# Health Systems and Telemedicine Adoption for Diabetes and Hypertension Care

*Hector P. Rodriguez, PhD, MPH; Elizabeth L. Ciemins, PhD, MPH, MA; Karl Rubio, MIA; Cori Rattelman, MS; John K. Cuddeback, MD, PhD; Jeff T. Mohl, PhD; Salma Bibi, MPH; and Stephen M. Shortell, PhD, MPH, MBA*

## ABSTRACT

**OBJECTIVES:** The COVID-19 pandemic accelerated telemedicine use nationally, but differences across health systems are understudied. We examine telemedicine use for adults with diabetes and/or hypertension across 10 health systems and analyze practice and patient characteristics associated with greater use.

**STUDY DESIGN:** Encounter-level data from the AMGA Optum Data Warehouse for March 13, 2020, to December 31, 2020, were analyzed, which included 3,016,761 clinical encounters from 764,521 adults with diabetes and/or hypertension attributed to 1 of 1207 practice sites with at least 50 system-attributed patients.

**METHODS:** Linear spline regression estimated whether practice size and ownership were associated with telemedicine during the adoption (weeks 0-4), de-adoption (weeks 5-12), and maintenance (weeks 13-42) periods, controlling for patient socioeconomic and clinical characteristics.

**RESULTS:** Telemedicine use peaked at 11% to 42% of weekly encounters after 4 weeks. In adjusted analyses, small practices had lower telemedicine use for adults with diabetes during the maintenance period compared with larger practices. Practice ownership was not associated with telemedicine use. Practices with higher proportions of Black patients continued to expand telemedicine use during the de-adoption and maintenance periods.

**CONCLUSIONS:** Practice ownership was not associated with telemedicine use during first months of the pandemic. Small practices de-adopted telemedicine to a greater degree than medium and large practices. Technical support for small practices, irrespective of their ownership, could enable telemedicine use for adults with diabetes and/or hypertension.

*Am J Manag Care*. 2023;29(1):42-49. doi:10.37765/ajmc.2023.89302

Prior to the COVID-19 pandemic, only about 50 health systems in the United States had an existing infrastructure for delivering telemedicine.[1] Health care systems and their affiliated medical practices faced barriers to implementing telemedicine, especially video-based clinical encounters, due to billing challenges, required technology and workflow changes, and unstable, low-quality internet connections for some patients.[2-4] Patient preferences for in-person communication, viewed as more trustworthy, also contributed to low telemedicine use before the pandemic.[5]

Evidence indicates that the pandemic rapidly accelerated telemedicine implementation nationally,[6-11] supported by a temporary federal waiver that permitted multiple flexibilities, including allowing audio-only encounters for Medicare telemedicine services, requiring managed care plans to reimburse clinicians at the same rate for telemedicine and in-person encounters, and permitting use of widely available platforms, such as FaceTime and Skype, without enforcement of Health Insurance Portability and Accountability Act penalties.[12] Large-scale national studies during the pandemic indicate that telemedicine use peaked early in the pandemic, by April or May 2020, and quickly tapered off through the end of the year.[4,7-9,13,14] To our knowledge, however, there is no evidence comparing health system maintenance of telemedicine after the first surge of the pandemic.

As a result of shelter-in-place ordinances, adults with diabetes and/or hypertension were vulnerable because their routine care involves close monitoring and medication management. These patients are not only likely to be at higher risk of COVID-19–related complications,[15] but also at risk for exacerbations due to reduced access to care and lower utilization.[16] Little research has compared telemedicine adoption and maintenance for adults with diabetes[15,17] and/or hypertension across multiple health systems.

Leveraging electronic health record (EHR) and administrative data from 10 members of AMGA (American Medical Group Association), we examine telemedicine adoption in health systems and analyze the physician practice and patient characteristics associated with rapid implementation through April 2020 and

maintenance of telemedicine services through December 2020. Medical specialists tended to use telemedicine more than primary care physicians and surgical specialists during the pandemic,[18] highlighting that practice ownership and specialty mix may contribute to telemedicine use. We hypothesized that independent practices would lag in telemedicine adoption compared with practices owned by systems because past evidence indicates that health system and medical group ownership of practices is associated with broader use of health information technology (IT) compared with independent physician practices, including disease registries, reminder systems, clinical decision support, and patient portals.[19,20] Past research also indicates that larger physician practices, as measured by total physicians, adopt more chronic care management processes and health IT functions compared with smaller practices,[19,21,22] although the capabilities of small practices are improving over time.[23] Given previously documented technical and cultural barriers associated with implementing telemedicine,[24] we hypothesized that small practices would be less likely to adopt and maintain telemedicine for adults with diabetes and/or hypertension compared with medium and large practices.

**TAKEAWAY POINTS**

This study of 10 health systems examines whether practice size and ownership were associated with more extensive adoption and maintenance of telemedicine for adults with diabetes and/or hypertension during the early stages of the COVID-19 pandemic.

