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Access to Telehealth and Changes in Diabetes Care Patterns Pre and During the COVID-19 Pandemic - Evidence from a Large Integrated Healthcare System

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Bachelor of Science

Texas A&M University

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Thesis Committee Chair: Jessica Harding, PhD

An abstract of

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

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Master of Public Health in Epidemiology

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Abstract

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Background: Current diabetes management guidelines recommend annual screening of hemoglobin A1c (HbA1c), blood pressure (BP), cholesterol, creatinine, urine albumin-creatinine ratio (UACR), and eye and foot exams. How the shift to telehealth during the COVID-19 pandemic affected adherence to these guidelines, overall and by age, sex and race, is unclear.

Methods: We included all adults (aged ≥18 years) with prevalent diabetes on January 1, 2018, and continuous enrollment at Kaiser Permanente Georgia (KPGA) through December 31, 2021. Prevalent diabetes was defined as a history of at least one of a diagnosis code for diabetes, use of anti-hyperglycemic medication, or at least one laboratory value of HbA1c, fasting plasma glucose or random glucose in the diabetic range. We defined pre (2018-2019) and during COVID-19 (2020-2021) periods. Telehealth utilization was defined as at least one virtual care visit or a scheduled telephone appointment in each period. Adherence to annual guidelines (i.e., at least one measurement per year) was determined from KPGA's electronic medical record data. Generalized estimating equations, adjusted for baseline age, were used to assess the within-subject change in telehealth utilization and guideline adherence by period.

Results: Among 22,854 adult KPGA members with prevalent diabetes, mean age was 58.9 (±13.0), 44.5% were men, and 57.5% were Black. Telehealth utilization increased from 38.7% in the pre period to 91.5% during COVID-19. The absolute decline in the percentage of those meeting annual guidelines for diabetes processes ranged from -40.7 to -1.9 among non telehealth users and -12.4 to -1.6 among telehealth users, with BP checks being the most disrupted among both telehealth and non telehealth users.

Conclusion: Among members of an integrated healthcare system, adherence to annual diabetes guidelines was disrupted during the pandemic but was less disrupted among telehealth users. Those who utilized telehealth were more likely to meet guideline recommended screenings, and this was amplified during the COVID-19 period where a large shift to telehealth occurred. Long-term follow-up is needed to assess telehealth's role in receiving diabetes care in a post COVID-19 era.

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LITERATURE REVIEW

Overview

Diabetes is a chronic condition that requires diligent management to prevent complications and premature death. Current guidelines recommend that people with diabetes have annual checks for blood pressure, hemoglobin A1C (HbA1C), eye and foot exams, body mass index (BMI), creatinine, cholesterol, and urine albumin-to-creatinine ratio (UARC) (1). This continuum of care and management requires many interactions with the healthcare system, and several historically required in-person visits. Beginning in March 2020, the COVID-19 pandemic disrupted access to routine care for people with diabetes, and may have exacerbated pre-existing inequitable access to care (2). However, the COVID-19 pandemic also brought about a shift from in-person health interactions to telehealth to a) alleviate the burden on the healthcare system and b) reduce the risk of infection from in-person visits, which is especially important for people with diabetes known to be at higher risk of developing severe COVID-19 (i.e., hospitalization, ICU admission, or mortality from COVID-19) (3). Some early evidence indicates that people with diabetes were more likely to access telehealth services during the COVID-19 pandemic as compared to previous years (4). These patterns are likely to continue in the future as the healthcare system adapts to virtual platforms to provide routine care where appropriate. Despite this, it is possible that disparities in access to in-person care (such as by race, age, and sex) may transcend access to telehealth services. In particular, owing to the need for access to stable internet and a reliable computer or smartphone to access telehealth services, it is anticipated that older adults and those of lower socioeconomic position may not have the same access as their younger and wealthier counterparts, respectively. Given the future landscape of healthcare likely includes telehealth, identifying patients with reduced access will be key to developing interventions and/or policies to promote access among these important subgroups who may benefit from these services. The purpose of this review is to: 1) summarize the literature describing the shift in telehealth caused by the COVID-19 pandemic among people with diabetes; 2) identify barriers in access to telehealth and changes in diabetes care patterns among people with diabetes, including subgroups with reduced access; and 3) identify gaps in the literature.

Epidemiology of Diabetes in the United States

Prevalence of Diabetes

The Centers for Disease Control and Prevention (CDC) report that among the United States (US) population 37.1 million adults aged 18 years or older—or 14.7% of all US adults—have diabetes (diagnosed or undiagnosed) (5). Based on 2019 crude estimates, the percentage of adults with diabetes increases with age, with 29.2% of adults aged 65 years or older living with diabetes. Research has shown that the prevalence of diabetes is higher in men (15.4%) as compared with women (14.1%) (6–8), and it is well documented that racial and ethnic minorities have a higher prevalence of diabetes compared to non-minoritized individuals (9). For example, the prevalence of diagnosed diabetes is highest among American Indians and Alaska Native persons (14.5%), followed by non-Hispanic Black persons (12.1%), those of Hispanic origin (11.8%), non-Hispanic Asian persons (9.5%) and non-Hispanic White persons (7.4%) (5). Prevalence also varies significantly by education level. Specifically, 13.4% of adults with less than a high school education have diagnosed diabetes versus 9.2% of those with a high school education and 7.1% of those with more than a high school education. Importantly, prevalence of diabetes is likely to continue among all groups owing to the increased survival and thus longer life expectancy (10).

Incidence of Diabetes

For incidence, 1.4 million new cases of diabetes are diagnosed every year (5). Compared to adults aged 18 to 44 years, incidence rates of diagnosed diabetes are higher among adults aged 45 to 64 years and those aged 65 years and older. Among US adults aged 18 years or older, age-adjusted data for 2018–2019 from the CDC shows that incidence of newly diagnosed diabetes estimates does not vary significantly by race and ethnicity, though these estimates do not account for the larger burden of undiagnosed cases among race and ethnic minorities (5). Additionally, incidence of newly diagnosed diabetes is lower among those with more than a high school education and similar for those with less than a high school education when compared to adults with a high school education only (5).

Diabetes-Related Complications

People with diabetes are at increased risk for several complications, including mortality. Specifically, people with diabetes are at increased risk for mortality, cardiovascular disease (CVD), retinopathy, neuropathy, lower-extremity amputations, infections, and cancer (11). Trends of diabetes-related complications have declined over time for CVD and mortality, but the burden remains high for all other complications due to the increasing prevalence of diabetes owing largely to an aging population (12). Diabetes was the seventh leading cause of death in the United States in 2019 (13) . Those with diabetes are twice as likely to have heart disease or a stroke than those without diabetes (14). By 2050, it is estimated that 16 million Americans over 40 years old will have diabetic retinopathy, with nearly 25% having manifestations severe enough to threaten vision (15). One study using a nationally representative sample and 12 to 16 years of follow-up found that at least 3.6% to 5.1% of all deaths and 5.2% to 6.8% of CVD deaths are attributable to diabetes in the general US population aged 30-75 years (16). Similar to patterns of prevalence and incidence, risk of diabetes-related complications is not uniform across the population (11). Those who identify as non-Hispanic Black, Native American and Alaskan Native and Hispanic are 2.3, 1.9, and 1.5 times more likely to die from diabetes compared to those who identify as non-Hispanic White (17). Additionally, those who identify as Hispanic, Black, and Native American have a 50%–100% greater burden of diabetes complications and mortality than those who identify as non-Hispanic White (18). It is estimated that the prevalence of diabetic retinopathy among non-Hispanic Black individuals with diabetes to be 38.8%, Hispanic individuals to be 31.0%, and non-Hispanic white individuals to be 26.4% (19). Black and Hispanic adults with diabetes disproportionately experience microvascular complications compared to White adults (20). Diabetic nephropathy is the leading cause of renal failure in the USA and disproportionately impacts minoritized populations (21) (22). Furthermore, there are differences in diabetes complications by age and sex. Peripheral vascular disease, heart disease and stroke all have a high prevalence among older adults with diabetes (23). One systematic review found that relative risks of vascular diseases conferred by diabetes are considerably greater in women with diabetes compared to men with diabetes (24). Considering macrovascular complications, research has found that diabetic women have a 3.5 fold higher increased CVD risk than non-diabetic women, against an observed increase of 2.1 fold in men with versus without diabetes (25). However, in an inpatient population, it has been found that hospitalized women with diabetes have fewer microvascular complication and a lower prevalence of coronary artery disease but a similar prevalence of congestive heart failure, stroke and peripheral artery disease when compared to men, despite similar body mass index and diabetes duration (26).

