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Short communication

Differences in diabetes control in telemedicine vs. in-person only visits in ambulatory care setting

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ABSTRACT

There is limited information regarding how telemedicine visits compare with in-person visits regarding diabetes outcomes in an ambulatory care setting. Our objective was to compare proportions of patients in ambulatory setting with uncontrolled diabetes among those with telemedicine visits versus in-person only visits and examine differences by age, race, gender, ethnicity, and insurance status. Adults with diabetes who attended an ambulatory primary or specialty clinic visit between May 2020 and May 2021 were included. Demographics including age, race, ethnicity, gender, insurance, and comorbidities were extracted from the electronic medical record. Patients were compared among three visit groups: those with in-person only visits, those with only one telemedicine visit, and those with 2 + telemedicine visits. The primary outcome was uncontrolled diabetes, defined as HbA1c $\geq$ 9.0 %. Multivariable logistic regression was used to assess differences in uncontrolled diabetes between visit groups following risk adjustment. A total of 18,148 patients met inclusion criteria and 2,101 (11.6 %) had uncontrolled diabetes. There was no difference in proportion of patients with uncontrolled diabetes between visit groups (in-person only visits: 834 (11.6 %); one telemedicine visit: 558 (11.8 %); 2 + telemedicine visits: 709 (11.4 %); $p = 0.80$)). Patients with 2 + telemedicine visits had significantly lower odds of uncontrolled diabetes compared to in-person only visits after risk adjustment (OR: 0.88; 95 % CI: 0.79–0.99, $p = 0.03$). Compared with in-person ambulatory visits, telemedicine visits were associated with a lower odds of uncontrolled diabetes. Further work is warranted to explore the relationship between telemedicine visits and diabetes outcomes.

1. Introduction

The current pandemic has affected healthcare systems globally with frequent lockdowns, shortage of healthcare staff, and resources diverted to care for patients with COVID-19. This has adversely affected who not only need acute care but also those with chronic conditions that require follow-up. Ambulatory continuity of care in conditions such as diabetes is critical for reducing complications, emergency room visits, and hospitalizations. (Mainous et al., 2004) Diabetes management has been disrupted during the pandemic, leaving many patients with limited healthcare access, worsened A1C control, and increased diabetes-related stress. (Fisher et al., 2020) Besides affecting prevention and management strategies, diabetes is also an independent predictor of poor prognosis in patients with COVID-19. (Guo et al., 2020; Gregory et al., 2021) Minority populations including African-Americans/Blacks and Hispanic/LatinX have a higher prevalence of diabetes, so the

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disproportionate effect of COVID-19 on minority populations worsens existing health inequities. (Leuchter et al., 2021) There is a need for ongoing research to assess the impact of COVID-19 on diabetes care to inform future clinical and public health strategies.

During the pandemic, some ambulatory care shifted to telemedicine visits, defined as synchronous video conferencing between patients and clinicians. (Gujral et al., 2020) Expanded insurance coverage and reimbursement for telemedicine caused by the pandemic have played a pivotal role in this care transformation to provide ongoing access for patients in the ambulatory setting. (Lau et al., 2020) Besides increasing healthcare access during the pandemic, there are recent reports that patient care using telemedicine can positively improve clinical outcomes. (Kubes et al., 2021; Reed et al., 2021) Delivery of care via telemedicine has shown benefits in patients with chronic conditions including hypertension and COPD. (McLean et al., 2011) Prior studies have shown that telemedicine can improve diabetes outcomes; however, these interventions included a broader definition of telemedicine ranging from medication adjustment via messaging system to video conferencing with remote glucose monitoring. (Faruque et al., 2017; Tchero et al., 2019).

Patients with diabetes are at a higher risk of complications from infectious diseases such as influenza and COVID-19 and should be protected from unavoidable in-person visits to healthcare practices. (Aberer et al., 2021) The importance of utilizing telemedicine to provide access, convenience, and safety is critical these high-risk patients. Telemedicine is likely to continue even after the pandemic, but there is limited data on the impact of visit modality on diabetes outcomes. We performed a retrospective study comparing ambulatory patients with telemedicine and in-person visits to evaluate diabetes control. We hypothesize that compared with in-person only visits, telemedicine visits have a lower proportion of uncontrolled diabetes regardless of age, gender, race, insurance, or comorbidities. We hypothesize that telemedicine utilization will promote more interaction between patients and providers, which could improve diabetes control.

