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Access to telehealth and changes in diabetes care patterns during the pandemic: evidence from a large integrated health system in the Southeast USA

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ABSTRACT

Introduction To examine the role of telehealth in diabetes care and management during versus pre-COVID-19 pandemic.

Research design and methods We included adults (≥18 years) with prevalent diabetes as of January 1, 2018, and continuously enrolled at Kaiser Permanente Georgia through December 31, 2021 (n=22,854). We defined pre (2018–2019) and during COVID-19 (2020–2021) periods. Logistic generalized estimating equations (GEEs) assessed the within-subject change in adherence to seven annual routine care processes (blood pressure (BP), hemoglobin A1C (HbA1c), cholesterol, creatinine, urine-albumin-creatinine ratio (UACR), eye and foot examinations) pre versus during COVID-19 among telehealth users (ie, more than one telehealth visit per year per period) and non-telehealth users. Linear GEE compared mean laboratory measurements pre versus during COVID-19 by telehealth use.

Results The proportion of telehealth users increased from 38.7% (2018–2019) to 91.5% (2020–2021). During (vs pre) the pandemic, adherence to all care processes declined in telehealth (range: 1.6% for foot examinations to 12.4% for BP) and non-telehealth users (range: 1.9% for foot examinations to 40.7% for BP). In telehealth users, average HbA1c (mean difference: 0.4% (95% CI 0.2% to 0.6%), systolic BP (1.62 mm Hg (1.44 to 1.81)), and creatinine (0.03 mg/dL (0.02 to 0.04)), worsened during (vs pre) COVID-19, while low density lipoprotein (LDL) cholesterol improved (−9.08 mg/dL (−9.77 to −8.39)). For UACR, odds of elevated risk of kidney disease increased by 48% (OR 1.48 (1.36–1.62)). Patterns were similar in non-telehealth users.

Conclusions Telehealth use increased during the pandemic and alleviated some of the observed declines in routine diabetes care and management.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The COVID-19 pandemic led to a shift in use of telehealth services, yet the extent to which this impacted adherence to recommended annual screenings and risk factor management among people with diabetes is less clear.

WHAT THIS STUDY ADDS

⇒ In this study, we show that telehealth use increased by 52.8% pre versus during the pandemic and uptake was similar across race, age, and sex groups.

⇒ Adherence to guideline-recommended screenings among people with diabetes declined during the COVID-19 pandemic, although this effect was ameliorated in telehealth versus non-telehealth users.

⇒ Our data also suggest that care disruptions may have led to worsening glucose, kidney, and (some) cardiovascular risk profiles, although the impact of telehealth is unclear.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ As we move into a telehealth-forward world, understanding the long-term implications of care gaps experienced during the pandemic will be important for the ongoing management of people with diabetes.

INTRODUCTION

To reduce the risk of diabetes-related complications including diabetic retinopathy, nephropathy, neuropathy, and cardiovascular disease (CVD), current guidelines from the American Diabetes Association (ADA) recommend that people with diabetes have at least annual checks to measure blood pressure (BP), HbA1c, eye and foot examinations, body mass index (BMI), serum creatinine (to estimate glomerular filrration (eGFR), and urine-albumin-to-creatinine ratio (UACR).[1] Historically, these annual checks have required in-person visits with healthcare providers. However, in March 2020, the COVID-19 pandemic severely disrupted access to routine healthcare with important implications for people managing their diabetes and future risk of complications.[2]

To ensure continuity of care during the pandemic, many providers shifted to offering telehealth visits. However, few studies today have examined the impact of telehealth on diabetes management to date, and those that have resulted in mixed outcomes. For example, an Australian study reported improved glycemic control in people with diabetes who used telehealth as compared with people who attended in-person consultations, although fewer people were having their glucose tested in the telehealth group.[3] In a California-based study, patients who used telehealth had a higher likelihood of meeting components in a five-item composite measure of diabetes quality of care (ie, systolic/diastolic blood pressure (BP) <140/90 mm Hg, HbA1c <8%, active prescription for statins and/or antiplatelet agents if not contraindicated, and non-use or quitting of tobacco) during the pandemic compared with those who did not use telehealth.[4] In contrast, an Italian study among people with type 2 diabetes reported that telehealth was linked to less frequent screenings of long-term complications (ie, retinopathy, CVD, myocardial infarction, stroke, foot complications, eGFR <60 mL/min, and dialysis).[5] In single-center studies in Romania, Saudi Arabia, and China, telehealth use during the pandemic appeared to be associated with improvements in glucose control, although most studies were limited to less than 6 months of follow-up, excluding the Romanian study which included 12 months of follow-up.[6–8] Evaluation of the extent to which the COVID-19 pandemic impacted the use of telehealth and diabetes management over a longer follow-up time is needed. Furthermore, whether telehealth access is equitable among subgroups of the population has not yet been explored. Understanding who is using telehealth and how it has impacted diabetes management during the pandemic is essential for public health planning.