Routine Diabetes Care

Maintaining routine care guidelines is imperative to preventing diabetes-related complications. Consequences of straying from routine care include heart disease, chronic kidney disease (CKD), nerve damage, and premature death (27), (28). The benefits of routine care include better control of blood pressure, glycemic control, and lower risk of complications such as amputation and blindness (29). For people with diabetes, research shows that blood pressure management can reduce the risk of heart disease and stroke by 12% to 27% and the risk of progression of kidney disease by 30% to 70% (30,31). Cholesterol management can reduce cardiovascular complications by 20% to 50% (32). Regular eye exams and timely treatment could prevent up to 90% of diabetes-related blindness (33). Additionally, regular foot exams and patient education could prevent up to 85% of diabetes-related amputations (12). The American Diabetes Association (ADA) annually updates the standards for diabetes quality of care in the US (1). The 2022 guidelines are described in **Table 1**.

Barriers in Access to Routine Diabetes Care

The proportion of patients with diabetes who achieve recommended A1C, blood pressure, and LDL cholesterol levels has fluctuated in recent years (34). Patients who have either private or public insurance coverage and stable health insurance coverage are more likely to meet quality indicators for diabetes care, are more likely to have had a foot exam and eye exam and have better A1C and blood pressure control in the last year compared with uninsured patients (35), (36). In 2010, the Affordable Care Act (ACA) was enacted to 1) make affordable insurance available to more people, 2) support innovative medical care delivery methods designed to lower the costs of health care generally and 3) expand the Medicaid program for to cover all adults with income below 138% of the federal poverty level (37). Despite the ACA enactment and Medicaid expansion in states choosing to adopt starting in 2014, there are still disproportionate benefits. One study using the Behavioral Risk Factor Surveillance System (BRFSS) data found that although the ACA and Medicaid expansion have resulted in increased access to care for many individuals with diabetes, those who identify as White benefit more from the expansion compared to those who identify as non-Hispanic Black, Hispanic, and other race/multiracial groups (38). Medical bills are inevitable in the US with the many healthcare system interactions people with diabetes require, but the culmination of these expenses can be an additional barrier to getting care. Compared with those without diabetes mellitus, individuals with diabetes mellitus have higher odds of financial hardship from medical bills or any of its consequences, including high financial distress, food insecurity, cost-related medication nonadherence, and foregone/delayed medical care (39). Distance and transportation are other barriers to receiving appropriate diabetes care. In a population of older, rural residents with diabetes in Vermont, lower driving distance was significantly associated with better glycemic control with a more pronounced effect among insulin users (40). One potential solution to transportation barriers is telemedicine, which has substantially increased in utilization since the start of the COVID-19 pandemic.

The Impact of COVID-19 on People with Diabetes

There is now a strong body of evidence that indicates that people with diabetes are at increased risk from severe COVID-19, including hospitalization, ICU admission and mortality compared to people without diabetes (3,41), (42). Nearly 4 in 10 adults who died from COVID-19 in the United States also had diabetes during March 2020 (43). In addition to the increased risk for severe COVID-19, the pandemic itself caused many changes in the lives of those with chronic conditions. For example, disrupted healthcare services during lockdowns combined with the fear of COVID-19 infection from in-person interactions reduced access to many routine care services for people with diabetes. **Figure 1** displays the direct and indirect effects of COVID-19 among those with diabetes. One global survey of health care professionals from 47 countries reported that diabetes was the chronic condition most impacted by COVID-19 due to disruptions in care (44). In England, a reduction in completion of routine diabetes care processes following the pandemic onset in 2020 was associated with increased non-COVID related mortality (45), highlighting the need to maintain routine diabetes care even during a pandemic. The reason for worse prognosis in people with diabetes during the COVID-19 pandemic is likely to be because of lower access to routine care when compared to before the COVID-19 pandemic. Several factors such as age, sex, ethnicity, socioeconomic factors, and presence of comorbidities such as hypertension and CVD are likely to contribute to differences in the impact of the COVID-19 pandemic on access to diabetes care.

Telehealth in People with Diabetes During COVID-19

An indirect effect of the COVID-19 pandemic on those with diabetes was the redirection of health services to telemedicine. Telemedicine uses communications technology, such as video calls and phone calls, to deliver health care to patients. It potentially allows for a decrease in the need to travel to in-person visits and increases the time that people with diabetes have available to address competing needs, such as family, work, and social obligations (46). For example, a study using electronic medical records from Federally Qualified Health Centers clinics locations in Texas from March 2020 to November 2020 found that residence in a metropolitan area and having non-acute visits were associated with increased telemedicine use (39). Additionally, there was a dose-response relationship between distance from the clinic and telemedicine use, with increasing likelihood of telemedicine use as distance from the clinic increased. In the last two years, telehealth use in the general population soared from less than 1% of outpatient visits before the pandemic to 13% of outpatient visits in the first 6 months of the COVID-19 pandemic. This rate declined to 11% during the following 6-month period, and then to 8% a year into the pandemic (47). Insurance claims from OptumLabs Data Warehouse for all patients early in the pandemic revealed that growth in telemedicine use offset roughly two-thirds of the decline in in-person visit volume (48). Electronic health record data from Epic’s Cosmos research platform found that all-cause telehealth utilization among those with type 2 diabetes increased by 44.2% between March 2019 to February 2020 and March 2020 to February 2021 (49). An audit of more than 125.8 million primary care visits from the US National Disease and Therapeutic Index showed that total primary care visit frequency decreased by 21.4% and new treatment visits for diabetes decreased by 16.4% during the second quarter of 2020 compared with the mean quarterly visit volume for the second quarters of 2018 and 2019 which were not compensated for by remote visits (50). It is likely that certain measures needed for routine diabetes care are likely impacted by the shift to telehealth, such as blood pressure monitoring and laboratory testing needed for HbA1c, eGFR, cholesterol, and other biomarkers where in-person examinations are required. Telehealth has the potential to positively transform the quality and cost-effectiveness of diabetes management, but with already existing inequities to access to diabetes care pre-COVID-19 pandemic, disparities in access to healthcare have likely persisted when healthcare shifted to telehealth (51). One study sought to estimate how many older adults may be left behind in the US in the migration to telemedicine caused by the pandemic and assessed unreadiness owing to inexperience with technology and physical disability (52). It was found that 13 million older adults may have trouble accessing telemedical services, a disproportionate number of those possibly being already disadvantaged. In a comparison of in-person visits and virtual care visits before and during the COVID-19 pandemic, patients who used more virtual care appeared to be higher users of the healthcare system in general (53), suggesting that higher use patients who had access to the healthcare system before the pandemic received similar access to the healthcare system during the pandemic through a combination of care services including virtual care. In the initial month of the COVID-19 pandemic in the US, the likelihood of a telehealth visit was reduced for those living in rural areas and non-White races (54). Additionally, among all telehealth visits, the likelihood of a full audio-video telehealth visit was reduced for patients who were older, Black, from urban areas, or who were of self-pay, Medicaid, or Medicare payer status. Disparities in access to the internet exist, especially for those who live in rural areas, are older in age, and are part of a minoritized population. In a study using 2016 and 2017 data from the BRFSS, the prevalence of internet use was 65% among those with diabetes compared with 86% among those without diabetes (55). When considering differences by race, the prevalence of internet use among those with hypertension or diabetes was 77% in White peoples, 62% in Blacks peoples, and 56% in Hispanics peoples, which was significant when Black peoples and Hispanic peoples were compared to White peoples after adjusting for age, sex, education, employment status, language spoken, income, and U.S. state.