2. Methods

2.1. Population

Emory Healthcare (EHC) is the largest healthcare system in the state of Georgia with more than 2800 physicians and 250 provider locations in urban, suburban and rural settings. EHC has 140 group practice locations and ambulatory service sites in 27 Georgia counties, including 15 officially designated medically underserved counties. EHC began using Zoom (Zoom Video Communication, Inc., San Jose, CA) in March 2020 to offer telemedicine appointments for ambulatory care visits and included both an audio and video component in a synchronous format, which is compliant with the Health Insurance Portability and Accountability Act (HIPAA) and approved for clinical use in the United States. Additionally, all EHC patients sign a notice of privacy practices when they establish as new patients, and there is nothing additional required for telemedicine visits. Our study included adult patients with either type-1 or type-2 diabetes, defined via ICD-10 codes, scheduled for at least one ambulatory visit between May 2020 and May 2021 within EHC.

2.2. Measures

We defined a telemedicine visit as a visit conducted with both audio and video and an in-person visit as one when the patient was physically present. Standard of outpatient care did not differ between telemedicine and in-person visits. Using the Andersen framework of health services utilization, we measured predisposing factors including age, sex, gender, race, and ethnicity, enabling factors including healthcare insurance, and needs factors including present comorbidities for each patient. (Andersen, 1995) Sociodemographic factors were extracted from the electronic medical record, with comorbidities identified by ICD-10 codes. A Charlson Comorbidity Index (CCI) was calculated for each patient for risk adjustment. (Charlson et al., 1987) Patients were divided into three groups: patients with in-person only visits, patients with one telemedicine visit, and patients with two or more telemedicine visits. We excluded patients with a positive SARS-Co-V-2 polymerase chain reaction test within 14 days of their visit, as these visits were intentionally assigned to telemedicine. No patient identifiers were used, and the study was reviewed and deemed exempt by Emory Institutional Review Board review. The primary outcome was proportion of patients with uncontrolled diabetes, defined as any HbA1c result $\geq$ 9.0 % during the study timeframe. We chose HbA1c as the endpoint of diabetes control as it is the primary metric used for diabetes management among most outpatient clinical care teams. (All About your A1C, 2021).

2.3. Statistical analysis

Differences in proportions of uncontrolled diabetes between groups were analyzed using the Chi-square test or, when appropriate, Fisher's exact test. Multivariable logistic regression was used to compare uncontrolled diabetes between groups adjusting for age, gender, race, ethnicity, insurance, and CCI. Statistical analyses were performed using R (version 4.0.2; Rstudio, Inc., Boston, MA). This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.

3. Results

A total of 18,148 patients with diabetes met the inclusion criteria. Of those, 7,172 (39.5 %) had only in-person visits, 4,742 (26.1 %) had one telemedicine visit, and 6,234 (34.4 %) had two or more telemedicine visits. The average age was 64.3 years (SD 12.8), 54.0 % were female, 44.5 % were White non-Hispanic, and 44.0 % were Black non-Hispanic, and 42.0 % had commercial insurance. Most patients had type-2 diabetes (94.2 %). The most common comorbidity was hypertension (87.1 %) (Table 1).

Approximately 2,101 (11.6 %) patients had uncontrolled diabetes. There was no difference in proportion of patients with uncontrolled diabetes between groups (in-person only visits: 834 (11.6 %); one telemedicine visit: 558 (11.8 %); two or more telemedicine visits: 709 (11.4 %); $p = 0.80$). Patients with two or more telemedicine visits had significantly lower odds of uncontrolled diabetes compared to only in-person visits after adjusting for age, gender, race, ethnicity, insurance, and CCI (OR: 0.88; 95 % CI: 0.79–0.99, $p = 0.03$) (Table 2).

