes at the Nebraska Medicine primary care PCMH clinics being managed by pharmacists in the Omaha, Nebraska community is warranted. Results of this study can be used to solidify or improve current pharmacist management services using geospatial information to guide decision making and planning of health care resources through the PCMH model of care.

Program Description

Each of the primary care clinic locations were accredited by NCQA as PCMH sites during the study period. Accreditation is based on multiple components and services offered that meet the mission of PCMH model of care.[12] One of which includes multidisciplinary care teams. The PCMH model at

Nebraska Medicine program is led by family medicine and internal medicine physicians and residents with behavioral health practitioners, dieticians, social worker, and pharmacists collaborating on patient care activities.

Each of the PCMH pharmacists practice ambulatory care pharmaceutical care services and have sufficient training represented by board certification, residency training, or other forms of equivalent experience. At Nebraska Medicine, pharmacists within the PCMH model utilize a collaborative practice agreement (CPA) where all the providers within the model agree on the types and scope of services the pharmacists may provide. The CPA was developed by Nebraska Medicine leadership between the pharmacist and provider groups and is regulated by the Nebraska Board of Pharmacy. Regulation requires updated CPA to be drafted, agreed, and signed upon by all parties and sent to the Board of Pharmacy every two years.[32,33]

Patients fall under CPA scope and may begin to receive PCMH pharmacist medication management services based on two major conditions: 1) the referral of the patient to pharmacist services, or 2) population health initiatives being performed at Nebraska Medicine. The scope of this project will only be discussing the former, but examples of population health initiatives include identification and patient outreach for prescribing of statin medications, medication adherence outreach, and other value-based arrangements of interest to the organization. Population health initiatives are not applicable to the project herein.

The size of the PCMH pharmacist group has grown, where in 2017 there were approximately six pharmacists shared between all clinic locations and affiliated College of Pharmacy faculty appointments. In 2023, presently the PCMH pharmacist program includes fourteen pharmacists, one post graduate year two ambulatory care resident, one pharmacist supervisor, and two program coordinators, management responsibilities, student pharmacist precepting, and College of Pharmacy faculty activities. All PCMH

clinics at Nebraska Medicine staff PCMH pharmacists, however most clinics do not have access to a PCMH pharmacist at clinic on all days of the work week. PCMH pharmacists are however reachable via online communications all throughout the week, where individual pharmacists take ownership of patients and workflow at their assigned clinics. PCMH clinics with dedicated pharmacists with 1 FTE per week are nearest to main campus but most PCMH clinics are often split between single pharmacists.

Patients can be referred to PCMH pharmacist diabetes management services at any time and for many reasons, most commonly however, patients will be referred after ineffective treatment or follow up, clinical inertia, more frequent contact with a medical professional is necessary, or extension education or monitoring requirements for patient safety. In patients with uncontrolled diabetes, the previous reasons are often in combination with hemoglobin hA1c values >9% persistence and challenges getting patterns to their therapeutic goals. Upon referral for diabetes medication management services by PCMH pharmacists, an electronic health record (EHR) tracking tool called episodes, is used to track longitudinal pharmacist management. Each encounter with a PCMH pharmacist is linked to a unique episode identification number and the discrete data elements that are related to PCMH pharmacist services can be reported easily. This is the source of the exposure of interest in this study.

Geographic Locality

Nebraska Medicine is an academic medical center located in the city of Omaha in Douglas and Sarpy Counties, Nebraska in the Midwest United States of America. The population of Omaha, Nebraska during 2020 was 486,051 with a population density of 3,433.4 people per square mile.[34] Notable points of reference include downtown Omaha, on the central eastern edge along the Nebraska-Iowa border. Across the Nebraska-Iowa border is Council Bluffs, Iowa. Northeast Omaha and Southeast Omaha are directly north and south of downtown respectively. Immediately west of downtown is the Midtown area, split into Northwest and Southwest Omaha which dips into Sarpy County, that includes the Nebraska Medicine main campus approximately intersecting the two areas. Areas west of the previous areas will

be designated as Western Douglas County. Southeast of Omaha includes Bellevue, Nebraska where the second Nebraska Medicine campus is located, Bellevue Medical Center (BMC), including one of the primary care PCMH clinics of interest. Of note, five zip codes within Douglas and Sarpy Counties include universities, academic centers, and a military base without residences. There are two additional health systems of comparable size as Nebraska Medicine with locations scattered throughout the Omaha metro. This project is a single institution EHR study and only information from Nebraska Medicine is present.

Nebraska Medicine operates fourteen primary care clinics across the Omaha metro which the PCMH model is used. Of note, four PCMH clinic locations are located on or near the primary Nebraska Medicine campus at 42nd Street and Emile Street in Midtown Omaha, Nebraska which includes Durham Outpatient Center (DOC) Family Medicine and DOC Internal Medicine, which is located at the same address on different floors of the building and will be represented as one location, as well as Home Instead Center for Successful Aging (HICSA) and Midtown Clinic.

This project identified patients with uncontrolled diabetes who received care at Nebraska Medicine and live within Omaha, Nebraska and describe their exposure to PCMH pharmacists by zip code. The crude prevalence of patients receiving PCMH pharmacist medication management services is presented as well as zip code specific prevalence. Additionally, patient characteristics and factors associated with pharmacist exposure at or before sampling are described.

Chapter 3: Methods

This project is a cross-sectional analysis of a secondary dataset with IRB approval (0806-21-EP). The data source for this project is an automated database query of identifiable patient data from the UNMC EHR Access Core. The analysis included all patients identified in the query after restricting to only Omaha, Bellevue, Council Bluffs, or adjacent to Omaha zip codes of interest. The patient specific index date was defined as the first instance identified in the EHR where an hA1c result of greater than 9% was recorded in the electronic health record in the study period. The overall time period for the data query includes dates between January 1st, 2017 to May 31st, 2021. Other inclusion criteria applied on or relative to index date includes age greater than or equal to 19 and at least one office visit in the previous two years at a PCMH clinic within Nebraska Medicine relative to index date. Patients were excluded if they had a diagnosis for type one diabetes or had a home address zip code outside of the Omaha metropolitan area. The exposure criteria to be assigned to the pharmacist group was defined as the creation of a PCMH Pharmacist Diabetes Management Episode within the EHR at any point during the query period. There are no outcomes variables after the index date event in the dataset.