- Health systems varied widely in their use of telemedicine; use peaked at 11% to 42% of weekly clinical encounters after 4 weeks of shelter-in-place ordinances, leveling off to 6% to 32% of weekly encounters after 13 weeks.
- Small practices (solo physicians and advanced practice clinician–only practices) had 1% to 2% lower telemedicine use compared with larger practices after week 13.
- Practices with higher proportions of Black patients continued to expand telemedicine use through the end of 2020, when practices with lower proportions of Black patients were de-adopting or maintaining telemedicine use levels.

# METHODS

## Data

Data are sourced from Optum data available to AMGA, a nonprofit trade association representing more than 400 multispecialty medical groups and health systems with a total of more than 175,000 physicians. Some AMGA members contributed data to a common data repository managed by Optum and through a partnership with AMGA provided access to their data. Because the data elements are derived from EHRs, practice management systems, disease registries, and population health software, data are mapped and normalized to allow valid and reliable comparisons across organizations. The 10 systems represent a diverse population of health care systems across urban, suburban, and rural locations in 9 US states and range in size from 14 to 638 practice locations and from 70 to 2100 physician full-time equivalents (**eAppendix Table 1** [eAppendix available at **ajmc.com**]). Encounter-level data for the early pandemic period, March 13, 2020, to December 31, 2020, were analyzed for patients with an established diagnosis of diabetes and/or hypertension. These encounter-level data documented telemedicine (remote video, audio only, or e-visit use[6]) and patient characteristics. e-Visits include clinician-patient communication about treatment through secure electronic messaging.

We assigned clinicians to practice locations using National Provider Identifiers (NPIs) available in 2019 IQVIA OneKey data crosswalked with the AMGA Optum data. OneKey is a commercially available database of physician practice characteristics that integrates data from the American Medical Association, public sources, and proprietary data to describe medical practices, including such information as practice ownership, size, addresses, and NPIs. Encounters without a practice site identifier were excluded (n = 361,745; 8.7%). Because we were interested in examining weekly practice-level trends, which required multiple patients per week for reliable estimates, we excluded encounters from practice sites with fewer than 50 patients (184,003 encounters; 4.4%) during the study period. Analytic sample exclusions are detailed in **eAppendix Table 2**.

The analytic sample includes 3,016,761 encounters from 764,521 adults with diabetes and/or hypertension. Because we were interested in telemedicine use among established patients of health care systems, we limited the analytic sample to patients with at least 1 visit and at least 1 diagnosis of diabetes and/or hypertension between January 1, 2019, and March 12, 2020. We transformed the data into a practice-week data set and analyzed weekly practice-level volume of telemedicine vs in-person encounters. Weeks were defined in increments of 7 days starting March 13, 2020, totaling 42 weeks through December 31, 2020. Weekly visits were adjusted for weeks with holidays by dividing the total number of visits by the fraction of nonholiday days over 7 days. For example, if 1 day of the week was a holiday and there were 10 total visits during that week for a practice, the 10 visits would be normalized to 11.67 weekly visits.

For regression analyses, we segmented the pandemic period into subperiods using splines and analyzed weekly practice-level telemedicine use as a proportion of total encounters for 3 periods separately for the 2 patient subgroups: (1) adults diagnosed with diabetes (with or without hypertension) and (2) adults diagnosed with hypertension (without diabetes). We examined the 2 subgroups separately because compared with hypertension (without diabetes), managing diabetes entails addressing more standards of care[25] and primary care practices were more likely to have established diabetes care management processes in place before the pandemic.[26,27] **eAppendix Table 3** summarizes encounter and patient counts for these 2 subgroups by practice ownership.

We identified 2 time cut points with marked changes in telemedicine volumes: (1) week 5 as the onset of a telemedicine de-adoption period and (2) week 13, when de-adoption slows down,

**TABLE 1.** Descriptive Summary of Patient Characteristics[a]

| Patient characteristics | Overall | Hypertension (without diabetes) | Diabetes (with or without hypertension) |
|---|---|---|---|
| Number of patients | 764,521 (100%) | 484,845 (63.4%) | 279,676 (36.6%) |
| Age in years, mean (SD) | 64.1 (14.0) | 63.8 (14.5) | 64.6 (13.2) |
| Female, % | 52.6 | 54.2 | 49.6 |
| Race/ethnicity, % | | | |
| White | 79.3 | 81.2 | 75.9 |
| Hispanic | 3.7 | 2.8 | 5.4 |
| Black | 5.0 | 4.4 | 6.0 |
| Asian | 1.1 | 0.9 | 1.5 |
| Other | 10.9 | 10.7 | 11.1 |
| Marital status, % | | | |
| Married or domestic partnership | 60.9 | 61.4 | 60.1 |
| Divorced | 8.6 | 8.4 | 8.9 |
| Never married | 13.2 | 12.9 | 13.9 |
| Widowed | 10.3 | 10.2 | 10.4 |
| Other | 7.0 | 7.1 | 6.7 |
| Median household income in US$, mean (SD) | 62,189.5 (20,464.7) | 63,123.9 (20,851.7) | 60,569.5 (19,671.2) |
| Encounter types, mean (SD) | | | |
| Total encounters | 3.9 (3.4) | 3.6 (3.1) | 4.4 (3.7) |
| Total in-person encounters | 3.2 (3.0) | 2.9 (2.7) | 3.6 (3.3) |
| Total telemedicine audio encounters | 0.2 (0.5) | 0.2 (0.5) | 0.2 (0.6) |
| Total telemedicine video encounters | 0.5 (1.1) | 0.5 (1.0) | 0.6 (1.2) |
| Total e-visit encounters | 0.0 (0.2) | 0.0 (0.2) | 0.0 (0.3) |