Therefore, using data from a large integrated healthcare system, we assessed changes in the uptake of telehealth pre versus during the COVID-19 pandemic and the impact on adherence to guideline-recommended routine care goal achievement (eg, HbA1c testing, glycemic control) with at least 2 years of post-pandemic data. We examined this in the overall population, and by age, sex, and race. This work is guided by the socioecological model of health, and although our analysis is limited to individual-level data, our interpretations consider the multiple levels of influence of health and health behaviors.

RESEARCH DESIGN AND METHODS

Data sources and study population

In this retrospective cohort study, we identified all adult (≥18 years) members of Kaiser Permanente Georgia (KPGA), a large health maintenance organization, with prevalent diabetes as of January 1, 2018 (n=39,327). Prevalent diabetes was defined as a history of at least one diagnosis code for diabetes (International Classification of Disease 9th Clinical Modification (ICD-9-CM) codes 249, 250 prior to October 2015, and ICD-10-CM codes E08–E13, from October 2015 onward), use of antihyperglycemic 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 diabetes, results of this study are broadly applicable to people with type 2 diabetes.[9]

KPGA members who were less than 18 years of age at study start (n=257), who died during follow-up (n=2159) or who discontinued their enrollment (ie, canceled their KPGA insurance coverage) prior to December 31, 2021 (n=13 057) were excluded. This allowed us to follow up the same individuals across pre (2018–2019) and during (2020–2021) pandemic periods. The final cohort included 22,584 adult members with prevalent diabetes and continuous enrollment from January 1, 2018 to December 31, 2021 (online supplemental figure 1). A comparison of those who were included in this study and those with who were excluded revealed that those who discontinued enrollment within the study period were more likely to be younger, identify as white or other race, be on a high deductible plan, not have English as their primary language, and had fewer comorbidities (online supplemental table 1). A waiver of informed consent was approved for use of this deidentified data.

Telehealth use

KPGA transitioned to a 'Virtual First' model of ambulatory care shortly after the March 13, 2020 declaration of the COVID-19 outbreak national emergency.[10] Telehealth in both the pre and during COVID-19 periods was defined as a virtual visit or scheduled telephone call. We classified individuals as a telehealth user if they had at least one telehealth visit per period (ie, in 2018 or 2019 for the pre-pandemic period and in 2020 or 2020 for the during pandemic period). All others were classified as non-telehealth users. We chose to classify telehealth utilization this way to keep the definition consistent in both time periods; telehealth utilization was less common during the pre-pandemic period, and therefore used our definition across both time periods.

Diabetes care processes and management

We examined seven annual diabetes care processes—measurement of HbA1c, UACR, BP, cholesterol, creatinine, eye examinations, and foot examinations (online supplemental table 2). BMI, although recommended by ADA, was not included as we did not have these data captured in both pre and during pandemic periods. We categorized people as meeting each guideline-recommended annual care process if they met at least one care goal per year in either of each 2-year period. All others were classified as not meeting the guideline-recommended goal. For diabetes management, we assessed five measures of control including HbA1c, UACR, BP, low density lipoprotein (LDL) cholesterol, and creatinine. For each period, we determined the

average of each measurement from KPGA's electronic medical record (EMR) which includes all laboratory measurements for each member within each period, with the exception of UACR. For UACR, data were highly skewed and thus we compared the proportion of adults considered at high risk for kidney disease (ie, defined as UACR ≥300 mg/g).[11] Of note, we were unable to ascertain whether the diabetes care process or measurement occurred during the telehealth visit or not. Foot examinations, for example, were unlikely to occur during a telehealth visit. The goal of this study, however, was to compare telehealth users with non-telehealth users rather than whether or not the diabetes care process occurred in the telehealth setting.