Existing literature reveals mixed outcomes of diabetes management through telemedicine. One study of a cohort of diabetes patients from two metropolitan hospitals in Sydney, Australia found that patients who received care via telehealth during the lockdown had marginally better glycemic control compared to visits 12 months earlier, but it was more difficult to access patients' glucose profiles during telehealth consultations and fewer patients had pathology tests performed prior to their appointments (56). A study utilizing a large cohort of type 2 diabetes patients from approximately one-third of diabetes clinics in Italy found that during the COVID-19 pandemic, telemedicine provided an acceptable quality of diabetes care, comparable to that of patients attending face-to-face consultation, although less frequent screening of complications occurred in subjects consulted by telemedicine (57). Among those with diabetes in Los Angeles County, US, telemedicine users had an increased likelihood of meeting one of five composite measures of routine care compared to those who used in-person care alone from March 2020 to December 2020 (58). Another US national cohort study found that almost half of adults with either type 1 diabetes or type 2 diabetes reported that the pandemic made their diabetes management more difficult despite the availability of telemedicine (59). Of the 763 people with type 1 diabetes who participated in the Taking Control of Your Diabetes study in the US, 46% reported that the pandemic hampered their management of diabetes. Furthermore, in approximately 25% of participants, there was an increase in the frequency of high blood glucose levels and greater variations in blood glucose despite availability of telemedicine. More research is needed to assess the impact of COVID-19 on access to telehealth among patients with diabetes as well as the disparities in access. Additionally, how the COVID-19 pandemic has impacted diabetes care via telehealth is less well studied, and disparities by important population subgroups including by age, race and sex, have not been explored.

Conclusion

Telehealth utilization increased to levels previously unseen during the COVID-19 pandemic. Although more diabetes patients utilized telehealth to receive healthcare than before the pandemic, it is likely that there are disparities in accessibility. More research is needed to identify the specific subgroups with reduced access, and the impact on diabetes care and management. Further research in these topics has the potential to identify driving forces of inaccessibility and inform care recommendations for people diagnosed with diabetes in a post COVID-19 era.

INTRODUCTION

In the US, 37.1 million, or 14.7%, of US adults—have diabetes, and 1.4 million new cases of diabetes are diagnosed every year (5). Diabetes risk is not uniform in the US population, with men (vs. women), older (vs. younger) adults, and minoritized (vs. White) populations have a greater risk of developing diabetes, as well as developing diabetes-related complications (5–9).

To reduce the risk of diabetes-related complications such as diabetic retinopathy, nephropathy, neuropathy, and cardiovascular disease, current guidelines recommend that people with diabetes have annual checks for blood pressure (BP), HbA1c, eye and foot exams, body mass index (BMI), creatinine (to estimate eGFR), and urine albumin-to-creatinine ratio (UACR) (1). Historically, these annual checks have required in-person visits with health care providers.

Though forms of telehealth have been around for decades, the COVID-19 pandemic propelled us into a virtual world, and several previously in-person interactions were alternatively delivered via telehealth. This was initially done to a) alleviate the burden on the healthcare system and b) reduce the risk of infection from in-person visits, which is particularly important for people with diabetes known to be at higher risk for severe COVID (i.e., hospitalization, ICU admission, mortality) (3). Telehealth has the added benefit of alleviating several barriers in access to routine care including distance and time (40). However, telehealth poses its own barriers including the necessity of broadband and technology literacy, and not all people have equitable access to these resources (52).

Studies of telehealth in diabetes reveal mixed outcomes of diabetes management. Telehealth utilization has been shown to improve glycemic control (56) and increase the likelihood of meeting routine care measures (58) but has also been linked to less frequent screening of complications (57) and fewer pathology tests (56). How the COVID-19 pandemic has impacted diabetes care overall, and via telehealth, is less well studied, and disparities by important population subgroups including by age, race and sex, have not been explored.

Given that the future landscape of healthcare delivery will likely include telehealth, identifying those with reduced access will be key to developing interventions and/or policies to promote access among these important subgroups who may benefit from these services.

Study Aims

Using data from a large integrated healthcare system, this retrospective study aimed to: 1) examine disparities in access to telehealth among people with diabetes pre (2018-2019) and during (2020-2021) the COVID-19 pandemic by race, age and sex; 2) compare adherence to diabetes care guidelines according to time period among telehealth users and non telehealth uses; and 3) compare adherence to diabetes care guidelines according to telehealth use in pre and during pandemic periods. We hypothesize that telehealth use will have increased in people with diabetes during (vs pre) COVID-19, and that utilization will differ by age, race, and sex. We also hypothesize that adherence to diabetes care guidelines will be higher in people using telehealth, especially in the COVID-19 period.

METHODS

Data Sources and Study population

The primary study population was identified from Kaiser Permanente Georgia (KPGA), an integrated health insurer that serves >260,000 adults in Atlanta and North Georgia. To be enrolled in the database, participants must have insurance with KPGA. KPGA has an extensive data repository of electronic medical records (EMR), including information related to patient demographics, diagnoses, procedures, claims, lab values, and prescribed medications.

In this study, we identified all KPGA adults with prevalent diabetes as of January 1, 2018 with at least 30 days of continuous enrollment with KPGA (n = 39,327), and followed them through December 31, 2021. Prevalent diabetes was defined as a history of at least one of a diagnosis code for diabetes (ICD-9-CM codes 249, 250 prior to October 2015, and ICD-10-CM codes E08-E13, from October 2015 onwards), use of anti-hyperglycemic medication, or one laboratory value of HbA1c ≥ 6.5%, fasting plasma glucose ≥ 126 dg/mL or random glucose ≥200 dg/mL. We did not differentiate between type 1 and type 2 diabetes, but as 95% of people with diabetes have type 2, results of this study are broadly applicable to people with type 2 diabetes (60). KPGA members who were less than 18 years of age at study start (n=257), who died during follow-up (n=2,159) or who discontinued their enrollment prior to December 31, 2021 (n = 13,057) were excluded. A comparison of those who were included in this study and those with discontinuous enrollment (died or discontinued enrollment and greater than or equal to 18 years of age) revealed that those who discontinued enrollment within the study period were more likely to be younger (18-64 years old vs 65+ years old), identify as White or Other race, be on a high deductible plan, not have English as their primary language, and have no comorbidities (**Supplementary Table 1**). They were less likely to have hypertension, hypertensive heart disease, renal failure, and hypertensive renal disease. The final cohort included 22,584 adult members with prevalent diabetes followed from January 1, 2018 to December 31, 2021 (**Figure 1**). We defined a pre-COVID-19 period as 2018-2019, and a during COVID-19 period as 2020-2021.