*(continued)*

as the telemedicine maintenance period. We confirmed these cut points by piecewise linear regression and spline analyses, given the nonlinearity of data as assessed by the Shapiro-Wilk test ($P < .0001$). Based on these analyses, we defined week 1 to week 4 as the telemedicine adoption period, week 5 to week 12 as the telemedicine de-adoption period, and week 13 to week 42 as the telemedicine maintenance period. **eAppendix Figure 1** summarizes temporal patterns in telemedicine use across the health care systems. The Office for the Protection of Human Subjects at the University of California, Berkeley approved reliance on Dartmouth College's Committee for the Protection of Human Subjects institutional review board for study approval (#28763).

## Outcome Measure

The study outcome measure is weekly practice-level telemedicine encounters as a proportion of all clinical encounters. Telemedicine encounters include encounters that occurred through remote video, audio, or an e-visit.

## Main Independent Variables

The main independent variables are practice ownership and practice size. Practice ownership is a categorical variable of independent practices, medical group–owned practices, and hospital and/or health care system–owned practices. Practices were categorized by size based on quartiles of the distribution of total physicians: (1) 0 to 1 physician, which included advanced practice clinician–only practices (0 physicians) and solo physician practices (1 physician), (2) 2 to 3 physicians, (3) 4 to 6 physicians, and (4) 7 physicians or more.

## Control Variables

Regression analyses controlled for practice and patient characteristics potentially associated with practice ownership, size, and telemedicine encounters. Practice characteristics included the number of advanced practice clinicians and specialty physician mix as measured by the ratio of specialists to primary care physicians. Practices without specialists were categorized into a group, and practice locations with specialists were categorized based on terciles of the distribution, resulting in a 4-part categorical variable consisting of specialty mix: no specialists (72.5%), low specialty mix (9.2%), moderate specialty mix (9.1%), and high specialty mix (9.2%).

Sociodemographic and clinical characteristics of patients were measured at the practice level and included the proportion of each practice's eligible patients of each sex, race/ethnicity, marital status, urbanicity category, and health insurance category and the proportions of patients with diagnoses of mental health conditions, atherosclerotic cardiovascular disease, chronic kidney disease, heart failure, obesity, and opioid use disorder. The means of practice-level median household income and median Charlson Comorbidity Index score[28] were also included as covariates. We controlled for the proportion of patients with prescriptions for diabetes and hypertension medications in each practice. For the regression models for adults with diabetes (with or without hypertension), we controlled for the proportion of each practice's patients with diabetes who were prescribed no glucose-lowering medications, noninsulin glucose-lowering medications only, and insulin (with or without other glucose-lowering medications). For the hypertension (without diabetes) regression models, instead of diabetes medications, we accounted for the proportion of patients prescribed antihypertensive medications. **Table 1** notes in detail the medications included.

## Statistical Analyses

Weekly patient encounters were analyzed from March 13 to December 31, 2020. Linear spline regression models were estimated to assess whether practice size and ownership were associated with

telemedicine adoption and total encounter volume, controlling for patient sociodemographic and clinical characteristics, in each of the 3 periods (adoption, de-adoption, and maintenance). System fixed effects accounted for idiosyncratic effects of the 10 health systems, and SEs were clustered at the practice level. Models were estimated separately for adults with diabetes (with or without hypertension) and adults with hypertension (without diabetes). We examined variance inflation factors (VIFs) and considered a VIF of greater than 2.0 as an indication of potential collinearity among model covariates.[29]

## RESULTS

Of the 1207 practice locations included in the analytic sample, most (76.9%) were owned by the health system that contributed data, whereas 5.2% were owned by a medical group affiliated with the health system and 17.9% were independent practices with a system affiliation (**eAppendix Table 4**). The mean (SD) patient age was 64.1 (14.0) years, and most patients were insured by Medicare (55.2%) or a commercial health plan (36.0%). Table 1 summarizes patient characteristics.

The mean (SD) number of encounters per patient during the study period was 3.9 (3.4). Adults with diabetes (with or without hypertension) had a mean (SD) of 4.4 (3.7) total encounters, whereas adults with hypertension (without diabetes) had a mean (SD) of 3.6 (3.1) total encounters. Overall, in-person visits had a mean (SD) of 3.2 (3.0) encounters, telemedicine video visits had a mean (SD) of 0.5 (1.1) encounters, and telemedicine audio-only visits had a mean (SD) of 0.2 (0.5) encounters during the study period.