Covariates

Member-level characteristics were ascertained from KPGA's EMR and included age, race, whether or not on a high deductible plan at enrollment, whether or not primary language is English, BMI, and comorbidities. Race was categorized as black, white, and other, with other consisting of KPGA members who selected Asian, Native Hawaiian/Pacific Islander, American Indian/Alaskan Native, multiple races, and other (not represented by the remaining categories) as their primary race. These races were combined due to the limited sample sizes of each of these categories of race. Ethnicity was not included due to missing data. For those missing self-reported race data (n=1106; 4.84%), a Bayesian method was applied that integrated surname and geocoded information to impute self-reported race.[12] This approach has previously shown high correlation (76%) with self-reported race with other KP databases.[12]

BMI was categorized as normal weight (from 18.5 to <25 kg/m^2), overweight (from 25.0 to <30.0 kg/m^2), and obese (≥30.0 kg/m^2). The number of comorbidities (categorized as none, 1, 2, 3+) was ascertained based on the following comorbidities that have a relation with diabetes: hypertension, congestive heart failure (CHF), hypertensive heart disease, renal failure, hypertensive renal disease, and hypothyroidism. Comorbidities were defined using the Elixhauser Comorbidity Index of ICD-9 and ICD-10 codes[13] and represent prevalent conditions as of January 1, 2018. In addition, retinopathy was defined as diabetes with ophthalmic complications, and neuropathy was defined as diabetes with neurological conditions or a history of non-traumatic amputation. We also included neighborhood-level variables, ascertained by linking member zip code to US census tract data, and included median household income (≤US$50,000, US$50,001–US$100,000, US$100,001–US$150,000, >US$150,000) and Social Vulnerability Index (SVI; quartile 1=low vulnerability and quartile 4=high vulnerability). For all non-laboratory measurement variables, <0.5% of data was missing.

Statistical analysis

All individuals in this longitudinal cohort were followed up from January 1, 2018 until December 31, 2021. We compared characteristics in telehealth versus non-telehealth in the pre-COVID period users using t-tests and χ^2 where appropriate. Means and medians were reported when summarizing the study population based on normality.

To compare changes in telehealth utilization pre versus during the pandemic, we summarized the proportion of people who used telehealth in both time periods and examined the absolute change over time, defined as the proportion using telehealth during the pandemic minus the proportion using telehealth pre-pandemic. We used generalized estimating equation (GEE) regressions to examine the within-subject change in telehealth use pre vs during COVID, adjusted for baseline age, and reported ORs and 95% CIs.

To examine changes in the proportion of people meeting guideline-recommended annual care goals (ie, screening for A1c, BP, etc), we similarly examined the absolute change over time in the proportion of KPGA members meeting each guideline in pre versus during COVID periods. This was stratified by telehealth status to determine if changes over time were different in telehealth and non-telehealth users. The within-subject change in adherence to guideline-recommended routine care processes pre versus during COVID, by telehealth use, and adjusted for baseline age, was assessed using GEE regression as described above. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test.

To compare mean laboratory measurements of HbA1c, BP, creatinine, and LDL cholesterol pre (2018–2019) versus during (2020–2021) the pandemic, we similarly examined the absolute change over time and performed linear GEE regressions, adjusted for baseline age and stratified by telehealth status. For UACR, we compared the proportion of adults at high risk for kidney disease (ie, UACR ≥300 mg/g) and reported ORs (reference=pre-period) as UACR was skewed and thus linear regression was not appropriate. Of note, the same individuals were included in the pre and during COVID-19 periods. Therefore, we did not adjust for race, sex, or comorbidities in analyses, which were only ascertained at baseline. All analyses were done overall, and by age, sex, and race subgroups.

Sensitivity analyses

In sensitivity analyses, we examined changes in adherence to recommended screenings among those without prevalent CHF, retinopathy, or neuropathy (n=12,437, ie, individuals who do not need to be 'screened' for complications as they already have them) and applied a looser definition of meeting screening guidelines (ie, at least one care process in each 2-year period (vs one per year in primary analyses)).