Baseline patient data includes demographic information on index date, such as age, gender, race, ethnicity, insurance status, and home address zip code. All baseline lab data were collected in the 365 days preceding the index date and included hA1c, BMI, eGFR, serum creatinine, blood pressure, lipid panel results, and urine albumin/serum creatinine and only the most recent value was used if not missing. eGFR was calculated using the single SCr value nearest to index date using the CKD-EPI equation without race.[35,36] All ambulatory prescription orders placed in the EHR for antihyperglycemic agents in the baseline period will be summarized by pharmaceutical class and count of unique medication classes per patient. Patient must have at least one order for each pharmaceutical class and individual agents within pharmaceutical classes are not elaborated further. Lastly, health resource utilization within the

EHR in the baseline period will be summarized and includes office visits, emergency department visits, and hospitalizations from within the EHR at the study institution.

Zip codes were used as geospatial identifier by patient home address zip code collected through the EHR. Home address zip code was used only for the mapping performed in this analysis, differences between patient characteristics between zip codes was not performed. Home addresses were generated as the most recent value that could be collected from the database and cannot be guaranteed to be the accurate home address on index date. Omaha-adjacent zip codes were selected on two criteria: contact with Omaha zip code and at least 20 patients in the dataset. Rural areas adjacent to the west and southwest of Omaha frequently contained small sample sizes and were not included in the analysis or mapping. Council Bluffs is a large urban center in near vicinity to downtown Omaha and was included due to enough patients and locality to the institution and clinics of interest. Bellevue, Nebraska was included due to Nebraska Medicine campus and location of PCMH clinic at this site as well.

Descriptive statistics (chi square for categorical variables, t-test for continuous variables, etc) of baseline patient characteristics of between patients who were managed by a pharmacist and those who were not managed by a pharmacist were performed. Histograms were used to evaluate continuous data and if an approximately normal distribution was observed, an appropriate equal or unequal variance t-test was performed based on the results of an equal variance test. If non-normal distributions were observed, Mann-Whitney U tests of medians were performed. Both mean and median values were presented but only the statistical test of the continuous statistical test that matches the relevant distribution p-value is displayed. Outlier values 1.5 times the 99^{th} percentile were removed for hemoglobin hA1c values. Continuous variables with frequent zero values, such as hospitalizations and emergency department (ED) utilization were recategorized and tested using chi square tests in addition to t-test or Mann-Whitney U tests. Omnibus chi square tests were used with categorical variables without more than two categories and if at least one level is statistically significant, pairwise

comparisons with Bonferroni corrected alpha values for each variable were only then performed. There are no outcome variables in this dataset. Modeling was underwent using log-binominal generalized linear models (GLM) and were used to predict the outcome of pharmacist diabetes management based on baseline patient characteristics and risk ratios will be presented for each variable. An exploratory multivariate model was made with all statistically significant baseline characteristics to elaborate on factors associated with pharmacist involvement. An alpha level of 0.05 was used for all statistical testing unless a Bonferroni correction was used. All data manipulation and statistical analyses were performed in Stata17.[37]

ArcGIS was used for all geospatial data and mapping. Upon removing patients with zip codes outside of the Omaha area of interest, the patient list was deidentified by assigning each patient a new subject identification number and only the zip code value, hA1c value on index date, and exposure to pharmacists were added to ArcGIS. A layer was created that established the zip code values and count of patients per zip code and the count of patients with pharmacist exposure values present. A second layer with the polygon shapes of each zip code[37] was combined with the patient sample layer and formatted. The resulting map was color coded to show the proportion of patients with pharmacist exposure to the total number of patients with a hemoglobin hA1c value greater than 9%. Only the proportion was presented on the map of each Omaha zip code and the counts in the numerator and denominator was censored. An additional layer was superimposed onto the map with 13 PCMH clinic locations presented by address, where two PCMH clinics are at the same address at the main campus location.[39]

Chapter 4: Results

During the study period, a total of 10,081 patients meeting inclusion criteria with a hemoglobin hA1c value greater than 9% were identified. Of these patients, 4,936 patients had home zip code addresses in the Omaha or adjacent areas of interest and are included in the descriptive analysis. Of the patients excluded, 4,366 (43.3%) were located elsewhere in Nebraska, 372 (3.6%) located elsewhere in Iowa, and the remaining located outside of Nebraska and Iowa, 407 (4.0%). Of the sample of interest, 1,287 (26.1%) patients had PCMH pharmacist diabetes medication management at any point during the study period while 3,649 (73.9%) patients did not have PCMH pharmacist diabetes management during the study period.

Several exploratory factors related to the exposure of interest of PCMH pharmacist management were identified. Of note, patients excluded due to being out of the Omaha area, 111 patients were exposed to PCMH pharmacists out of the representative zip codes. All but two zip codes had less than three patients who saw a pharmacist total and many of the zip codes had less than ten total patients with uncontrolled diabetes. Patients who saw a PCMH pharmacist had a mean time after their index date of an hA1c value greater than 9% to opening a pharmacist episode of approximately 11 months or 333 days. Additionally, 106 of the 1,287 patients had a PCMH pharmacist episode after the index hA1c value. Table Two describes the sample between the overall population from each year period and proportion of each year resulting between patients who saw a PCMH pharmacist at any point in time and those who did not.