Analyses of weekly trends revealed that telemedicine accounted for a high of 28% of weekly encounters in weeks 3 through 5 of shelter-in-place ordinances, declined starting in week 6 through week 12, and stabilized from week 13 through the end of the calendar year or the maintenance period, when telemedicine accounted for 17% of weekly encounters (**Figure 1**). There was high variation in telemedicine use across the 10 health systems over time (**Figure 2**), with peak telemedicine use ranging from 11% to 42% of weekly encounters across the health systems, leveling off during the maintenance period at 6% to 32% of weekly encounters. Total encounter volume stabilized by week 12 (**eAppendix Figure 2**).

**TABLE 1.** (*Continued*) Descriptive Summary of Patient Characteristics[a]

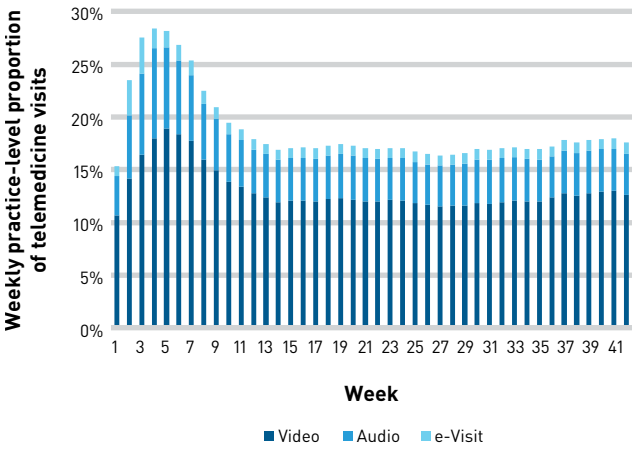
| Patient characteristics | Overall | Hypertension (without diabetes) | Diabetes (with or without hypertension) |
|---|---|---|---|
| Telemedicine exposed, % | 39.4 | 37.4 | 42.6 |
| Urbanicity, % | | | |
| Metropolitan | 77.0 | 77.6 | 75.9 |
| Isolated | 4.5 | 4.4 | 4.8 |
| Rural (large) | 10.4 | 10.0 | 11.0 |
| Rural (small) | 7.0 | 6.9 | 7.3 |
| Insurance class, % | | | |
| Commercial | 36.0 | 38.3 | 32.0 |
| Dual Medicare/Medicaid | 1.3 | 1.2 | 1.3 |
| Medicaid | 3.2 | 2.7 | 3.9 |
| Medicare | 55.2 | 53.3 | 58.5 |
| Other | 4.4 | 4.4 | 4.3 |
| CCI score, mean (SD) | 1.9 (2.2) | 1.5 (1.9) | 2.6 (2.4) |
| Comorbidities, % | | | |
| ASCVD | 24.0 | 21.3 | 28.7 |
| Chronic kidney disease | 16.2 | 11.2 | 24.7 |
| Heart failure | 8.1 | 6.2 | 11.4 |
| Mental health diagnosis | 34.0 | 34.0 | 33.9 |
| Obesity | 26.6 | 22.0 | 34.7 |
| Opioid use disorder | 1.3 | 1.2 | 1.3 |
| Diagnoses, % | | | |
| Diabetes only | 6.6 | – | 18.0 |
| Hypertension only | 63.4 | 100.0 | – |
| Diabetes and hypertension | 30.0 | – | 82.0 |
| Prescriptions, % | | | |
| Diabetes medication | | | |
| None | – | – | 20.9 |
| Noninsulin drugs only | – | – | 44.9 |
| Insulin | – | – | 34.2 |
| Antihypertensive medication | 84.2 | 86.4 | 80.4 |

ASCVD, atherosclerotic cardiovascular disease; CCI, Charlson Comorbidity Index; NLM-VSAC, National Library of Medicine Value Set Authority Center.

[a]Diagnoses are obtained from the NLM-VSAC, and we included all codes classified as mental health conditions by NLM-VSAC. Insulin included prescriptions classified as insulin (basal), insulin (bolus), or insulin combination (basal and bolus). Noninsulin glucose-lowering medications included biguanides, sulfonylureas, thiazolidinediones, α-glucosidase inhibitors (< 1%), meglitinides (< 1%), dipeptidyl peptidase 4 inhibitors, sodium-glucose co-transporter 2 inhibitors, amylin (< 1%), and glucagon-like peptide 1 agonists. Antihypertensive medications included 1 or more of the following prescriptions: diuretics, β-blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, calcium channel blockers, α-blockers, α-2 receptor agonists, combined α- and β-blockers, central agonists, peripheral adrenergic inhibitors, and vasodilators.