Telehealth and Diabetes Care Outcomes

KPGA transitioned to a “Virtual First” model of ambulatory care shortly after the March 13, 2020 declaration of the COVID-19 outbreak national emergency (61). Telehealth in both the pre and during COVID-19 periods was defined as a virtual visit or scheduled telephone call, extracted from KPGA EMR. We classified individuals as a telehealth user if they had at least one telehealth visit (i.e., in 2018 or 2019). We examined seven annual diabetes care processes in the pre and during COVID-19 periods, **Table 1**. We categorized people as meeting annual care guidelines if they had at least one visit per year in each period (i.e., in 2018 and 2019). All others were classified as not meeting guidelines.

Other variables of interest

Baseline characteristics, determined from KPGA EMR and defined as January 1, 2018 included age, sex, self-reported race (Black, White, Other), primary language as English (yes or no), being on a high deductible plan (yes or no), BMI in kg/m^2 (18.5 to <25, 25 to <30, ≥30), comorbidities (i.e., hypertension, congestive heart failure, renal failure, hypothyroidism, hypertensive heart disease, and hypertensive renal disease), and smoking status. Other race was defined as KPGA members who selected Asian, Native Hawaiian/Pacific Islander, American Indian/Alaskan Native, multiple races, and other (values that did not fit well into other values) as their primary race. Median household income and Social Vulnerability Index were determined via linkage to US census tract data. For those missing self-reported race data (n = 1,106, 4.84%), we imputed race based on a previously validated Bayesian Improved Surname and Geocoding (BISG) algorithm (62). This algorithm has previously shown to have a 93% and 94% predictive ability. There is less than 5% of missing data for variables with missing data. A complete case analysis was conducted.

Statistical analysis

Differences in baseline demographic characteristics by telehealth utilization in the pre-COVID-19 period were examined using Chi-square tests for categorical variables, independent t-tests for normally distributed continuous variables, and two-sample Mann-Whitney U tests for non-normally distributed continuous variables. Normality was assessed for all continuous variables using histogram density plots.

Generalized Estimating Equations (GEE) adjusted for baseline age, were used to examine 1) the change in telehealth pre and during COVID-19, 2) the change in adherence to individual diabetes management guidelines stratified pre and during, stratified by telehealth status, and 3) the association between telehealth utilization and adherence to individual diabetes management guidelines completion stratified pre and during COVID-19 with odds ratios (OR) and 95% confidence intervals (CI) reported. The GEE regression technique allows us to take into account the correlation of within-subject data in longitudinal data that is present due to repeated measures for each individual. To compare telehealth utilization pre and during the pandemic, we summarized the proportion of people who utilized telehealth in both time periods, and examined the absolute change over time, defined as the proportion utilizing telehealth during the pandemic minus the proportion utilizing telehealth pre pandemic. To compare obtaining annual diabetes care pre and during the pandemic, we summarized the proportion of people meeting care guidelines in both time periods, and examined the absolute change over time, defined as the proportion meeting guidelines during the pandemic minus the proportion meeting guidelines pre pandemic. Analyses for aim 1 and aim 3 were stratified by age, sex and race, analyses for aim 2 were stratified by telehealth users and non users, and aim 3 analyses were additionally stratified by time period. All analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, North Carolina).

This study was approved by the institutional review board at Emory University (STUDY00002924) and the institutional review board at KPGA (IRB 00000406).

RESULTS

Baseline characteristics

This study included 22,584 KPGA members with prevalent diabetes (mean age 58.9 years [SD: 13.0], 55.5% women) that were enrolled from January 1, 2018 to December 31, 2021. Those who utilized telehealth in the pre-COVID-19 period were more likely to be women, identify as Black, be overweight, a smoker, have English as their primary language, have comorbidities (i.e., hypertension, congestive heart failure, hypertensive heart disease, renal failure, hypertensive renal disease, and hypothyroidism), and have two and three or more comorbidities (vs. none or one) compared to those who did not utilize telehealth, **Table 2**.

Changes in telehealth use pre and during the COVID-19 pandemic

Overall, telehealth utilization increased from 38.7% pre pandemic and 91.5% during the pandemic (**Table 3**). The odds of telehealth utilization in the COVID-19 period (vs pre period) were 17 times higher (95% CI: 16.4, 18.1). For subgroups of interest, increases in telehealth utilization were broadly similar across ages, sexes and races. The absolute change in telehealth utilization from pre to during the COVID-19 pandemic ranged from 49.9% in men to 57.4% among Other race group. The increase in the likelihood of telehealth use during vs pre the COVID-19 pandemic was similar across groups.

Changes in adherence to annual guidelines pre and during the COVID-19 pandemic, stratified by age, sex and race

Among telehealth users, the absolute decline in meeting annual guidelines pre to during the COVID-19 pandemic for checks of HbA1c, UACR, BP, cholesterol, creatinine, eye exams and foot exams was -6.3, -7.5, -12.4, -10.2, -7.1, -4.3, and -1.6, respectively (**Table 4**). Conversely, among non telehealth users, the absolute decline in the percentage meeting annual guidelines pre to during the COVID-19 pandemic for checks of the seven aforementioned processes was -29.4, -18.0, -40.7, -18.6, -31.6, -7.7, and -1.9, respectively. Annual foot exams experienced the smallest absolute decline among both telehealth users (-1.6) and non telehealth users (-1.9). Annual blood pressure checks experienced the largest absolute decline among both telehealth users (-12.4) and non telehealth users (-40.7). Among both non telehealth and telehealth users, the odds of completing annual diabetes care guidelines during the pandemic (vs pre pandemic) for all processes was lower, with odds of annual completion ranging from 25% (OR: 0.75, 95% CI: 0.72, 0.78) (UACR) to 86% (OR: 0.14, 95% CI: 0.12, 0.15) (BP) lower odds among telehealth users in the pandemic period (vs pre) and 53% (OR: 0.47, 95% 0.42, 0.52; OR: 0.47, 95% CI: 0.39, 0.56) (UACR and eye exams) to 87% (OR: 0.13, 95% CI: 0.11, 0.14) (BP) lower odds in non telehealth users in the pandemic period (vs pre). The odds of completing annual checks of blood pressure during the pandemic (vs pre) was similar in telehealth users (86%) and non telehealth users (87%).

Association between telehealth utilization and adherence to annual guidelines, stratified by period and age, sex and race

Telehealth users in both the pre and during pandemic periods had higher odds of completing annual diabetes management guidelines compared to non telehealth users (**Table 5**). In the pre pandemic period, the odds of completing annual diabetes management guidelines for HbA1c, UACR, BP, cholesterol, creatinine, eye exams and foot exams were 1.4 (95% CI: 1.3, 1.5), 1.3 (1.2, 1.4), 3.8, (3.3, 3.4), 1.1 (1.1, 1.2), 2.1 (1.9, 2.2), 1.1 (1.1, 1.2), and 1.3 (1.1, 1.5) times higher for those who utilized telehealth compared to those who did not, respectively. In the COVID-19 period, this effect is increased for all processes and nearly doubles for HbA1c (OR: 2.6, 95% CI: 2.4, 2.8) and creatinine (OR: 4.0, 95% CI: 3.6, 4.3).