We performed an additional sub-analysis stratified by diabetes type (Table 3). Two or more telemedicine visits was associated with a higher odds of uncontrolled diabetes among patients with type-1 diabetes, although these results were not significant (OR: 1.81; 95 % CI: 0.30, 1.10, $p = 0.50$). Conversely, two or more telemedicine visits was associated with a lower odds of uncontrolled diabetes among patients with type-2 diabetes, and these results nearly reached statistical significance (OR: 0.89; 95 % CI: 0.79, 1.01, $p = 0.06$).

During post-hoc analysis, it was determined that the total number of visits per patient could be a potential confounding factor, as patients who attended more visits may have increased HbA1c monitoring. To determine if number of visits was a significant confounder, we performed an additional sub-analysis by visit frequency and compared patients who attended two or more in-person visits to patients who attended two or more telemedicine visits. There was no significant difference in uncontrolled diabetes between visit frequency groups (OR: 1.10, 95 % CI: 0.97, 1.22, $p = 0.06$); this association was unchanged after risk adjustment (OR: 0.94, 95 % CI: 0.87, 1.08, $p = 0.63$).

4. Discussion

Telemedicine expansion during COVID-19 presents an opportunity

Table 1
Characteristics of Patients with Diabetes by Visit Group, May 2020 – May 2021.

	Only In-Person Visits (n = 7,172)	One Telemedicine Visit (n = 4,742)	2 + Telemedicine Visits (n = 6,234)	p-value
Gender, No. (%)				
Male	3,614 (50.4)	2,252 (47.5)	2,546 (40.8)	< 0.01
Female	3,558 (49.6)	2,490 (52.5)	3,688 (59.2)	< 0.01
Age, No. (%)				
< 18	2 (0.0)	2 (0.0)	1 (0.0)	0.72
18–34	120 (1.7)	79 (1.7)	134 (2.1)	0.07
35–64	3,087 (43.0)	2,212 (46.6)	2,941 (47.2)	< 0.01
65+	3,963 (55.3)	2,449 (51.6)	3,158 (50.7)	< 0.01
Race, No. (%)				
White	3,507 (48.9)	2,079 (43.8)	2,496 (40.0)	< 0.01
Black	2,761 (37.9)	2,071 (43.7)	3,198 (51.3)	< 0.01
Asian	282 (3.9)	155 (3.3)	150 (2.4)	< 0.01
American Indian/ Alaska Native	21 (0.3)	13 (0.3)	18 (0.3)	0.98
Native Hawaiian/ Pacific Islander	7 (0.1)	6 (0.1)	16 (0.3)	0.06
Multiple	28 (0.4)	47 (1.0)	39 (0.6)	< 0.01
Unknown	611 (8.5)	371 (7.8)	317 (5.1)	< 0.01
Ethnic Group, No. (%)				
Non-Hispanic	5,477 (76.4)	3,714 (78.3)	5,289 (84.8)	< 0.01
Hispanic	211 (3.1)	136 (2.9)	191 (3.1)	0.82
Unknown	1,474 (20.6)	892 (18.8)	758 (12.2)	< 0.01
Insurance, No. (%)				
Commercial	2,977 (41.5)	2,076 (43.8)	2,510 (40.3)	< 0.01
Medicare	3,921 (54.7)	2,488 (52.5)	3,449 (55.3)	< 0.01
Medicaid	75 (1.0)	52 (1.1)	133 (2.1)	< 0.01
Uninsured	199 (2.8)	126 (2.7)	142 (2.3)	0.18
Diabetes Type, No. (%)				
Type 1	34 (0.5)	23 (0.5)	19 (0.3)	0.23
Type 2	6808 (94.9)	4516 (95.2)	5766 (92.5)	< 0.01
Both Type 1 and Type 2	330 (4.6)	203 (4.3)	449 (7.2)	< 0.01
Comorbidities, No. (%)				
Hypertension	6,103 (85.1)	4,125 (87.0)	5,574 (89.4)	< 0.01
AMI	343 (4.8)	263 (5.5)	483 (7.7)	< 0.01
Congestive heart failure	723 (10.1)	527 (11.1)	1,119 (17.9)	< 0.01
Peripheral vascular disease	832 (11.9)	563 (11.9)	1,151 (18.5)	< 0.01
Cerebrovascular disease	822 (11.5)	608 (12.8)	1,084 (17.4)	< 0.01
Dementia	203 (2.8)	126 (2.7)	286 (4.6)	< 0.01
COPD	1,398 (19.5)	993 (20.9)	1,763 (28.3)	< 0.01
Rheumatoid arthritis	169 (2.4)	161 (3.4)	324 (5.2)	< 0.01
Peptic ulcer disease	110 (1.5)	87 (1.8)	203 (3.3)	< 0.01
Liver disease	651 (9.1)	529 (11.2)	1,089 (17.5)	< 0.01
Hemiplegia/ paraplegia	75 (1.0)	72 (1.5)	185 (3.0)	< 0.01
Renal disease	1,410 (19.8)	1,048 (22.1)	1,667 (26.7)	< 0.01
Malignancy	791 (11.0)	570 (12.0)	1,020 (16.4)	< 0.01
HIV/AIDS	25 (0.3)	29 (0.6)	44 (0.7)	0.01
Charlson Comorbidity Index, No. (%)				
0–1 (low risk)	3,179 (44.3)	1,971 (41.6)	1,878 (30.1)	< 0.01
2–3 (medium risk)	3,051 (42.5)	2,017 (42.5)	2,732 (43.8)	0.25
4+ (high risk)	942 (13.1)	754 (15.9)	1,624 (26.1)	< 0.01