Data and resource availability

The data that support the findings of this study are available from KPGA, but restrictions apply to the availability of these data, which were used under license for the current study and therefore are not publicly available. Data are, however, available from the authors on reasonable request and with permission of KPGA.

RESULTS

Baseline characteristics

Among the 22,584 KPGA members with prevalent diabetes that were continuously enrolled between 2018 and 2021, mean age was 58.9 (±13.0) years, 55.5% were women, and 57.5% identified as black (table 1). Those who used 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 (ie, hypertension, CHF, hypertensive heart disease, renal failure, hypertensive renal disease, and hypothyroidism), and have more than two comorbidities (vs none or one) compared with those who did not use telehealth. Patterns were similar in telehealth versus non-telehealth users during COVID (table 1).

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

Overall, the proportion of KPGA members using telehealth increased by 52.8%, from 38.7% pre-pandemic to 91.5% during the pandemic (table 2). The odds of telehealth utilization, adjusted for age, were 17 times higher (95% CI 16.4 to 18.1) pre versus during COVID-19, and this was similar across age, sex, and race groups.

Changes in adherence to annual guideline-recommended care goals pre and during the COVID-19 pandemic in telehealth users and non-users

Among telehealth users, the proportion of individuals meeting care guidelines declined across all indices during versus pre-pandemic periods, with greatest absolute declines seen for BP (−12.4%) and smallest for foot examinations (−1.6%) (table 3). Among non-telehealth users, absolute declines were greater as compared with telehealth users, with greatest declines of 40.7% for BP and smallest declines of 1.9% for foot examinations. Patterns were similar across age, sex, and race subgroups (online supplemental file 1).

The relative impact of telehealth on adherence to each care goal was greater in the during versus pre-pandemic periods (online supplemental file 1). For example, pre-COVID-19, telehealth users were 40% (OR 1.4 (95% CI 1.3 to 1.5)) more likely to adhere to annual HbA1c screenings, while during COVID-19, telehealth users were 160% (OR 2.6 (2.4 to 2.8)) more likely to adhere to the same screenings.

Changes in mean diabetes measurements pre versus during the COVID-19 pandemic

Among telehealth users, there was an increase in mean HbA1c (mean difference: 0.4% (95% CI 0.2% to 0.6%), systolic BP (1.62 mm Hg (1.44 to 1.81)), and creatinine (0.03 mg/dL (0.02 to 0.04)), while mean LDL cholesterol declined (−9.08 mg/dL (−9.77 to −8.39)). For UACR, the odds of an elevated risk of kidney disease increased by 48% (OR 1.48 (1.36 to 1.62)) (table 4). Among non-telehealth users, patterns were similar though declines in LDL cholesterol were smaller (−4.36 mg/dL (−5.92 to −2.81), HbA1c increases were smaller (0.17% (0.11% to 0.22%)), and increases in systolic BP were greater (2.05 mm Hg (1.51 to 2.60)) as compared with telehealth users.

Sensitivity analyses

When the definition of 'meeting guideline-recommended care goals' for diabetes care process was loosened from one per year to one per 2 years, patterns were similar. As expected, however, the proportion of individuals meeting guidelines was greater (online supplemental table 5). Restricting to people without prevalent neuropathy, retinopathy, or CHF also yielded similar findings to the total population (online supplemental table 6).

DISCUSSION

Among people with diabetes in a managed care setting, telehealth utilization increased significantly during the COVID-19 pandemic and this shift was similar across race, age, and sex. Adherence to all seven diabetes care processes decreased significantly during the pandemic with greatest declines seen for adherence to BP screening which typically requires in-person visits. Importantly, those who were using telehealth appear to be less impacted by the healthcare disruptions that the COVID-19 pandemic generated and were more likely to continue to adhere to annual diabetes screenings. Further, we show preliminary evidence that disruptions to diabetes care may have led to worsening glucose, kidney, and some cardiovascular risk profiles. These findings have important implications for understanding the role of telehealth in the management of diabetes and diabetes-related complications in a post-COVID-19 world.