All age, sex and race subgroups who utilized telehealth (vs did not) were more likely to adhere to guidelines, and this likelihood of adherence was even greater in the during vs. pre pandemic period with some exceptions (**Table 6**). Comparing telehealth users to non telehealth users, those aged 65+ years at the beginning of the study experienced a decrease in the odds of annual checks of blood pressure (from 5.1 [3.5, 4.5] to 4.8 [4.0, 5.7]) in pre vs during periods. Men experienced a decrease in the odds of annual checks of blood pressure (from 4.0 [3.3, 4.9] to 3.8 [3.2, 4.5]) in pre vs during periods. Those who identified as White experienced a decrease in annual checks of blood pressure (from 4.0 [3.3, 4.9] to 3.8 [3.2, 4.5]) in pre vs during periods. Those who identified as Other race experienced a decrease in the odds of annual eye (from 1.4 [1.1, 1.9] to 1.2 [0.8, 1.9] and foot (from 1.5 [0.7, 3.1] to 0.8 [0.3, 2.2]) exams in pre vs during periods.

DISCUSSION

Among those with diabetes within an integrated healthcare system telehealth use increased dramatically (i.e., by 52.8%) during the COVID-19 pandemic. Adherence to annual diabetes care guidelines was disrupted during the pandemic. However, those who utilized telehealth experienced less disruption in receiving annual diabetes care compared to non telehealth users and were more likely to adhere to annual care guidelines both pre pandemic and during the pandemic. Annual checks of BP were the most disrupted by the pandemic, but less so for telehealth users. There were no differences in these trends by age, sex or race. The broader use of telehealth during the COVID-19 pandemic has exposed potential diabetes care gaps. These results have important implications for understanding the delivery of diabetes care in a post COVID-19 world.

The COVID-19 pandemic brought on an increased use and willingness to use telehealth across all demographic subgroups in the general population (63).The 52.8% increase in telehealth utilization among people with diabetes seen in our study is similar to data from Epic's Cosmos research platform that found a 44.2% increase in all-cause telehealth visits among people with diabetes between March 2019 and February 2021 (49). Similarly, among a non-diabetes specific cohort, a KPGA study found that scheduled telephone appointments and video visits for primary care visits increased 20% and 15%, respectively, between 2019 and 2020 to June 30, 2021 (61). Additionally, this same KPGA study found that the odds of patients using virtual only care (vs in person care) was 20.2 (95% CI: 19.8, 20.7) higher during the pandemic versus pre pandemic. This finding is consistent with our odds of telehealth utilization during the COVID-19 (vs pre) overall in our population of KPGA members with prevalent diabetes. Our findings of similar use of telehealth across age, race, and sex subgroups is dissimilar with studies that show that older adults (52,61), minoritized populations (61,64,65), and men (65,66) are less likely to access telehealth. Differences are likely explained by the relatively uniform access to care in our patient population by way of private health insurance.

In this study, adherence to all annual guidelines declined between 2018 to 2019 and 2020 to 2021 among telehealth users and non telehealth users. Annual checks of blood pressure were most impacted by the disruption of in-person care during the pandemic. Additionally, there were decreased likelihoods of completing BP, foot and eye exams during the pandemic when compared to pre pandemic, which are processes that must be conducted in-person by a healthcare professional. These findings are consistent with findings by Quinton et al., who found that the largest differences in obtaining routine diabetes care between telehealth users and non users were in indicators most likely impacted by a disruption of in-person care. Additionally, Carr et al. (64) found that between March 2020 to December 2020, blood pressure had the highest reduction in the frequency of checks when compared to HbA1c, cholesterol, serum creatinine, urine albumin, and BMI. This is likely due to the requirement for in-person visits for these diabetes care processes.

Our findings of telehealth utilizers being more likely to adhere to annual diabetes care guidelines are consistent with findings of Stamenova et al. (53), who found that patients with a chronic disease who were high users of virtual care appeared to be higher users of the healthcare system in general during the pandemic. Similarly, Quinton et al. (58) found that among those with diabetes in Los Angeles County, US, telemedicine users had an increased likelihood of meeting one of five composite measures of routine care compared to those who used in-person care alone from March 2020 to December 2020.

The mechanisms via which telehealth increases adherence to diabetes care guidelines are unknown. It is possible that telehealth may reduce barriers such as distance to a healthcare provider and/or transportation to healthcare, making overall access and subsequent adherence to guidelines easier (40). It is possible that telehealth users reflect those who are more health conscious, and thus more likely to adhere to recommended guidelines. However, it is more likely that telehealth users simply reflect a population with greater need for healthcare utilization. In this study, we show that telehealth users in the pre pandemic period have a higher burden of chronic conditions (e.g., hypertension, congestive heart failure, hypertensive heart disease, renal disease, hypertensive renal disease, hypothyroidism) as compared with non-telehealth users. Future research is needed to understand the mechanisms by which telehealth improves access and adherence to care guidelines among people with diabetes.

These findings have important implications for diabetes care in a post COVID-19 era. Based on this study, KPGA efficiently shifted to telehealth delivery, with more than 91% of our study population accessing telehealth during the COVID-19 pandemic. This was similar by age, sex and race groups, suggesting equitable access. However, it is estimated that 27.2 million people in the United States are uninsured (64) and 23% of working-age adults are underinsured or had coverage that did not provide them with affordable access to health care (65). There is a need to develop and implement more equitable policies to improve access to telehealth services via health insurance. Additionally, the broader use of telehealth during the COVID-19 pandemic has exposed potential diabetes care gaps. In our study population, there was a significant decrease in proportion of people completing annual guidelines for BP, as well as a decrease in completing annual guidelines eye and foot exams during the pandemic. These findings suggest that there is a possibility of an increased risk of complications including CVD, retinopathy, and neuropathy. Clinicians should be aware of these care gaps and be vigilant in mitigating the consequential complications through rigorous monitoring of glucose levels and encouraging adherence to annual check-ups. Additionally, changes to delivery of diabetes care through telemedicine should be made to narrow these care gaps. Research has shown that greater digital competency in the context of telehealth is associated with greater odds of telehealth use and willingness to continue using telehealth services beyond the pandemic (66). Addressing policy changes to address the digital divide as a social determinant of health may strengthen existing health care and public health systems to allow for greater accessibility of telehealth for those seeking healthcare (67). The long-term sustainability of telehealth has the potential to increase accessibility to care for those with diabetes.

This study has several limitations. First, this study includes a select population consisting of people living in one geographical location with continuous enrollment within a large integrated health system. Thus, results are not generalizable to US adults without health insurance. Nonetheless, these findings allow us to examine the impact of the COVID-19 pandemic on healthcare access among people with relatively uniform access to healthcare via health insurance, the aim of this work. Further we show the difference between those with vs without continuous enrollment is minimal. Second, this study uses three broad categories for race (Black, White, Other) as we lacked power to look at individual races within the Other race group. However, those who identified as Black made up more than half of this study population, a group that is historically underrepresented in research, which is a strength of this study. Third, insurance information such as being on a high deductible plan, which causes differential access to healthcare, was captured only at study entry. Thus, differential access to healthcare within an insured population cannot be examined. Finally, we were limited to data captured within the electronic medical record system of KP at baseline (i.e., pre-pandemic). Therefore, we could not examine the impact of the pandemic on incident comorbidities, nor could we explore the impact of social determinants not captured in EMR data (i.e., education, income).