Table One - Exploratory Sampling Factors for Total Sample, Pharmacist Exposure, Non-Pharmacist Exposure Groups by Index Date Calendar Year Occurrence					
	2017	2018	2019	2020	Thru 5/2021
Index Date by Calendar Year					
Patient Index Date per Calendar Year, n (%)	1668 (33.8%)	1021 (20.7%)	965 (19.6%)	886 (18.0%)	392 (7.9%)
Index Date during each Calendar Year by Exposure Groups					
Patients Exposed to PCMH Pharmacists, n (%)	452 (27.1%)	244 (23.9%)	259 (26.8%)	229 (25.8%)	102 (26.0%)
Patients not Exposed to PCMH Pharmacists, n (%)	1216 (72.9%)	777 (76.1%)	706 (73.2%)	657 (74.2%)	290 (74.0%)
Notes: description of sample selection by calendar year period and exposure criteria. Index date by calendar year shows the proportion of patients in each calendar in which their index date occurs of the total sample of patients. Index date during each calendar year by exposure groups demonstrates the proportion of patients in each exposure group on the calendar year in which their index date occurs.					

Descriptive statistics of the baseline characteristics between patients with uncontrolled diabetes who saw a PCMH pharmacist and those who did not see a PCMH pharmacist is presented in Table Two. Patients who saw a PCMH pharmacist in the study period were significantly younger (55.4 vs 57.1, p-value <0.001) on index date, had a higher proportion of females (54.0% vs 48.3%, p-value <0.001), had a higher proportion of Black or African American race (30.2% vs 19.1%, p-value <0.001), and a higher proportion of insurance status equal to uninsured or participating in grants (18.1% vs 14.2%, p-value <0.001). Patients who saw a pharmacist had a statistically significant higher mean hA1c values (10.9 vs 10.7, p-value <0.001). Other laboratory values were frequently missing and there were significant differences between groups in the proportion of patients with missing labs between groups. Of missing labs, patients who saw a pharmacist had a smaller proportion of missing HDL, LDL and UACR results. Patients who saw a pharmacist had a statistically significant higher mean eGFR values (82.9 vs 78.9, p-value <0.001). There was not a statistically significant difference in missing BMI or blood pressure results between groups. Patients who saw a pharmacist had a statistically significant higher BMI (35.8 vs 34.7, p-value <0.001) and diastolic blood pressure (76.3 vs 75.4, p-value 0.0231).

Patients who saw a pharmacist when categorizing any healthcare utilization in the baseline period was statistically significant lower proportion of any ED visits (27.9% vs 36.0%, p-value <0.001), lower proportion of any hospitalizations (29.2% vs 39.1%, p-value <0.001), and higher proportion of any office visits (94.1% vs 87.3%, p-value <0.001). The proportion of patients who had no diabetes medication in the baseline period that saw a pharmacist were statistically higher than patients who did not see a pharmacist (11.1% vs 14.0%, p-value 0.008). Patients who saw a pharmacist had a statistically significant higher proportion of biguanides (63.4% vs 53.3%, p-value <0.001), sulfonylureas (29.1% vs 22.6%, p-value <0.001), and lower proportion of bolus insulin utilization (38.1% vs 48.3%, p-value <0.001). The mean number of pharmaceutical classes during the baseline period was not statistically significant between groups.

TABLE TWO: BASELINE CHARACTERISTICS	No Pharmacist Management n=3,649		Pharmacist Management n=1,287		p-value
MEAN AGE ON INDEX DATE (SD)	57.1	(13.9)	55.4	(13.0)	**<0.001[a]**
MEDIAN AGE (IQR)	58	(18)	56	(18)	
GENDER, n (%)					**<0.001[c]**
FEMALE	1,762	48.3%	695	54.0%	
MALE	1,887	51.7%	592	46.0%	
ETHNICITY, n (%)					0.602[c]
HISPANIC OR LATINO	356	9.8%	119	9.3%	
NOT HISPANIC OR LATINO	3,283	90.2%	1,163	90.7%	
RACE, n (%)					<0.001[d]
American Indian or Alaska Native	60	1.6%	15	1.2%	0.227[e]
Asian	77	2.1%	21	1.6%	0.29[e]
Black or African American	697	19.1%	389	30.2%	**<0.001[e]**
Native Hawaiian or other Pacific Islander	20	0.5%	9	0.7%	0.542[e]
Unknown	303	8.3%	93	7.2%	0.221[e]
White or Caucasian	2,492	68.3%	760	59.1%	**<0.001[e]**
MISSING INSURANCE, n (%)	252	6.9%	75	5.8%	0.181[c]
INSURANCE TYPE, n (%)					0.004[d]
Commerical	1,479	43.5%	510	42.1%	0.379[f]
Medicare	1,200	35.3%	387	31.9%	0.033[f]
Medicaid	235	6.9%	96	7.9%	0.246[f]
Uninsured/grants	483	14.2%	219	18.1%	**0.001[f]**
LABORATORY DATA					
MEAN INDEX HA1C VALUE (SD)	10.7	(1.5)	10.9	(1.6)	**<0.001[a]**
MEDIAN INDEX HA1C VALUE (IQR)	10	(2)	11	(2)	
MEAN eGFR (SD)	78.9	(28.0)	82.9	(25.6)	**<0.001[a]**
MEDIAN eGFR (IQR)	83	40	87	36	
MISSING HDL LABS, n (%)	1,505	41.2%	430	33.4%	**<0.001[c]**
MEAN HDL (SD)	40.7	(13.7)	40.7	(11.5)	0.776[g]
MEDIAN HDL (IQR)	39	(13)	39	(14)	
MISSING LDL LABS, n (%)	1,608	44.1%	485	37.7%	**<0.001[c]**
MEAN LDL (SD)	90.2	(40.4)	94.7	(43.1)	**0.0114[a]**
MEDIAN LDL (IQR)	84	(51)	89	(61)	
MISSING UACR LABS, n (%)	2,283	62.6%	628	48.8%	**<0.001[c]**
MEAN UACR (SD)	240.6	(790.3)	254.7	(874.5)	
MEDIAN UACR (IQR)	30	(104)	28	(109)	0.97[b]
ALBUMINEMIA CATEGORY, n (%)					0.667[d]
NORMAL (<30)	677	49.6%	335	50.8%	
ELEVATED (30-299)	500	36.6%	228	34.6%	
SEVERELY ELEVATED (>299)	189	13.8%	96	14.6%	
VITAL SIGN DATA					
MISSING BMI DATA, n (%)	142	3.9%	35	2.7%	0.052[c]
MEAN BMI (SD)	34.7	(9.5)	35.8	(8.4)	**<0.001[a]**
MEDIAN BMI (IQR)	33	(10)	35	(11)	
MISSING BLOOD PRESSURE DATA, n (%)	48	1.3%	13	1.0%	0.394[c]
MEAN SYSTOLIC BLOOD PRESSURE (SD)	132.3	(18.9)	132.2	(17.7)	0.840[a]
MEDIAN SYSTOLIC BLOOD PRESSURE (IQR)	131	(23)	130	(22)	
MEAN DIASTOLIC BLOOD PRESSURE (SD)	75.4	(12.4)	76.3	(11.9)	**0.0231[g]**
MEDIAN DIASTOLIC BLOOD PRESSURE (IQR)	75	(16)	76	(16)	