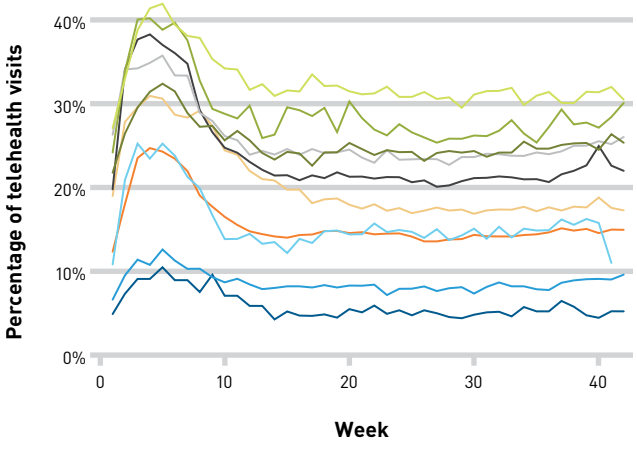
Results from regression analyses of adults with diabetes indicate that during the maintenance period, small practices (ie, practices with only advanced practice clinicians [0 physicians] and solo practices [1 physician]) had 2% lower telemedicine use compared with larger practices (**Table 2**). Practice ownership was not associated with telemedicine use in any period for adults with diabetes.

**FIGURE 1.** COVID-19–Era Weekly Composition of Telemedicine Visits Among Adults With Diabetes and/or Hypertension Across 10 Health Care Systems[a]




[a]Analyses of weekly practice-level telemedicine visits as a proportion of overall visits among adults with diabetes and/or hypertension. Overall visits include in-person and telemedicine visits (video, audio, and e-visits).

**FIGURE 2.** Weekly Telemedicine Use Trends for Adults With Diabetes and/or Hypertension by Health System, March 15-December 31, 2020[a]




[a]Analyses of weekly health care system–level telemedicine visits as a proportion of overall visits among adults with diabetes and/or hypertension. Overall visits include in-person and telemedicine visits (video, audio, and e-visits). The 10 trend lines depict the weekly telemedicine use pattern for each of the 10 health care systems.

**TABLE 2.** Practice and Patient Characteristics Associated With Telemedicine Use for Adults With Diabetes[a]

| | Patients (n = 279,676) | | |
|---|---|---|---|
| | Adoption period | De-adoption period | Maintenance period |
| Week | 0.05*** | −0.02*** | −0.00* |
| **Practice characteristics** | | | |
| Total advanced practice clinicians (standardized) | 0.00 | −0.00 | 0.00 |
| Size | | | |
| Small: 0 to 1 physician (ref) | – | – | – |
| Medium: 2 to 3 physicians | 0.01 | 0.02 | 0.02** |
| Medium: 4 to 6 physicians | 0.01 | 0.01 | 0.02** |
| Large: 7 or more physicians | 0.01 | 0.01 | 0.02* |
| Specialty mix | | | |
| No specialists (ref) | – | – | – |
| Low specialty | 0.02 | 0.02 | 0.01 |
| Moderate specialty | 0.01 | 0.02 | 0.02* |
| High specialty | 0.01 | 0.02 | 0.00 |
| Ownership | | | |
| System (ref) | – | – | – |
| Medical group | −0.00 | −0.01 | −0.01 |
| Independent | −0.00 | −0.01 | −0.01 |
| **Patient characteristics** | | | |
| Age (standardized) | −0.00 | −0.01* | −0.02*** |
| Female | 0.04** | 0.03** | 0.03*** |
| Race/ethnicity | | | |
| White (ref) | – | – | – |
| Hispanic | −0.02 | 0.01 | 0.04 |
| Black | 0.03 | 0.09*** | 0.06*** |
| Asian | −0.04 | −0.02 | 0.02 |
| Other | −0.02 | 0.00 | −0.00 |
| Marital status | | | |
| Married or domestic partnership (ref) | – | – | – |
| Divorced | −0.02 | 0.01 | −0.01 |
| Never married | 0.02 | 0.01 | 0.01 |
| Widowed | −0.02 | 0.01 | −0.00 |
| Other | 0.05* | 0.04 | 0.04** |
| Median household income (standardized) | 0.03*** | 0.04*** | 0.02*** |

*(continued)*

Several practice characteristics were associated with telemedicine use among the diabetes patient sample (Table 2). Across periods, practices with greater shares of patients from rural and isolated areas had lower telemedicine use compared with practices with relatively more patients from metropolitan areas. For a 1% increase in the proportion of female patients, practices had 3% to 4% higher telemedicine use. For a 1% increase in the proportion of Black patients, practices had 9% and 6% greater telemedicine use during the de-adoption and maintenance periods, respectively. To illustrate the effect size, the mean telemedicine use rate was 19% and a mean of 6% of patients were Black; an absolute increase of 1% in Black patients (to 7% of patients) increases the practice telemedicine use