Conclusions

Among individuals with diabetes within an integrated healthcare system, telehealth use substantially increased during COVID-19 pandemic, and was associated with greater adherence to annual diabetes care guidelines despite disruptions to care. Those who utilized telehealth experienced less disruption in receiving annual diabetes care compared to non telehealth users and were more likely to adhere to annual care guidelines both pre pandemic and during the pandemic. The pandemic caused the most disruption in adherence to annual guidelines for BP, but less so for telehealth users. Long-term follow-up is needed to assess telehealth's role in receiving diabetes care in a post COVID-19 era.

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TABLES

Table 1. A summary of diabetes care guidelines and assessment of completion

Diabetes Care Measure	Purpose	Frequency of checks based on ADA guidelines	Definition of assessment of completion
A1C blood tests (1)	A high A1C increases the risk for complications such as nerve damage, kidney disease and vision impairment	Every six months if the last A1C was in goal range or every three months if medications have changed or the last A1C was not in the target range	At least one lab record for HbA1c per year
Urine Albumin-to-Creatinine Ratio (UACR) (1)	Can indicate if kidney damage is present based on high levels	Annually if individuals have type 2 diabetes or have had type 1 diabetes for at least five years	At least one lab record for UACR per year
Blood pressure (1)	High blood pressure increases chances of heart disease, stroke, vision loss and kidney disease	At every visit with a health care provider	At least one lab record for BP per year
Cholesterol (1)	High low-density lipoprotein (LDL) and triglycerides indicate a risk for cardiovascular disease	Annually	At least one lab record for cholesterol per year
Estimated glomerular filtration rate (eGFR) (1)	An estimate of how well kidneys are functioning based on the level of creatinine in the blood	Annually	At least one lab record for creatinine per year
Dilated eye exam (1)	Diabetes increases the risk for diabetic eye disease	Annually	At least one procedure code record for eye exam per year*
Foot exam (68)	Diabetes increases the risk for ulcers and amputations	Annually	At least one procedure code record for foot exam per year**

*CPT codes: 92002, 92004, 92012, 92014, 92015, 99172 and 99173
**CPT codes: G0245, G0246, G0247, G9226, 11055, 11056, 11057, 11719, 11720, 11721, S0390

Table 2. Baseline characteristics of adult KPGA members with prevalent diabetes in the pre COVID-19 period (2018-2019) in telehealth and non telehealth users

Characteristics	Total population	Telehealth users	Non telehealth users
n (%)	22,854 (100.0)	8833 (38.6)	14021 (61.4)
Demographics			
Age in years, mean (SD)	58.90 (13.0)	59.52 (12.7)	58.50 (13.2)
Age category (%)			
18-44	13.2	11.9	14.1
45-64	51.0	51.3	50.7
65+	35.8	36.8	35.2
Sex (%)			
Women	55.5	61.6	51.7
Men	44.5	38.4	48.3
Race (%)			
White	32.6	33.4	32.1
Black	57.5	59.1	56.6
Other*	9.9	7.5	11.4
High deductible plan at time of enrollment (%)			
Yes	1.9	1.7	2.0
No	98.1	98.3	98.0
Primary language English (%)			
Yes	95.0	97.3	93.6
No	5.0	2.8	6.4
Neighborhood and SES characteristics			
Median household income (USD), median (IQR)	67159 (50705-83958)	67159 (50705-82901)	67048 (50705-84342)
Median household income category (%)			
≤$50,000	24.0	24	23.4
$50,001 - $100,000	64.1	64.5	63.8

$100,001 - $150,000	10.1	9.7	10.3
>$150,000	1.9	1.8	1.9
Social vulnerability index, median (IQR)	0.49 (0.27-0.73)	0.50 (0.27-0.73)	0.49 (0.26-0.73)
Social vulnerability index categories			
Quartile 1 (low vulnerability)	22.8	22.2	23.2
Quartile 2	28.6	28.5	28.7
Quartile 3	27.3	28	26.9
Quartile 4 (high vulnerability)	21.3	21.4	21.3
Comorbidities			
Body mass index in kg/m^2, median (IQR)	32.1 (28.0-37.2)	32.4 (28.3-37.6)	31.9 (27.8-36.9)
Body mass index categories (%)			
Normal weight (18.5 to <25)	10.4	9.1	11.2
Overweight (25.0 to <30.0)	26.7	26.3	27
Obese (≥30.0)	62.9	64.6	61.8
Ever a smoker (%)			
Yes	10.7	11.5	10.2
No	89.3	88.5	89.8
Hypertension (%)	81.7	85.3	79.5
Congestive heart failure (%)	12.9	16.3	10.8
Hypertensive heart disease (%)	22.2	25.5	20.2
Renal failure (%)	20.3	23.6	18.1
Hypertensive renal disease (%)	17.9	21	16
Hypothyroidism (%)	12.5	15.2	10.7
Number of comorbidities (%)**			
None	15.7	12.1	17.9

1	42.7	40.4	44.1
2	17.8	18.8	17.2
≥3	23.8	28.7	20.8

*Includes Asian, Native Hawaiian/Pacific Islander, American Indian/Alaskan Native, other, and multiple races

**Comorbidities assessed were hypertension, congestive heart failure, hypertensive heart disease, renal failure, hypertensive renal disease, and hypothyroidism

Abbreviations: SD = standard deviation; IQR = interquartile range; SES = socio-economic status; USD = United States dollar

Table 3. Changes in telehealth use pre and during the COVID-19 pandemic

	% Utilized Telehealth			
	Pre Pandemic (2018-2019)	**During Pandemic (2020-2021)**	**Absolute Change (%)**	**OR (95% CI)***
Time period (during vs pre COVID-19)	38.7	91.5	52.8	17.3 (16.4, 18.1)
Stratifying factors				
Age (years)				
18-44	34.7	89.9	55.2	16.8 (14.7, 19.1)
45-64	38.9	91	52.1	15.9 (14.8, 17.0)
65+	39.7	92.9	53.2	15.0 (12.4, 18.1)
Sex				
Women	42.9	92.8	49.9	17.4 (16.2, 18.6)
Men	33.3	89.9	56.6	17.9 (16.7, 19.3)
Race				
White	39.6	92.2	52.6	18.2 (16.6, 19.9)
Black	39.7	92	52.3	13.6 (10.2, 18.3)
Other	29.4	86.8	57.4	15.8 (13.7, 18.1)

*ORs adjusted for age at baseline. OR estimates likelihood of being a telehealth user in the during vs pre COVID-19 periods

Table 4. Changes in adherence to annual guidelines pre pandemic vs. during pandemic, stratified by telehealth use