Abbreviations: AMI, acute myocardial infarction; COPD, chronic obstructive. pulmonary disease.

Table 2
Crude and Risk-Adjusted Uncontrolled Diabetes Among Patients with Diabetes by Visit Group, May 2020 – May 2021.

Visit Group	**Uncontrolled Diabetes No. (%)**	**Odds Ratio (95 % CI)**	**p-value**	**Adjusted Odds Ratio (95 % CI)[a]**	**p-value**
Only In-Person Visits (n = 7,172)	834 (11.6)	Ref	Ref	Ref	Ref
One Telemedicine Visit (n = 4,742)	558 (11.8)	1.01 (0.90, 1.14)	0.82	0.86 (0.85,1.08)	0.52
2 + Telemedicine Visits (n = 6,234)	709 (11.4)	0.98 (0.88, 1.08)	0.64	0.88 (0.79, 0.99)	0.03

[a] Adjusted for age, gender, race, ethnicity, insurance, and Charlson Comorbidity Index (CCI), which is a composite score used to predict one-year mortality. Components of CCI include myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic obstructive pulmonary disease, rheumatic disease, peptic ulcer disease, liver disease, diabetes, hemiplegia/paraplegia, renal disease, malignancy, HIV/AIDS.

to generate evidence regarding its effect on diabetes outcomes and other chronic conditions. In a retrospective study of adult patients with diabetes receiving ambulatory care at a large academic healthcare system, telemedicine visits were associated with lower odds of uncontrolled type-2 diabetes compared with in-person only visits during the COVID-19 pandemic. Moreover, this association was unchanged after adjusting for sociodemographics and comorbidities. Our original hypothesis that telemedicine utilization would improve diabetes control due to the increase in interaction opportunities between patients and providers may explain our results, particularly because providers at EHC do not have the capability of controlling visit options and therefore cannot assign a

Table 3
Crude and Risk-Adjusted Uncontrolled Diabetes Among Patients with Diabetes by Visit Group and Diabetes Type, May 2020 – May 2021.

Visit Group	Uncontrolled Diabetes No. (%)	Odds Ratio (95 % CI)	p-value	Adjusted Odds Ratio (95 % CI)[a]	p-value
Type 1 Diabetes					
Only In-Person Visits (n = 34)	6 (17.6)	Ref	Ref	Ref	Ref
One Telemedicine Visit (n = 23)	5 (21.7)	1.30 (0.33, 4.94)	0.71	0.62 (0.11, 3.00)	0.57
2 + Telemedicine Visits (n = 19)	5 (26.3)	1.67 (0.41, 6.51)	0.48	1.81 (0.30, 1.10)	0.50
Type 2 Diabetes					
Only In-Person Visits (n = 4,516)	751 (11.0)	Ref	Ref	Ref	Ref
One Telemedicine Visit (n = 5,766)	516 (11.4)	1.04 (0.92, 1.17)	0.51	0.99 (0.87, 1.11)	0.83
2 + Telemedicine Visits (n = 6,808)	612 (10.6)	0.98 (0.86, 1.07)	0.45	0.89 (0.79, 1.01)	0.06