**TABLE 2.** (*Continued*) Practice and Patient Characteristics Associated With Telemedicine Use for Adults With Diabetes[a]

| | Patients (n = 279,676) | | |
|---|---|---|---|
| | Adoption period | De-adoption period | Maintenance period |
| Urbanicity | | | |
| Metropolitan (ref) | – | – | – |
| Isolated | −0.03 | −0.04* | −0.03*** |
| Rural (large) | −0.03 | −0.06*** | −0.04*** |
| Rural (small) | −0.06*** | −0.06*** | −0.04*** |
| Insurance class | | | |
| Medicare (ref) | – | – | – |
| Commercial | 0.02 | −0.00 | 0.00 |
| Dual Medicare/Medicaid | 0.06 | 0.04 | 0.04 |
| Medicaid | 0.00 | −0.06** | −0.03* |
| Other | 0.02 | 0.01 | −0.02 |
| CCI score (standardized) | −0.01 | −0.02*** | −0.00 |
| Comorbidities | | | |
| ASCVD | −0.02 | −0.03* | 0.01 |
| Chronic kidney disease | 0.01 | 0.05*** | 0.04*** |
| Heart failure | 0.00 | 0.01 | −0.00 |
| Mental health diagnosis | 0.02 | −0.00 | 0.03*** |
| Obesity | −0.02 | −0.05*** | 0.01 |
| Hypertension | 0.02 | 0.02 | 0.02 |
| Diabetes medication | | | |
| No prescriptions (ref) | – | – | – |
| Noninsulin only | 0.01 | −0.00 | 0.02* |
| Insulin with or without noninsulin medications | 0.02 | 0.02 | 0.02* |
| Constant | −0.08 | 0.24*** | 0.10*** |
| Observations | 4297 | 9018 | 33,963 |

ASCVD, atherosclerotic cardiovascular disease; CCI, Charlson Comorbidity Index; ref, reference.

*$P < .05$; **$P < .01$; ***$P < .001$.

[a]Practices with at least 50 attributed patients are included. The regression models are linear spline models from weeks 1 to 4, weeks 5 to 12, and weeks 13 to 42. The models include system fixed effects, but these effects are omitted in the regression outputs above for brevity. The models also include SEs clustered at the practice level.

**TABLE 3.** Practice/Patient Characteristics Associated With Telemedicine Use for Adults With Hypertension[a]

| | Patients (n = 484,845) | | |
|---|---|---|---|
| | Adoption period | De-adoption period | Maintenance period |
| Week | 0.05*** | −0.02 | 0.00 |
| **Practice characteristics** | | | |
| Total advanced practice clinicians (standardized) | 0.01*** | −0.00 | 0.00 |
| Size | | | |
| Small, 0 to 1 physician (ref) | – | – | – |
| Medium, 2 to 3 physicians | 0.00 | 0.01 | 0.01 |
| Medium, 4 to 6 physicians | 0.01 | 0.01 | 0.01 |
| Large, 7 or more physicians | −0.01 | −0.01 | 0.00 |
| Specialty mix | | | |
| No specialty (ref) | – | – | – |
| Low specialty | 0.02 | 0.01 | 0.01 |
| Moderate specialty | 0.02 | 0.01 | 0.01 |
| High specialty | 0.04* | 0.02 | 0.01 |
| Ownership | | | |
| System (ref) | – | – | – |
| Medical group | 0.02 | 0.01 | −0.01 |
| Independent | −0.01 | 0.00 | −0.00 |
| **Patient characteristics** | | | |
| Age (standardized) | 0.00 | −0.02** | −0.02** |
| Female | 0.03* | 0.02 | 0.01 |
| Race/ethnicity | | | |
| White (ref) | – | – | – |
| Hispanic | −0.01 | 0.05 | 0.05* |
| Black | 0.02 | 0.11*** | 0.06*** |
| Asian | 0.16* | −0.02 | −0.02 |
| Other | −0.00 | 0.02 | 0.00 |
| Marital status | | | |
| Married or domestic partnership (ref) | – | – | – |
| Divorced | −0.00 | −0.02 | −0.01 |
| Never married | 0.00 | −0.01 | 0.00 |
| Widowed | −0.01 | 0.02 | 0.00 |
| Other | 0.05* | 0.05* | 0.04** |
| Median household income (standardized) | 0.03*** | 0.04*** | 0.02*** |

*(continued)*

rates to 21% and 20% during the de-adoption and maintenance periods, respectively.

Practice size and ownership were not associated with telemedicine use for hypertension (without diabetes) samples in any of the 3 periods (**Table 3**). High specialty mix compared with practices with no specialists at the practice level was associated with 4% greater telemedicine use as a percentage of total encounters for patients with hypertension during the telemedicine adoption period.