The significant 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.[14] Similarly, among a non-diabetes-specific cohort, a Kaiser Permanente (KP) study found that for those who used scheduled telephone appointments and video visits for primary care visits, the likelihood of patients using virtual only care (vs in person care) was 20.2 (95% CI 19.8 to 20.7) times higher during the pandemic vs pre-pandemic in the KPGA cohort.[10] Two other KP studies of three geographically diverse KP regions (Colorado, Georgia, and Mid-Atlantic States) with non-diabetes-specific

Table 1 Baseline characteristics of adult KPGA members with prevalent diabetes in telehealth and non-telehealth users

	2018–2019			2020–2021	
Characteristics	**Total population**	**Telehealth users**	**Non-telehealth users**	**Telehealth users**	**Non-telehealth users**
N (%)	22,854 (100.0)	8833 (38.6)	14,021 (61.4)	20,920 (91.5)	1934 (8.5)
Demographics					
Age in years, mean (SD)	58.9 (13.0)	59.5 (12.7)	58.5 (13.2)	59.1 (13.0)	57.1 (13.2)
Age category (%)					
18–44	13.2	11.9	14.1	13.0	15.8
45–64	51.0	51.3	50.7	50.7	54.2
65+	35.8	36.8	35.2	29.9	36.4
Sex (%)					
Women	55.5	61.6	51.7	56.3	47.0
Men	44.5	38.4	48.3	43.7	53.0
Race (%)					
White	32.6	33.4	32.1	32.9	29.9
Black	57.5	59.1	56.6	57.8	54.7
Other*	9.9	7.5	11.4	9.4	15.5
High deductible plan at time of enrollment (%)					
Yes	1.9	1.7	2.0	1.8	3.0
No	98.1	98.3	98.0	98.2	97.1
Primary language English (%)					
Yes	95.0	97.3	93.6	95.6	88.9
No	5.0	2.8	6.4	4.4	11.1
Neighborhood and SES characteristics					
Median household income (US$), median (IQR)	67,159 (50,705–83,958)	67,159 (50,705–82,901)	67,048 (50,705–84,342)	67,159 (50,893–83,958)	66,991 (49,719–84,545)
Median household income category (%)					
≤US$50,000	24.0	24.0	23.4	23.8	25.3
US$50,001–US$100,000	64.1	64.5	63.8	64.3	61.9
US$100,001–US$150,000	10.1	9.7	10.3	10.0	11.0
>US$150,000	1.9	1.8	1.9	1.9	1.9

Continued

Table 1 Continued

	2018–2019		2020–2021		
Social Vulnerability Index, median (IQR)	0.49 (0.27–0.73)	0.50 (0.27–0.73)	0.49 (0.26–0.73)	0.49 (0.27–0.73)	0.49 (0.25–0.73)
Social Vulnerability Index categories					
Quartile 1 (low vulnerability)	22.8	22.2	23.2	22.6	24.6
Quartile 2	28.6	28.5	28.7	28.7	27.0
Quartile 3	27.3	28.0	26.9	27.3	27.0
Quartile 4 (high vulnerability)	21.3	21.4	21.3	21.3	21.4
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)	32.2 (28.1–37.3)	30.8 (26.9–35.6)
Body mass index categories (%)					
Normal weight (18.5–<25 kg/m^2)	10.4	9.1	11.2	10.0	14.6
Overweight (25.0–<30.0 kg/m^2)	26.7	26.3	27.0	26.3	30.6
Obese (≥30.0 kg/m^2)	62.9	64.6	61.8	63.6	54.8
Ever a smoker (%)					
Yes	10.7	11.5	10.2	10.9	9.1
No	89.3	88.5	89.8	89.1	91.0
Hypertension (%)	81.7	85.3	79.5	82.9	68.6
Congestive heart failure (%)	12.9	16.3	10.8	13.6	5.2
Hypertensive heart disease (%)	22.2	25.5	20.2	23.2	11.8
Renal failure (%)	20.3	23.6	18.1	21.1	11.4
Hypertensive renal disease (%)	17.9	21.0	16.0	18.8	8.3
Hypothyroidism (%)	12.5	15.2	10.7	13.0	6.5

Continued

Table 1 Continued

	2018–2019			2020–2021		
Number of comorbidities (%)†						
None	15.7	12.1	17.9	14.5	28.8	
1	42.7	40.4	44.1	42.3	47.1	
2	17.8	18.8	17.2	18.2	13.2	
≥3	23.8	28.7	20.8	25.0	11.0	

*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.
KPGA, Kaiser Permanente Georgia; SES, socioeconomic status.

cohorts found increases in virtual care encounters across regions.[15 16] Our findings of similar use of telehealth across age, race, and sex subgroups is dissimilar with some other studies that show that older adults,[10 17] minority populations,[10 18 19] and men[19] are less likely to access telehealth in non-diabetes-specific studies. Differences in findings may be explained by the relatively uniform access to care in our patient population by way of health insurance, an important finding.