[a] Adjusted for age, gender, race, ethnicity, insurance, and Charlson Comorbidity Index (CCI), which is a composite score used to predict one-year mortality. Components of CCI include myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic obstructive pulmonary disease, rheumatic disease, peptic ulcer disease, liver disease, diabetes, hemiplegia/paraplegia, renal disease, malignancy, HIV/AIDS.

particular patient to a specific visit type.

We did not find our hypothesis to be true for patients with type-1 diabetes. Our study is similar to pre-pandemic studies that have reported on telemedicine in diabetes care. (Aberer et al., 2021; De Groot et al., 2021) The results of these studies had a few inconsistences though as patients with type-1 diabetes and telemedicine delivered without synchronous video elements failed to demonstrate improved A1C outcomes. (So and Chung, 2018) In our study, visits conducted via telemedicine showed better outcomes for patients with type-2 diabetes but not for patients with type-1 diabetes. Patients with type-1 diabetes require more frequent medication adjustment and thus may benefit from in-person visits. This finding needs further exploration as our sample of patients was very small for patients with type-1 diabetes (n = 76).

Several barriers to widespread telemedicine adoption have been encountered, including payment regulations, lack of infrastructure, and concerns about acceptance. (Scott Kruse et al., 2018) Since the pandemic, telemedicine use has increased dramatically with reimbursement codes enacted by CMS as well as legislation granting telemedicine parity of reimbursement with in-person visits. Despite easing barriers, a lack of access to video technology and broadband availability can potentially exacerbate health disparities. However, recent studies reflect that widespread availability of smartphones and better broadband availability have helped with telemedicine access, particularly for racial and ethnic minorities. (Campos-Castillo and Anthony, 2021) Our study benefitted from the fact that we were able to extract and analyze an abundant number of variables that represented core aspects of Andersen's model of healthcare utilization, which demonstrate patient-level factors that contribute to a patient's utilization of healthcare services. Our study shows that with further research, telemedicine has the potential to act as an enabling factor in Andersen's model, increasing access to healthcare and thereby leading to improved patient outcomes.

4.1. Limitations

Our study has notable strengths including a large sample size encompassing a diverse patient population and urbanization setting. There are a few limitations that need to be acknowledged. Our study is not a randomized clinical trial, but observational and from a single large healthcare system that used a common platform (Zoom) for telemedicine visits and thus a causal relationship cannot be implied. Despite robust adjustment for patient risk factors, there is the possibility of unmeasured confounding. Additionally, there is potential for selection bias, as patients with better diabetes control may opt for telemedicine visits, as there is less of a need to examine these patients in-person. However, there is no protocol in primary care clinics to guide patients for a particular type of visit. We currently don't have robust data on other diabetes quality metrics such as ophthalmology referrals, lipid levels. Future studies should examine if telemedicine visits are favorable for these important outcomes as well.

5. Conclusions

Our study shows that telemedicine visits were associated with lower odds of uncontrolled type-2 diabetes compared with in-person only visits in outpatient clinic settings. Continued adoption of telemedicine is contingent on regulatory reimbursements and evidence that it improves clinical care along with patient and provider satisfaction. Further work is warranted to explore the role of telemedicine in improving equitable access, and what aspects of diabetes care can be replaced by telemedicine.

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CRediT authorship contribution statement

Julianne N. Kubes: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Validation, Writing – original draft, Visualization. **Laura Jones:** Data curation, Writing – review & editing. **Saria Hassan:** Methodology, Writing – review & editing, Supervision. **Nicole Franks:** Resources, Writing – review & editing, Project administration, Funding acquisition. **Zanthia Wiley:** Resources, Writing – review & editing, Project administration, Funding acquisition. **Ambar Kulshreshtha:** Conceptualization, Methodology, Validation, Writing – original draft, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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