TABLE TWO: BASELINE CHARACTERISTICS (CONTINUED)	No Pharmacist Management n=3,649		Pharmacist Management n=1,287		p-value
HEALTHCARE UTILIZATION DATA					
MEAN ED ENCOUNTERS (SD)	0.6	(1.2)	0.5	(1.4)	
MEDIAN ED ENCOUNTERS (IQR)	0	(1)	0	(1)	**<0.001[b]**
ED VISITS CATEGORIES, n (%)					**<0.001[c]**
NO ED VISITS IN BASELINE PERIOD	2,336	64.0%	928	72.1%	
ANY ED VISITS IN BASELINE PERIOD	1,313	36.0%	359	27.9%	
MEAN ED VISITS IN PATIENTS WITH 1+ ED VISITS	1.73	1.46	1.89	2.14	0.192[a]
MEAN HOSPITALIZATIONS (SD)	0.7	(1.3)	0.6	(1.5)	**0.003[a]**
MEDIAN HOSPITALIZATIONS (IQR)	0	(1)	0	(1)	
HOSPITALIZATIONS CATEGORIES, n (%)					**<0.001[c]**
NO HOSPITAL VISITS	2,222	60.9%	911	70.8%	
ANY HOSPITAL VISITS	1,427	39.1%	376	29.2%	
MEAN HOSPITAL VISITS IN PATIENTS WITH 1+ HOSPITALIZATIONS	1.79	1.47	1.94	2.14	0.2241[a]
MEAN OFFICE VISITS (SD)	2.8	(3.2)	3.3	(3.5)	
MEDIAN OFFICE VISITS (IQR)	2	(3)	2	(3)	**<0.001[b]**
OFFICE VISITS CATEGORIES, n (%)					<0.001[c]
NO OFFICE VISITS	463	12.7%	76	5.9%	
ANY OFFICE VISITS	3,186	87.3%	1,211	94.1%	
PRESCRIPTION UTILIZATION DATA					
NO DM MEDICATIONS AT BASELINE, n (%)	511	14.0%	143	11.1%	**0.008[c]**
DPP4 INHIBITOR, n (%)	413	11.3%	151	11.7%	0.688[c]
SGLT2 INHIBITOR, n (%)	3,417	93.6%	1,205	93.6%	0.986[c]
BIGUANIDES, n (%)	1,944	53.3%	816	63.4%	**<0.001[c]**
SULFONYLUREA, n (%)	824	22.6%	375	29.1%	**<0.001[c]**
THIAZOLIDINEDIONES, n (%)	111	3.0%	36	2.8%	0.657[c]
GLP-1 AGONIST, n (%)	466	12.8%	154	12.0%	0.454[c]
BOLUS INSULIN, n (%)	1,761	48.3%	490	38.1%	**<0.001[c]**
BASAL INSULIN, n (%)	1,742	47.7%	603	46.9%	0.584[c]
MEAN PHARMACEUTICAL CLASSES (SD)	2.05	(1.3)	2.10	(1.2)	0.2219

Details: baseline characteristics between patients with uncontrolled diabetes who saw a PCMH pharmacist compared to patients who did not see a PCMH pharmacist. Statistically significant p-values are bolded and only pairwise comparisons in categorical variable with more than two categories are bolded when the omnibus test is statistically significant. Statistical testing used:

a- UNEQUAL VARIANCE T-TEST
b- MANN-WHITNEY U TEST
c- CHI-SQUARE TEST
d- OMNIBUS CHI-SQUARE TEST:
BONFERRONI CORRECTED ALPHA VALUE: e = 0.0083, f = 0.0125
g- EQUAL VARIANCE T-TEST

Geospatial Analysis

The results of the mapping can be seen in Figure One. The mean proportion of patients with uncontrolled diabetes per zip code of the included area was 25.3%. The zip codes with the lowest and highest proportion of pharmacist management were 68005 in Bellevue, Nebraska at 9.1% and 68108 in Southeast Omaha immediately adjacent to downtown Omaha at 50%. General areas with higher numeric proportions of patients with uncontrolled diabetes who saw a pharmacist include Southwest, Southeast, and North Omaha while areas with lower proportions of patients who saw a pharmacist were in Bellevue, Nebraska, and scattered zip codes across Western Douglas County areas. Upon visually inspecting PCMH clinic locations and zip codes nearest, clinics located on or near main campus had higher proportions of patients who saw pharmacists, but this was not similar to the second campus in Bellevue, Nebraska.