	Non telehealth users				Telehealth users			
	% Meeting Annual Guidelines				% Meeting Annual Guidelines			
Diabetes care processes	Pre Pandemic (2018-2019)	During Pandemic (2020-2021)	Absolute Change (During vs Pre)	Odds Ratio (95% Confidence Interval)*	Pre Pandemic (2018-2019)	During Pandemic (2020-2021)	Absolute Change (During vs Pre)	Odds Ratio (95% Confidence Interval)*
HbA1c	75.8	46.4	-29.4	0.39 (0.36, 0.42)	84.0	77.7	-6.3	0.71 (0.67, 0.74)
UACR	34.8	16.8	-18	0.47 (0.42, 0.52)	42.6	35.1	-7.5	0.75 (0.72, 0.78)
Blood pressure	90.7	50.0	-40.7	0.13 (0.11, 0.14)	97.7	85.3	-12.4	0.14 (0.12, 0.15)
Cholesterol	37.3	18.7	-18.6	0.42 (0.38, 0.47)	41.2	31.0	-10.2	0.65 (0.62, 0.68)
Creatinine	78.1	46.5	-31.6	0.30 (0.28, 0.33)	89.7	82.6	-7.1	0.58 (0.54, 0.62)
Eye exam	13.3	5.6	-7.7	0.47 (0.39, 0.56)	15.8	11.5	-4.3	0.69 (0.65, 0.74)
Foot exam	2.2	0.3	-1.9	0.34 (0.27, 0.44)	3.6	2.0	-1.6	0.61 (0.54, 0.69)

*Compares during vs pre period, adjusted for baseline age
Abbreviations: KPGA = Kaiser Permanente Georgia; UACR urine albumin-to-creatinine ratio

Table 5. Association between telehealth use and adherence to annual guidelines, stratified by period

Diabetes care processes	Telehealth use	Pre COVID-19*	During COVID-19*
	No	Ref	Ref
HbA1c	Yes	1.4 (1.3, 1.5)	2.6 (2.4, 2.8)
	No	Ref	Ref
UACR	Yes	1.3 (1.2, 1.4)	2.1 (1.9, 2.3)
	No	Ref	Ref
Blood pressure	Yes	3.8 (3.3, 4.4)	4.1 (3.7, 4.5)
	No	Ref	Ref
Cholesterol	Yes	1.1 (1.1, 1.2)	1.7 (1.5, 1.9)
	No	Ref	Ref
Creatinine	Yes	2.1 (1.9, 2.2)	4.0 (3.6, 4.3)
	No	Ref	Ref
Eye exam	Yes	1.1 (1.1, 1.2)	1.7 (1.4, 2.0)
	No	Ref	Ref
Foot exam	Yes	1.3 (1.1, 1.5)	2.3 (1.7, 2.9)

*ORs adjusted for age at baseline
Abbreviations: KPGA = Kaiser Permanente Georgia; UACR = Urine albumin-to-creatinine ratio

Table 6. Association between telehealth use and adherence to annual guidelines, stratified by period and age, sex and race

	Odds Ratio (95% CI)*	
Diabetes Care Process	**Pre Pandemic (2018-2019)**	**During Pandemic (2020-2021)**
By Age		
18-44 years		
HbA1c	1.5 (1.3, 1.7)	2.9 (2.3, 3.7)
UACR	1.7 (1.4, 2.0)	2.9 (2.0, 4.2)
Blood pressure	2.9 (2.2, 3.7)	3.7 (3.0, 4.6)
Cholesterol	1.3 (1.1, 1.6)	2.0 (1.4, 2.9)
Creatinine	1.9 (1.7, 2.2)	3.5 (2.8, 4.4)
Eye exam	1.3 (0.8, 2.1)	1.5 (0.6, 3.3)
Foot exam	1.1 (0.4, 3.8)	1.9 (0.9, 4.3)
45-64 years		
HbA1c	1.5 (1.4, 1.6)	2.9 (2.5, 3.1)
UACR	1.3 (1.3, 1.4)	2.0 (1.8, 2.3)
Blood pressure	4.1 (3.4, 4.9)	3.9 (3.5, 4.4)
Cholesterol	1.2 (1.1, 1.3)	1.9 (1.6, 2.2)
Creatinine	2.0 (1.8, 2.3)	3.8 (3.4, 3.2)
Eye exam	1.2 (1.0, 1.4)	2.0 (1.4, 2.9)
Foot exam	1.8 (1.3, 2.4)	3.1 (1.7, 5.8)
65+ years		
HbA1c	1.3 (1.1, 1.4)	2.3 (1.9, 2.7)
UACR	1.1 (1.0, 1.2)	2.0 (1.7, 2.3)
Blood pressure	5.1 (3.5, 7.3)	4.8 (4.0, 5.7)
Cholesterol	1.0 (0.9, 1.1)	1.4 (1.2, 1.7)
Creatinine	2.3 (1.9, 2.7)	4.5 (3.8, 5.4)
Eye exam	1.1 (1.0, 1.2)	1.6 (1.3, 1.9)
Foot exam	1.2 (1.0, 1.4)	1.9 (1.4, 2.5)
By Sex		
Women		
HbA1c	1.4 (1.2, 1.5)	2.3 (2.0, 2.6)

UACR	1.3 (1.2, 1.4)	1.9 (1.6, 2.2)
Blood pressure	3.4 (2.8, 4.2)	4.1 (3.6, 4.6)
Cholesterol	1.2 (1.1, 1.2)	1.6 (1.4, 1.9)
Creatinine	2.0 (1.9, 2.3)	3.8 (3.4, 4.4)
Eye exam	1.1 (1.0, 1.2)	1.7 (1.3, 2.2)
Foot exam	1.4 (1.2, 1.8)	2.9 (1.9, 4.2)
Men		
HbA1c	1.5 (1.4, 1.7)	2.9 (2.6, 3.3)
UACR	1.4 (1.3, 1.5)	2.3 (2.0, 2.6)
Blood pressure	4.0 (3.3, 4.9)	3.9 (3.4, 4.5)
Cholesterol	1.1 (1.0, 1.2)	1.8 (1.6, 2.1)
Creatinine	2.1 (1.9, 2.4)	4.2 (3.7, 4.8)
Eye exam	1.2 (1.1, 1.3)	1.6 (1.3, 2.1)
Foot exam	1.2 (1.0, 1.5)	2.1 (1.5, 2.9)
By Race		
White		
HbA1c	1.2 (1.1, 1.4)	2.0 (1.8, 2.4)
UACR	1.2 (1.1, 1.3)	1.6 (1.3, 1.9)
Blood pressure	4.3 (3.3, 5.6)	3.8 (3.2, 4.5)
Cholesterol	1.0 (0.9, 1.1)	1.4 (1.2, 1.7)
Creatinine	2.0 (1.7, 2.3)	3.4 (2.9, 4.0)
Eye exam	0.9 (0.8, 1.1)	1.4 (1.1, 1.9)
Foot exam	1.3 (1.0, 1.6)	3.1 (1.7, 5.8)
Black		
HbA1c	1.5 (1.4, 1.7)	2.9 (2.6, 3.2)
UACR	1.3 (1.2, 1.4)	2.3 (2.0, 2.7)
Blood pressure	3.9 (3.3, 4.7)	4.2 (3.7, 4.7)
Cholesterol	1.2 (1.1, 1.3)	2.0 (1.7, 2.3)
Creatinine	2.2 (2.0, 2.4)	4.3 (3.8, 4.8)
Eye exam	1.2 (1.1, 1.4)	2.1 (1.6, 2.7)
Foot exam	1.3 (1.1, 1.5)	2.1 (1.6, 2.9)
Other		