In this study, screenings for all diabetes care processes declined during COVID-19, with greatest declines seen for those requiring in-person care such as BP and creatinine measurements. Other studies have found that screenings that needed in-person completion,[4] including BP,[20] were most impacted by a disruption of in-person diabetes care. Our findings of telehealth users being more likely to adhere to annual diabetes care guidelines are consistent with findings of Quinton *et al*,[4] who found that among those with diabetes in Los Angeles County, USA, telehealth users had an increased likelihood of meeting one of five composite measures of routine care compared with those who used in-person care alone during the first 9 months of the pandemic.

Our examination of average laboratory measurements suggests that HbA1c, BP, and UACR worsened over time, while LDL cholesterol significantly improved. This was especially true for telehealth users (vs non-telehealth users). These data should be interpreted with caution owing to the large proportion of individuals in our population missing recorded laboratory measurements (pre-pandemic ranging from 0.2% for BP and 33.6% for UACR; during pandemic ranging from 3.8% for BP and 36.8% for UACR). A study of Medicare patients with type 2 diabetes in Louisiana found that HbA1c control, BP, and LDL cholesterol was better among those who used telehealth during the pandemic compared with those who did not.[21] This same study found that telehealth users saw an improvement in average HbA1c during the pandemic, whereas we found a worsening in HbA1c regardless of telehealth status. Among 130 adults with uncontrolled type 2 diabetes in Saudi Arabia, HbA1c significantly decreased from 9.98 to 8.32 ($p<0.001$) after implementation of a telehealth care intervention during the pandemic.[5] In another single center randomized controlled trial in China, individuals with type 2 diabetes during the COVID pandemic were randomized to receive telehealth (vs conventional outpatient appointment) and, at the end of 6 months, those in the intervention arm had better glucose control, lower weight, and better depression scores than the control arm.[6] In Romania, HbA1c increased during the pandemic among 328 individuals with type 2 diabetes from a single center, yet telemedicine appeared to attenuate some of these increases.[7] Despite the promising findings of these early studies on the impact of telehealth for diabetes management, longer follow-up is needed to fully elucidate the impact of the COVID-19 pandemic on long term glucose, cardiovascular, and kidney risk factor profiles, and the

Table 2 Changes in the proportion of KPGA members using telehealth pre and during the COVID-19 pandemic

	Pre-pandemic (2018–2019) (%)	During pandemic (2020–2021) (%)	Absolute change (%)	OR (95% CI)*
Overall	38.7	91.5	52.8	17.3 (16.4 to 18.1)
Age (years)				
18–44	34.7	89.9	55.2	16.8 (14.7 to 19.1)
45–64	38.9	91.0	52.1	15.9 (14.8 to 17.0)
65+	39.7	92.9	53.2	15.0 (12.4 to 18.1)
Sex				
Women	42.9	92.8	49.9	17.4 (16.2 to 18.6)
Men	33.3	89.9	56.6	17.9 (16.7 to 19.3)
Race				
White	39.6	92.2	52.6	18.2 (16.6 to 19.9)
Black	39.7	92.0	52.3	13.6 (10.2 to 8.3)
Other†	29.4	86.8	57.4	15.8 (13.7 to 18.1)

*Compares during versus pre period, adjusted for baseline age.
†Includes Asian, Native Hawaiian/Pacific Islander, American Indian/Alaskan Native, other, and multiple races.
KPGA, Kaiser Permanente Georgia.

impact telehealth has in mitigating complications. Use of national cross-sectional biomedical surveys (eg, National Health and Nutrition Examination Survey), rather than EMR or randomized controlled trial-based designs which may be less generalizable, will be important to assess changes in risk factor profiles over the course of the pandemic.