Patient characteristics associated with telemedicine use were similar for patients with hypertension and patients with diabetes, with the notable exception of insurance type. Among patients with

**TABLE 3.** (*Continued*) Practice/Patient Characteristics Associated With Telemedicine Use for Adults With Hypertension[a]

| | Patients (n = 484,845) | | |
|---|---|---|---|
| | Adoption period | De-adoption period | Maintenance period |
| Urbanicity | | | |
| Metropolitan (ref) | – | – | – |
| Isolated | −0.04 | −0.06** | −0.03** |
| Rural (large) | −0.04** | −0.07*** | −0.05*** |
| Rural (small) | −0.03 | −0.06*** | −0.03*** |
| Insurance class | | | |
| Medicare (ref) | – | – | – |
| Commercial | 0.04* | −0.02 | 0.01 |
| Dual Medicare/Medicaid | 0.01 | 0.02 | 0.02 |
| Medicaid | −0.01 | −0.06* | −0.05*** |
| Other | 0.09* | −0.02 | 0.01 |
| CCI score (standardized) | −0.02*** | −0.02*** | 0.00 |
| Comorbidities | | | |
| ASCVD | −0.05** | −0.00 | −0.01* |
| Chronic kidney disease | 0.05 | 0.01 | 0.04* |
| Heart failure | 0.02 | 0.03 | −0.01 |
| Mental health diagnosis | 0.05** | 0.02 | 0.06*** |
| Obesity | −0.05** | −0.03* | −0.00 |
| Antihypertensive medication | −0.02 | −0.02 | 0.01 |
| Constant | −0.03 | 0.34*** | 0.13*** |
| Observations | 4445 | 9260 | 35,034 |

ASCVD, atherosclerotic cardiovascular disease; CCI, Charlson Comorbidity Index; ref, reference.

*$P < .05$; **$P < .01$; ***$P < .001$.

[a]Practices with at least 50 attributed patients are included. The regression models are linear spline models from weeks 1 to 4, weeks 5 to 12, and weeks 13 to 42. The models include system fixed effects, but these effects are omitted in the regression outputs above for brevity. The models also include SEs clustered at the practice level.

hypertension, Medicare and Medicaid insurance were significantly associated with less telemedicine use compared with commercially insured patients.

The low VIFs among all the variables (VIF < 2.0) across all models indicate that collinearity among covariates is not a significant concern.

# DISCUSSION

Weekly practice-level telemedicine use for adults with diabetes and hypertension varied widely across 10 health systems during the early COVID-19 pandemic. The wide range of 11% to 42% of telemedicine visits as a share of total weekly encounter volume during the adoption period (weeks 1-4), the peak of telemedicine utilization, demonstrates that health systems had a strong influence on remote diabetes and hypertension care management during the early pandemic. We found that many systems institutionalized telemedicine, with use at levels upward of one-third of total encounter volume during the maintenance period, whereas other systems did not scale up telemedicine beyond 11% of weekly encounters at any point in 2020.

Our results highlight that small practices face difficulty maintaining telemedicine for adults with diabetes or intentionally choose to de-adopt telemedicine over time. This finding is consistent with past research highlighting the challenges that small practices face when attempting to implement care delivery and payment reforms.[23,30] Importantly, this relationship did not extend to adults with hypertension (without diabetes), potentially because managing diabetes entails addressing more standards of care[25] compared with hypertension (without diabetes) and primary care practices were more likely to have established care management processes in place before the pandemic for diabetes than for hypertension.[26,27]

Small practices may need technical assistance and resources from health systems, payers, and governments to help them maintain telemedicine for patients with diabetes and other chronic conditions. Health Information Technology for Economic and Clinical Health Act infrastructural investments in small practices to expand health IT functionality[31] might be leveraged to support telemedicine as a patient-centered option that could reduce treatment burden for adults with chronic conditions.[32]

We anticipated that health system–owned practices would have higher telemedicine use compared with independent practices affiliated with health systems, but we found no such relationship in our main analyses. The study results suggest that health systems can influence telemedicine adoption and implementation equally for their owned and affiliated practices. Comparable telemedicine use for system-owned and independent practices within the 10 health care systems we examined stands in stark contrast to past evidence about independent practices that documents deficiencies in chronic care management capabilities.[19,20] Our results highlight the potential chronic care management benefits of health care system affiliation for independent practices.

We also found that practices with relatively higher proportions of Black patients continued to expand telemedicine use through the end of 2020, at a time when practices with lower proportions of Black patients were de-adopting or maintaining telemedicine use levels. Practices with high shares of Black patients may have redesigned care more extensively to accommodate patients during the pandemic. This finding is in contrast to evidence outside of health systems and in single health systems that found that Black patients were less likely to use telemedicine compared with White patients.[33,34] Increased telemedicine use among practices with relatively high shares of Black patients may also reflect Black patients' perceptions of the pandemic as a greater health threat compared with White patients, perhaps due to the consequences of systemic racism.[35]

## Limitations

The study results should be considered in light of some limitations. First, we focused on practice size and ownership because extensive research highlights their association with practice capabilities,[19,21,22] including health IT. We did not assess practice-level health IT or

organizational culture because data are not available to assess these factors. These factors may, however, help to explain differences in telemedicine use and should be assessed in future research. Second, although practices with relatively high proportions of Black patients increased telemedicine use relative to practices with lower proportions of Black patients, unmeasured social and economic factors could account for this relationship. Moreover, Black patients may not have been the higher telemedicine users within these practices; evidence is needed to clarify why and how practices with high concentrations of Black patients accelerated telemedicine implementation. Finally, the analyses are cross-sectional, so temporal ordering and causal relationships cannot be assessed. Future research could examine the impact of practice ownership changes[36] and telemedicine use to elucidate the causal effect of practice ownership changes on telemedicine use.