Figure One – Map of Omaha, Nebraska area with proportion of patents with uncontrolled diabetes who saw a pharmacist.

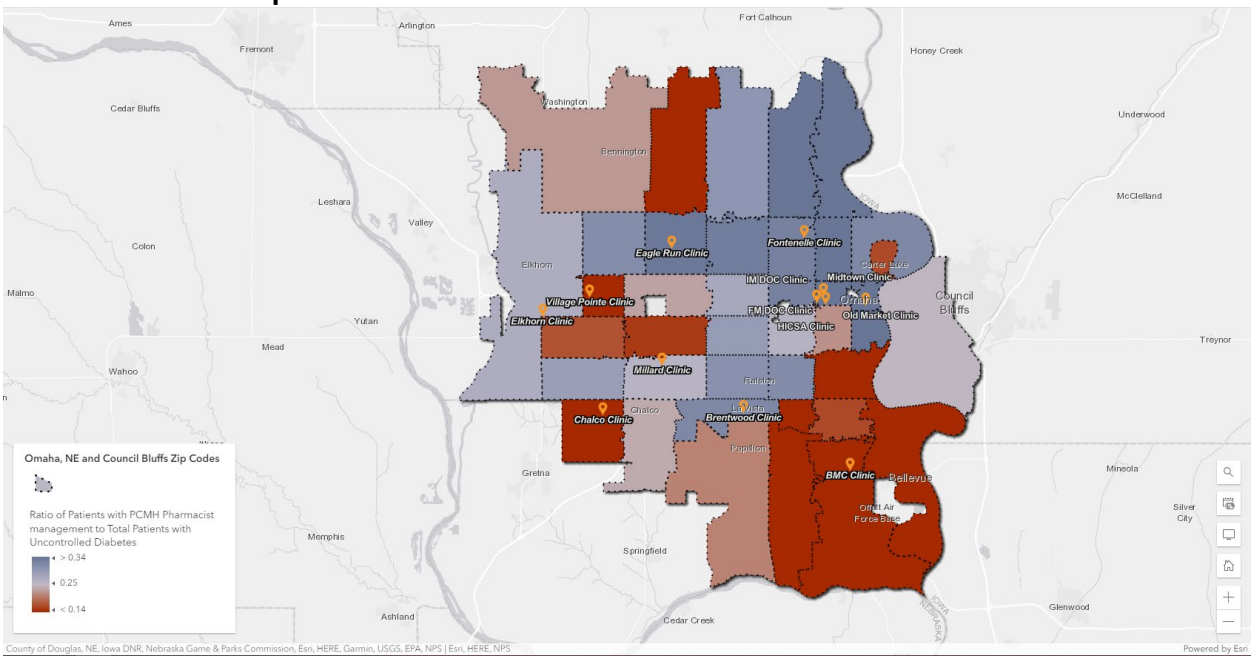

Figure One: Mapping of zip codes by the proportion of pharmacist who saw an ambulatory care pharmacist to all patients with uncontrolled diabetes. Individual addresses of Nebraska Medicine PCMH clinics are presented as orange points.

Prediction model and factors associated with exposure to PCMH Pharmacist

The prediction model and risk ratios are presented in Table Three. Several factors were significantly associated with the outcome of interest of being exposed to PCMH pharmacists during the study period. When holding all factors constant, demographic factors included male patients risk ratio 0.876 times as likely compared to females and Black or African Americans were 1.457 time as likely compared to White or Caucasian patients to see a PCMH pharmacist and these were statistically significant. Utilization factors in the baseline period that were statistically significant were ED, hospitalizations, and office visits, however ED and office visits had risk ratios greater than one while hospitalizations were less than one. Otherwise, patients with no medication utilization in the baseline period were 0.752 times as likely to be exposed to a PCMH pharmacists compared to patients with medications in the baseline period when holding all other factors constant.

Table Three – GLM Log-Binominal model predicting factors associated with exposure to PCMH Pharmacist

Model Output	Log likelihood =-1427.72	n=2,467 AIC = 1.176 BIC = -16226	Outcome = PCMH Pharmacist Exposure Covariates = statistically significant difference in baseline characteristics	
Covariate Name	Risk Ratio	Standard Error	p-value	95% Confidence Interval
Age (continuous)	1.004	0.0034	0.918	0.994-1.007
Gender				
Female	Reference			
Male	0.877	.0552	**0.037**	0.775-0.992
Race				
White or Caucasian	Reference			
American Indian or Alaska Native	0.952	0.3410	0.891	0.472-1.921
Asian	1.22	0.2672	0.362	0.795-1.875
Black or African American	1.457	0.1022	**<0.001**	1.270-1.672
Hawaiian or Other Pacific Islander	0.972	0.3705	0.941	0.460-2.052
Unknown	1.064	0.1330	0.620	0.833-1.360
Insurance				
Commerical	Reference			
Medicare	1.152	0.0962	0.090	0.978-1.357
Medicaid	1.082	0.135	0.526	0.848-1.382
Uninsured or Grants	1.194	0.1014	**0.037**	1.101-1.410
Hemoglobin A1c (continuous)	h	0.2260	**<0.001**	1.069-1.158
eGFR (continuous)	1.004	0.0016	**0.008**	1.001-1.007
LDL (continuous)	1.000	0.0007	0.726	0.999-1.002
BMI (continuous)	1.007	0.0036	0.064	0.999-1.014
Diastolic Blood Pressure (continuous)	0.996	0.0025	0.098	0.991-1.000
ED Visits (continuous)	1.501	0.282	**0.029**	1.043-2.173
Hospital Visits (continuous)	0.639	0.1181	**0.015**	0.444-0.918
Office Visits (continuous)	1.026	0.0092	**0.004**	1.008-1.044
Medications in Baseline Period				
No	Reference			
Yes	0.752	0.0967	**0.027**	0.585-0.968
Metformin Utilization				
No	Reference			
Yes	1.005	0.0782	0.950	0.863-1.170
Sulfonylurea Utilization				
No	Reference			
Yes	1.173	0.0800	**0.019**	1.026-1.341
Thiazolidinediones Utilization				
No	Reference			
Yes	0.941	0.1776	0.746	0.650-1.362
Bolus Insulin Utilization				
No	Reference			
Yes	0.839	0.0648	**0.023**	0.721-0.976
Constant Term	0.060	0.0287	**<0.001**	0.024-0.153