The mechanisms via which telehealth increases adherence to guideline-recommended diabetes care goals and improved diabetes management compared with those using in-person visits alone are not entirely clear. Telehealth may alleviate several barriers in access to routine care including distance to healthcare services and time.[22] However, telehealth poses its own barriers, including the necessity of broadband and technology literacy, and not all people have equitable access to these resources.[23 24] Additionally, 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 also possible that telehealth users simply reflect a population with greater need for healthcare utilization.[25] Earlier research has shown that patients with a chronic disease who were high users of virtual care during the pandemic tended to be higher users of the healthcare system in general.[4] In our study, telehealth users in the pre-pandemic period were less healthy than non-telehealth users, and were more likely to be adhering to annual screening guidelines prior to the pandemic suggesting it is possible that this reflects a less healthy cohort, but one that is engaged with care.

These findings have important implications for diabetes care in a post-COVID-19 era. Based on this study, KPGA efficiently increased telehealth visits, 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 relative uniform access which is not reflected in non-insured populations.[10 17–19] 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, and a suggestion of worsening risk profiles. These findings suggest that there is a possibility of an increased risk of diabetes complications in the future. 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. Clinicians may also consider offering telehealth to some patients where appropriate to increase uptake of routine guideline-recommended screenings.[23] Finally, policies that address the digital divide as a social determinant of health may strengthen existing healthcare and public health systems to allow for greater accessibility of telehealth for those seeking healthcare.[26]

This study has several limitations. First, this study includes a select population of people within an integrated health system living in one US state. Therefore, results are not generalizable to US adults without health insurance in other states. 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 goal of our study. Second, this study uses three broad categories for race (black, white, other) as we lacked power to look at individual races grouped into the other race group. However, those who identified as black made up more than half of this study population, a group that is historically under-represented in research. Third, it is

Table 3 Change in the proportion of KPGA members with prevalent diabetes adhering to annual diabetes care guidelines during versus pre-COVID (2018–2021), stratified by telehealth use

Diabetes care processes	Non telehealth users				Telehealth users			
	Pre-pandemic (2018–2019) (%)	During pandemic (2020–2021) (%)	Absolute change (during vs pre) (%)	OR (95% CI)*	Pre-pandemic (2018–2019) (%)	During pandemic (2020–2021) (%)	Absolute change (during vs pre) (%)	OR (95% CI)*
HbA1c	75.8	46.4	−29.4	0.39 (0.36 to 0.42)	84.0	77.7	−6.3	0.71 (0.67 to 0.74)
UACR	34.8	16.8	−18.0	0.47 (0.42 to 0.52)	42.6	35.1	−7.5	0.75 (0.72 to 0.78)
Blood pressure	90.7	50.0	−40.7	0.13 (0.11 to 0.14)	97.7	85.3	−12.4	0.14 (0.12 to 0.15)
Cholesterol	37.3	18.7	−18.6	0.42 (0.38 to 0.47)	41.2	31.0	−10.2	0.65 (0.62 to 0.68)
Creatinine	78.1	46.5	−31.6	0.30 (0.28 to 0.33)	89.7	82.6	−7.1	0.58 (0.54 to 0.62)
Eye examination	13.3	5.6	−7.7	0.47 (0.39 to 0.56)	15.8	11.5	−4.3	0.69 (0.65 to 0.74)
Foot examination	2.2	0.3	−1.9	0.34 (0.27 to 0.44)	3.6	2.0	−1.6	0.61 (0.54 to 0.69)

*Compares during versus pre-period, adjusted for baseline age. All 95% CI that do not include one are significant at p<0.05.
KPGA, Kaiser Permanente Georgia; UACR, urine albumin-to-creatinine ratio.