HbA1c	1.4 (1.1, 1.7)	2.9 (2.3, 3.6)
UACR	1.3 (1.1, 1.5)	2.0 (1.5, 2.6)
Blood pressure	2.6 (1.8, 3.7)	4.1 (3.2, 5.2)
Cholesterol	1.3 (1.1, 1.5)	2.1 (1.6, 2.7)
Creatinine	1.6 (1.3, 2.1)	3.9 (3.1, 4.9)
Eye exam	1.4 (1.1, 1.9)	1.2 (0.8, 1.9)
Foot exam	1.5 (0.7, 3.1)	0.8 (0.3, 2.2)

*Compares telehealth utilization vs no telehealth utilization, adjusted for baseline age.
Abbreviations: GEE = generalized estimating equation; KPGA = Kaiser Permanente Georgia; UACR = Urine-albumin-creatinine ratio

FIGURES

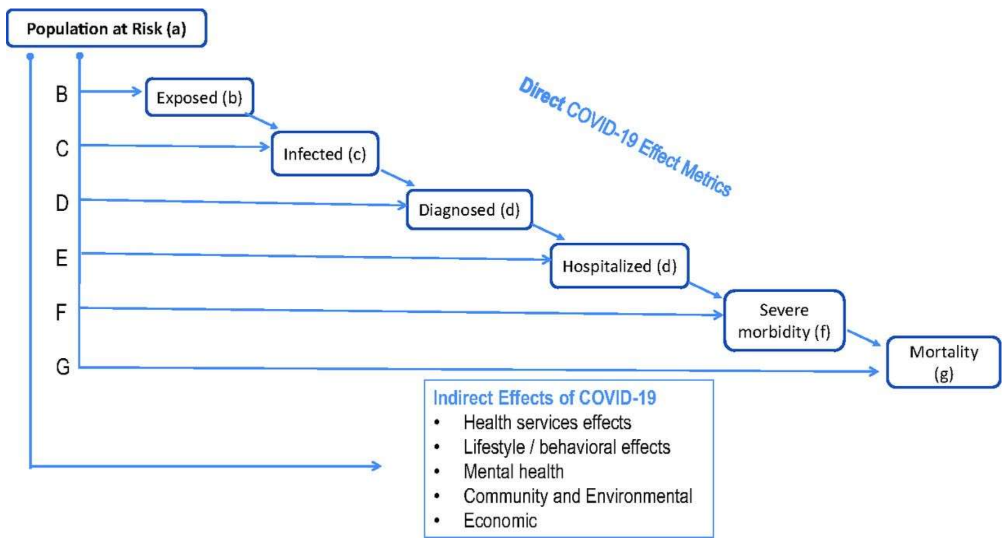

Figure 1. Cascade of metrics for epidemiologic studies to consider in studies of the association of diabetes with direct and indirect outcomes of the COVID-19 pandemic. From Gregg, E. W., Sophiea, M. K., & Weldegiorgis, M. (2021). Diabetes and COVID-19: Population Impact 18 Months Into the Pandemic. Diabetes Care, 44(9), 1916–1923. https://doi.org/10.2337/dci21-0001

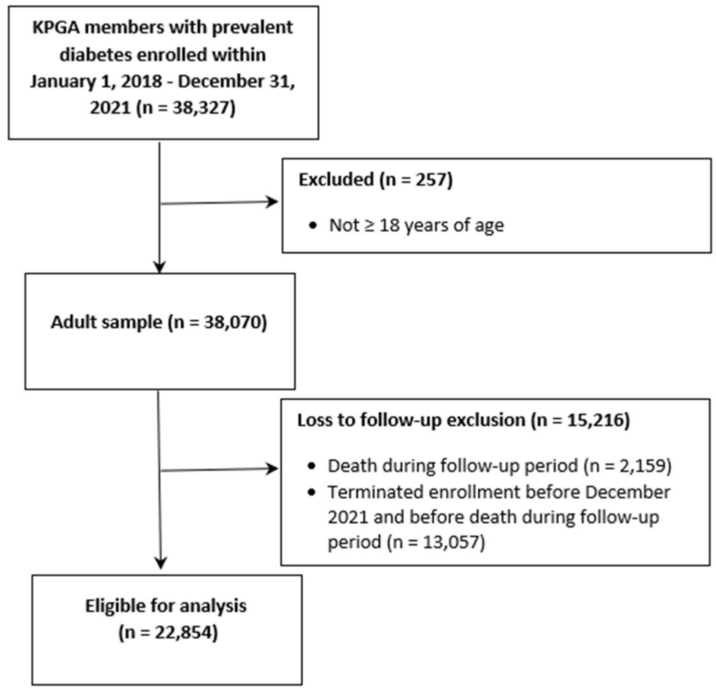

Figure 2. Flow diagram of study inclusion and exclusion criteria for study population; adult KPGA members with prevalent diabetes; 2018-2021

SUPPLEMENTARY

Supplementary table 1. Baseline characteristics of KPGA members with continuous enrollment and discontinuous enrollment from January 1, 2018 to December 31, 2021

Characteristics	Continuous enrollment	Died or discontinued enrollment*
n (%)	22854 (60.0)	15216 (40.0)
Demographics		
Age in years, mean (SD)	58.9 (13.0)	52.4 (13.5)
Age category (%)		
18-44	13.2	22.2
45-64	51.0	54.3
65+	35.8	23.5
Sex (%)		
Female	55.5	54.5
Male	44.5	45.5
Race (%)		
White	32.6	35.4
Black	57.5	49.9
Other**	9.9	14.8
High deductible plan at time of enrollment (%)		
Yes	1.9	4.4
No	98.1	95.6
Primary language English (%)		
Yes	95.0	91.3
No	5.0	8.8
Neighborhood and SES characteristics		
Median household income (USD), median (IQR)	67159 (50705-83958)	66244 (50118-84120)
Median household income (%)		
≤$50,000	24.0	24.8
$50,001 - $100,000	64.1	63.9
$100,001 - $150,000	10.1	9.6

>$150,000	1.9	1.7
Social vulnerability index, median (IQR)	0.49 (0.27-0.73)	0.48 (0.26-0.73)
Social vulnerability index categories		
Quartile 1 (low vulnerability)	22.8	23.7
Quartile 2	28.6	28.2
Quartile 3	27.3	26.2
Quartile 4 (high vulnerability)	21.3	21.9
Comorbidities		
Body mass index in kg/m^2, median (IQR)	32.08 (27.98-37.18)	32.12 (27.78-37.64)
Body mass index (%)		
Normal weight (18.5 to <25)	10.4	12.1
Overweight (25 to <30)	26.7	25.3
Obese (≥30)	62.9	62.5
Ever a smoker (%)		
Yes	10.7	13.0
No	89.3	87.0
Hypertension (%)	81.7	72.8
Congestive heart failure (%)	12.9	14.7
Hypertensive heart disease (%)	22.2	16.5
Renal failure (%)	20.2	18.7
Hypertensive renal disease (%)	17.9	15.7
Hypothyroidism (%)	12.5	12.5
Number of comorbidities (%)**		
None	15.7	24.0
1	42.7	42.1
2	17.8	12.8
≥3	23.8	21.2

*≥18 years of age

**Includes Asian, Native Hawaiian/Pacific Islander, American Indian/Alaskan Native, and multiple races

***Comorbidities assessed were hypertension, congestive heart failure, hypertensive heart disease, renal failure, hypertensive renal disease, and hypothyroidism
Abbreviation: SD = standard deviation; IQR = interquartile range; SES = socio-economic status; USD = United States dollar