Notes: GLM Log-Binominal model predicting the outcome of exposure to PCMH pharmacist diabetes medication management and resulting risk ratios. Continuous values are used by default and categorical covariates have reference groups presented above. All Stata commands utilized the default binreg options but coefficients were exponentiated to be shown as a risk ratio. The 'search', 'difficult', and 'ml' options were utilized to improve modeling efficiency to identify a starting value for the estimation.

Discussion

This descriptive cross-sectional analysis demonstrated the crude proportion of patients with uncontrolled diabetes from a single academic medical center in Omaha, Nebraska who saw a PCMH pharmacist was 26.1% and zip code specific trends variated between 9.1% to 50%. Patient characteristics in the baseline period generally showed a statistically significant difference in mean hemoglobin hA1c, age, and healthcare utilization. The results of this study may be useful for future research into programmatic outcomes of pharmacist services and evaluating risk factors geospatially distributed across Omaha, Nebraska.

The geospatial analysis of this project of patients with uncontrolled diabetes can be compared to the Douglas County Community Needs Assessment (CHNA), most recently performed in 2021.[4] When comparing within regions of Douglas County, Northeast (12.3), Southeast (13.7), Northwest (11.6), Southwest (12.0), and Western Douglas (8.1) have a numerically comparable rate of high blood sugar and correlates well with the results of this study where pharmacists are managing a higher proportional trend of patients in the areas with relatively more abundant patients. Risk factors such as poor healthcare and medication access correlate with the areas of relatively higher proportions of high blood sugars represented by this project. While not quantified directly, PCMH pharmacist services involving medication and healthcare access may lower this disparity, especially in the areas where there is a higher proportion of patient at risk. Other studies involving the sampled patient population in this project have been evaluated. One observational study found increased medication access and adherence when using pharmacy provided services but zip code level data was not determined.[40] When evaluating the community in which the single institution resides, these interventions may alleviate negative diabetes outcomes in Omaha, Nebraska when comparing the Douglas County areas to benchmarks and external

populations, where rates of high blood sugars and age-adjusted death are worse in Douglas County compared to other areas.[4] Future outcome-based studies may find a more definitive answer to this hypothesis, however.

Pertaining to the exposure of interest, the results of this descriptive study are challenging to compare to existing literature pertaining to pharmacist services. There is a sparsity of literature describing ambulatory care pharmacist services and the geospatial distribution within a at risk patient population regardless of regionality or locality. Literature evaluating pharmacist services provided often is evaluating medication access factors within community pharmacy locations and not ambulatory care services specifically.[16] Of note, Nebraska Medicine is one health system following a multidisciplinary model of care that utilizes pharmacists in the study area. While other health systems utilize multidisciplinary care teams and follow a PCMH or PCMH-like model, most if not all comparable health systems in size and reach utilize ambulatory care pharmacists and the opportunity for ambulatory care pharmacists may be limited geographically. Further evaluation of this topic and patient outcomes may support decision-making to include pharmacists in programs and expansion of patient care responsibilities in Omaha, Nebraska.

Many challenges arise when promoting more ambulatory care pharmacist services. This includes chiefly: funding and challenges in measuring effectiveness in multidisciplinary teams. For the program of interest, the PCMH pharmacists fall under the outpatient pharmacy department cost centers and are funded through the pharmacy department, rather than the PCMH clinics themselves. The outpatient pharmacy department is a high-volume dispensing pharmacy that consists of three locations during the study period. During the calendar year 2019, the annual prescriptions dispensed through the outpatient pharmacy was over 294,000, with an average workday dispensing ranging between 1,000 to 1,200 prescriptions, based on internal records. In contrast, each clinic has its own cost center that keeps track of budget and revenue generating activities. PCMH pharmacists can bill for their services but only

through the clinics, not as independent providers. The predominate billing from PCMH pharmacist arise from in-person office visits, even though the predominate form of patient encounters by PCMH pharmacists is through telephone outreach at Nebraska Medicine. This leads to a situation where heath systems must finance pharmacists for their services through other means, as opposed to pharmacist service existing by self-sustainability. Policy changes that favor reimbursement to pharmacists may address this limitation so that other health systems may be able to fund pharmacist to trend patients with chronic diseases.

Limitations of this project are notable due to the cross-sectional nature of the analysis and the methods used to collect the data. The source of data was used for another project and the analysis was post-hoc in nature from a separate research question. This led to limited aspects of the data that may have improved accuracy and relevance. Notably, the exposure of interest was distinct from the date of the initial hemoglobin hA1c greater than 9% and less likely to be directly related. This is significant because most patients saw a pharmacist on average almost eleven months after the index event and all baseline characteristics data was dependent on the index date and not the exposure. The sequence of events is realistic however, as providers will initially manage, treat, and monitor patients and when additional assistance is needed, refer to the pharmacist as necessary. The descriptive analysis is appropriate, only baseline characteristics are decoupled from when the pharmacist saw the patient and all descriptive characteristics are at or before index date regardless of pharmacist exposure. The data query was intentionally designed to include only patients that had an office visit at the study institution during the two years prior to their index date to remove patients with missing information but validation of this data would need to be explored further. Patients were identified based on their first instance of an hA1c greater than 9% and there was a relatively higher count of patients at the beginning of the study period compared to the end of the study period. This may result in some temporal bias where patients have repeated hA1c values greater than 9% and this was not quantified. More equal sampling over time

to match the exposure to pharmacists may improve generalizability in outcome-based research questions in the future.