possible that the use of CPT codes to capture eye and foot examinations underestimates the proportion of people meeting these screening guidelines. Nonetheless, using CPT code in both the pre and during pandemic periods allows us to compare changes in care processes over time. Fourth, analyses of average lab measurements over time are limited to those who had a measurement recorded which may over or underestimate true estimates. Further, for some measurements, in particular UACR, there is a large proportion of missing data (>30%) and thus results should be interpreted with caution, and conversion of creatinine to eGFR was unavailable. Fifth, this study did not distinguish diabetes type, and telehealth use may be different in people with type 1 and type 2 diabetes. Future studies should examine telehealth use in these groups separately. Sixth, we were unable to ascertain whether the diabetes care process occurred during the telehealth visit or not. It is reasonable to assume that for some measurements, such as foot examinations and blood pressure, in-person visits were required. Nonetheless, the goal of the study was to compare the behavior of the average telehealth user with respect to meeting diabetes care guidelines to the average non-telehealth user as a broad indicator of healthcare engagement. Seventh, we are unable to account for differences in policies or individual-level behaviors that may have changed because of the pandemic, possibly confounding our results. Therefore, conclusions pertain to the cumulative effect of the COVID-19 pandemic on diabetes screenings. Finally, we were limited to data captured within the KPGA EMR at baseline (ie, 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 (ie, education, health literacy, access to broadband). Future research should consider the impact of the pandemic on these factors.

CONCLUSIONS

The COVID-19 pandemic led to a significant shift in the way healthcare is delivered and accessed for people with diabetes. Ongoing surveillance of the impact of telehealth on adherence to routine care guidelines and diabetes management, and eventually on risk of diabetes complications, will be an essential component of diabetes care in a post-COVID-19 era.

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Table 4 Change in mean diabetes care measurements during versus pre-COVID among KPGA adult members with prevalent diabetes (2018–2021), stratified by telehealth use

	Non-telehealth users				Telehealth users			
Diabetes care process	**Pre-pandemic (2018–2019)**	**During pandemic (2020–2021)**	**Absolute change (during vs pre)**	**Mean difference (95%CI)***	**Pre-pandemic (2018–2019)**	**During pandemic (2020–2021)**	**Absolute change (during vs pre)**	**Mean difference (95% CI)***
HbA1c (mean (SD); %)	7.1 (1.5)	7.2 (1.7)	0.1	0.17 (0.11 to 0.22)	7.2 (1.6)	7.3 (1.6)	0.1	0.4 (0.2 to 0.6)
Systolic BP (mean (SD); mm Hg)	132.4 (12.6)	133.9 (14.1)	1.5	2.05 (1.51 to 2.60)	132.3 (11.5)	134.1 (12.9)	1.8	1.62 (1.44 to 1.81)
Diastolic BP (mean (SD); mm Hg)	72.6 (8.9)	73.2 (10.0)	0.6	0.2 (–0.14 to 0.56)	72.0 (8.4)	72.2 (9.1)	0.2	–0.04 (–0.16 to 0.08)
LDL cholesterol (mean (SD); mg/dL)	101.0 (39.0)	98.1 (36.3)	–2.9	–4.36 (–5.92 to –2.81)	100.1 (39.4)	91.5 (35.7)	–8.6	–9.08 (–9.77 to –8.39)
Creatinine (mean (SD); mg/dL)	1.1 (0.7)	1.0 (0.5)	–0.1	–0.02 (–0.04 to –0.01)	1.1 (0.7)	1.1 (0.8)	0.0	0.03 (0.02 to 0.04)
				OR (95% CI)†				**OR (95% CI)†**
UACR (%, >300 mg/g)†	6.0	6.1	0.1	1.26 (1.04 to 0.53)	6.9	9.7	2.8	1.48 (1.36 to 1.62)

Missingness: Pre-pandemic non-telehealth users: HbA1c=8.2%, BP=3.2%, cholesterol=20.3%, creatinine=8.8%, UACR=33.6%; pre-pandemic telehealth users: HbA1c=3.0%, BP=0.2%, cholesterol=15.4%, creatinine=2.5%, UACR=27.6%. During pandemic non-telehealth users: HbA1c=8.2%, BP=5.0%, cholesterol=20.3%, creatinine=8.8%, UACR=33.6%. During pandemic telehealth users: HbA1c=5.3%, BP=3.8%, cholesterol=24.0%, creatinine=3.3%, UACR=36.8%.
*Compares during versus pre-period, adjusted for baseline age; a 95% CI that does not include 0 is significant at p<0.05.
†A 95% CI that does not include one is significant at p<0.05.
BP, blood pressure; GEE, generalized estimating equatio; KPGA, Kaiser Permanente Georgia; UACR, urine-albumin-creatinine ratio.

study design, oversaw data analysis, and revised/edited the manuscript. All authors approve the final version of this manuscript. JLH is the guarantor of this work and takes responsibility for the decision to submit this work.

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