All data was generated through a single EHR and any information outside of the study institution is not measurable. There is a high probability that misclassification bias is present in all presented information due to the possibility of patient dynamically utilizing services across different heath systems in the overlapping area. Zip codes were attempted to be gathered on index date as well but limitations in the data query and lack of the ability to validate the data make the veracity of the zip code information questionable. Also, 43% of the sample was located outside of the Omaha, Nebraska area but still in Nebraska. This may be indicative of patients that were in Omaha on index date but more likely representative of regional coverage of the academic medical center. Other unmeasured factors that may have substantial impact on the aims of this descriptive study include comorbid conditions, duration of diabetes diagnosis, social risk factors and social determinates of health, and missingness of laboratory values in a subset of the sample of interest. Additionally, a measurement of unmeasured factors could have been extrapolated if census track data was accessible. Future studies of ambulatory care pharmacists and geospatial data should evaluate patient outcomes to determine if pharmacist service prevalence is correlated positively with more patients reaching and sustaining therapeutic endpoints.

Conclusion

This descriptive cross-sectional study evaluating the geospatial distribution of patient with uncontrolled diabetes in Omaha, Nebraska explored the prevalence of pharmacist management by zip code. Pharmacist involvement in the management of patients with uncontrolled diabetes may contribute to reaching public health goals of diabetes in Omaha, Nebraska. Further evaluation and research of ambulatory care pharmacist services may lead to more efficient resource allocation and the impact of diabetes medication management services.

References

1. Kaufman BG, Spivack BS, Stearns SC, Song PH, O'Brien EC. Impact of Accountable Care Organizations on Utilization, Care, and Outcomes: A Systematic Review. Med Care Res Rev. 2019;76(3):255-290. doi:10.1177/1077558717745916
2. Zanotto BS, Etges APBDS, Marcolino MAZ, Polanczyk CA. Value-Based Healthcare Initiatives in Practice: A Systematic Review. J Healthc Manag. 2021;66(5):340-365. Published 2021 Jun 29. doi:10.1097/JHM-D-20-00283
3. American Society of Health-System Pharmacists (ASHP). Section of Ambulatory Care Practitioners. FAQ: Basics of Ambulatory Care Pharmacy Practice. 2019. Available at: https://www.ashp.org/-/media/assets/pharmacy-practice/resource-centers/ambulatory-care/basics-of-ambulatory-care-pharmacy-practice. Accessed November 6th, 2023.
4. Centers for Disease Control and Prevention (CDC). Division of Diabetes Translation. Diabetes Basics. 2023. Available at: https://www.cdc.gov/diabetes/basics/diabetes.html. Accessed August 13, 2023
5. Centers for Disease Control and Prevention (CDC). National Diabetes Statistics Report. Prevalence of Diagnosed Diabetes. 2022. Available at: https://www.cdc.gov/diabetes/data/statistics-report/diagnosed-diabetes.html. Accessed November 7th, 2023.
6. Douglas County Health Department. Community Health Needs Assessment. 2021. Available at: https://www.douglascountyhealth.com/images/CHNS/CHA/2021_PRC_CHNA_Report_-_Omaha_Metro_Area.pdf. Accessed August 13, 2023
7. American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2021 [published correction appears in Diabetes Care. 2021 Sep;44(9):2182]. Diabetes Care. 2021;44(Suppl 1):S15-S33. doi:10.2337/dc21-S002
8. Diabetes Control and Complications Trial Research Group, Nathan DM, Genuth S, et al. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med. 1993;329(14):977-986. doi:10.1056/NEJM199309303291401
9. Laiteerapong N, Ham SA, Gao Y, et al. The Legacy Effect in Type 2 Diabetes: Impact of Early Glycemic Control on Future Complications (The Diabetes & Aging Study). Diabetes Care. 2019;42(3):416-426. doi:10.2337/dc17-1144
10. ElSayed NA, Aleppo G, Aroda VR, et al. 6. Glycemic Targets: Standards of Care in Diabetes-2023. Diabetes Care. 2023;46(Suppl 1):S97-S110. doi:10.2337/dc23-S006
11. Samson SL, Vellanki P, Blonde L, et al. American Association of Clinical Endocrinology Consensus Statement: Comprehensive Type 2 Diabetes Management Algorithm - 2023 Update [published correction appears in Endocr Pract. 2023 Sep;29(9):746]. Endocr Pract. 2023;29(5):305-340. doi:10.1016/j.eprac.2023.02.001
12. National Committee for Quality Assurance (NCQA). HEDIS Measures and Technical Resources. Available at: https://www.ncqa.org/wp-content/uploads/HEDIS-MY-2024-Measure-Description.pdf. Accessed August 13, 2023
13. Peck KA, Usadi B, Mainor AJ, Fisher ES, Colla CH. ACO Contracts With Downside Financial Risk Growing, But Still In The Minority. Health Aff (Millwood). 2019;38(7):1201-1206. doi:10.1377/hlthaff.2018.05386
14. Centers for Medicare & Medicaid Services (CMS). ACO REACH. 2022. Available at: https://www.cms.gov/priorities/innovation/innovation-models/aco-reach. Accessed November 7th, 2023.

15. U.S Department of Health and Human Services. Office of Disease Prevention and Health Promotion. Social Determinants of Health. 2020. Available at: https://health.gov/healthypeople/priority-areas/social-determinants-health. Accessed November 8th, 2023.
16. National Committee for Quality Assurance (NCQA). Patient-centered medical home (PCMH).Published June 2019. Available at: https://www.ncqa.org/programs/health-care-providers-practices/patient-centered-medical-home-pcmh. Accessed January 22, 2021
17. Phillips RS, Sullivan EE, Mayo-Smith MF. The patient-centered medical home and the challenge of evaluating complex interventions. JAMA Netw Open. 2020;3(2):e1920827
18. John JR, Jani H, Peters K, Agho K, Tannous WK. The effectiveness of patient-centred medical home-based models of care versus standard primary care in chronic disease management: A systematic review and meta-analysis of randomised and non-randomised controlled trials. Int J Environ Res Public Health. 2020;17(18):6886. doi: 10.3390/ijerph17186886
19. Kozminski M, Busby R, McGivney MS, Klatt PM, Hackett SR, Merenstein JH. Pharmacist integration into the medical home: qualitative analysis. J Am Pharm Assoc (2003). 2011;51(2):173-183. doi:10.1331/JAPhA.2011.10188
20. Tate ML, Hopper S, Bergeron SP. Clinical and Economic Benefits of Pharmacist Involvement in a Community Hospital-Affiliated Patient-Centered Medical Home. J Manag Care Spec Pharm. 2018;24(2):160-164. doi:10.18553/jmcp.2018.24.2.160
21. Greer N, Bolduc J, Geurkink E, et al. Pharmacist-Led Chronic Disease Management: A Systematic Review of Effectiveness and Harms Compared With Usual Care. Ann Intern Med. 2016;165(1):30-40. doi:10.7326/M15-3058
22. Ackroyd SA, Wexler DJ. Effectiveness of diabetes interventions in the patient-centered medical home. Curr Diab Rep. 2014;14(3):471
23. Fazel MT, Bagalagel A, Lee JK, Martin JR, Slack MK. Impact of di7abetes care by pharmacists as part of health care team in ambulatory settings: A systematic review and meta-analysis. Ann Pharmacother. 2017;51(10):890-907
24. Benedict AW, Spence MM, Sie JL, et al. Evaluation of a Pharmacist-Managed Diabetes Program in a Primary Care Setting Within an Integrated Health Care System. J Manag Care Spec Pharm. 2018;24(2):114-122. Doi:10.18553/jmcp.2018.24.2.114
25. Choe HM, Mitrovich S, Dubay D, Hayward RA, Krein SL, Vijan S. Proactive case management of high-risk patients with type 2 diabetes mellitus by a clinical pharmacist: a randomized controlled trial. Am J Manag Care. 2005;11(4):253-260
26. Schwenka N, Donovan A, Franck L, Coan C, McAdam-Marx C, Shin E. Patient-centered medical home pharmacists' impact on composite quality care measures for patients with uncontrolled type 2 diabetes [published online ahead of print, 2023 Jun 8]. J Am Pharm Assoc (2003). 2023;S1544-3191(23)00171-1. doi:10.1016/j.japh.2023.06.004
27. Trueman C, Donovan A, Coan C, McAdam-Marx C, Shin E. Pharmacist Impact on Evidence-Based Prescribing of Diabetes Medications in Patients with Clinical Atherosclerotic Cardiovascular Disease (ASCVD). Accepted for Publication in J Manag Care Spec Pharm September, 2023.
28. Fernandes BD, Foppa AA, Almeida PHRF, Lakhani A, Lima TM. Application and utility of geographic information systems in pharmacy specific health research: A scoping review. Res Social Adm Pharm. 2022;18(8):3263-3271. doi:10.1016/j.sapharm.2021.11.004
29. Lin SJ. Access to community pharmacies by the elderly in Illinois: a geographic information systems analysis. J Med Syst. 2004;28(3):301-309. doi:10.1023/b:joms.0000032846.20676.94
30. Dodson ZM, Enki Yoo EH, Martin-Gill C, Roth R. Spatial Methods to Enhance Public Health Surveillance and Resource Deployment in the Opioid Epidemic. Am J Public Health. 2018;108(9):1191-1196. doi:10.2105/AJPH.2018.304524

31. Wasem Alsabbagh M, Houle SKD. The association between the rate of potentially pharmacist-manageable emergency department visits and community income level and primary care provider availability: A spatial analysis. Can Pharm J (Ott). 2022;155(3):164-168. Published 2022 Mar 30. doi:10.1177/17151635221087621
32. Jun JK. The Role of Pharmacy Through Collaborative Practice in an Ambulatory Care Clinic. Am J Lifestyle Med. 2017;13(3):275-281. Published 2017 Feb 8. doi:10.1177/1559827617691721
33. LB166 § 15 Act 38-2867.03. 2017. Available at: https://nebraskalegislature.gov/laws/statutes.php?statute=38-2867.03. Accessed November 9th, 2023.
34. United States Census. QuickFacts Omaha city, Nebraska. 2022. Available at: https://www.census.gov/quickfacts/fact/table/omahacitynebraska/POP010220. Accessed November 6th, 2023.
35. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate. Ann Intern Med. 2009;150(9):604-612.
36. Levey AS, Stevens LA. Estimating GFR using the CKD Epidemiology Collaboration (CKD-EPI) creatinine equation: more accurate GFR estimates, lower CKD prevalence estimates, and better risk predictions. Am J Kidney Dis. 2010;55(4):622-627.
37. StataCorp. 2021. Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC
38. Esri Canada. “USA ZIP Code Boundaries” [Web Map]. https://services.arcgis.com/P3ePLMYs2RVChkJx/arcgis/rest/services/USA_ZIP_Code_Areas_anaylsis/FeatureServer. (September 26,2023).
39. Nebraska Medicine. Patient-Centered Medical Home. Online. Available at: https://www.nebraskamed.com/primary-care/pcmh. Accessed November. 7th 2023
40. Franck L, Donovan A, Kellison M, McAdam-Marx C. Assessment of medication adherence after enrollment in a health system funded medication assistance program for patients with diabetes. J Am Pharm Assoc (2003). 2023;63(4):1222-1229.e3. doi:10.1016/j.japh.2023.04.007