## CONCLUSIONS

Telemedicine use for adults with diabetes and hypertension varied widely across 10 health systems during the early COVID-19 pandemic period. Solo physician and advanced practice clinician–only practices had significantly lower telemedicine use among adults with diabetes with or without hypertension, highlighting that technical support for small practices, irrespective of ownership, could support more extensive telemedicine use for adults with diabetes and/or hypertension. ■

***Author Affiliations:*** School of Public Health, University of California, Berkeley (HPR, KR, SB, SMS), Berkeley, CA; AMGA (ELC, CR, JKC, JTM), Alexandria, VA.

***Source of Funding:*** This study was supported by the Agency for Healthcare Research and Quality's Comparative Health System Performance Initiative under grant No. 1U19HS024075, which examines how health care delivery systems promote evidence-based practices and patient-centered outcomes research in delivering care.

***Author Disclosures:*** The authors report no relationship or financial interest with any entity that would pose a conflict of interest with the subject matter of this article.

***Authorship Information:*** Concept and design (HPR, ELC, CR, JKC, SMS); acquisition of data (ELC, CR, JTM, SB); analysis and interpretation of data (HPR, ELC, KR, CR, JKC, JTM, SMS); drafting of the manuscript (HPR, KR); critical revision of the manuscript for important intellectual content (HPR, ELC, KR, CR, JKC, JTM, SB, SMS); statistical analysis (HPR, KR); provision of patients or study materials (ELC, JKC); obtaining funding (HPR); administrative, technical, or logistic support (ELC, SB); and supervision (HPR, ELC).

***Address Correspondence to:*** Hector P. Rodriguez, PhD, MPH, University of California, Berkeley, 2121 Berkeley Way, Berkeley, CA 94720-7360. Email: hrod@berkeley.edu.

## REFERENCES

1. Hollander JE, Carr BG. Virtually perfect? telemedicine for Covid-19. *N Engl J Med*. 2020;382(18):1679-1681. doi:10.1056/NEJMp2003539
2. Graetz I, Gordon N, Fung V, Hamity C, Reed ME. The digital divide and patient portals: internet access explained differences in patient portal use for secure messaging by age, race, and income. *Med Care*. 2016;54(8):772-779. doi:10.1097/MLR.0000000000000560
3. Sarkar U, Karter AJ, Liu JY, et al. Social disparities in internet patient portal use in diabetes: evidence that the digital divide extends beyond access. *J Am Med Inform Assoc*. 2011;18(3):318-321. doi:10.1136/jamia.2010.006015
4. Khoong EC, Butler BA, Mesina O, et al. Patient interest in and barriers to telemedicine video visits in a multilingual urban safety-net system. *J Am Med Inform Assoc*. 2021;28(2):349-353. doi:10.1093/jamia/ocaa234
5. So CF, Chung JW. Telehealth for diabetes self-management in primary healthcare: a systematic review and meta-analysis. *J Telemed Telecare*. 2018;24(5):356-364. doi:10.1177/1357633X17700552
6. Mann DM, Chen J, Chunara R, Testa PA, Nov O. COVID-19 transforms health care through telemedicine: evidence from the field. *J Am Med Inform Assoc*. 2020;27(7):1132-1135. doi:10.1093/jamia/ocaa072
7. Alexander GC, Tajanlangit M, Heyward J, Mansour O, Qato DM, Stafford RS. Use and content of primary care office-based vs telemedicine care visits during the COVID-19 pandemic in the US. *JAMA Netw Open*. 2020;3(10):e2021476. doi:10.1001/jamanetworkopen.2020.21476
8. Eberly LA, Kallan MJ, Julien HM, et al. Patient characteristics associated with telemedicine access for primary and specialty ambulatory care during the COVID-19 pandemic. *JAMA Netw Open*. 2020;3(12):e2031640. doi:10.1001/jamanetworkopen.2020.31640
9. Patel SY, Mehrotra A, Huskamp HA, Uscher-Pines L, Ganguli I, Barnett ML. Variation in telemedicine use and outpatient care during the COVID-19 pandemic in the United States. *Health Aff (Millwood)*. 2021;40(2):349-358. doi:10.1377/hlthaff.2020.01786
10. Cantor JH, McBain RK, Pera MF, Bravata DM, Whaley CM. Who is (and is not) receiving telemedicine care during the COVID-19 pandemic. *Am J Prev Med*. 2021;61(3):434-438. doi:10.1016/j.amepre.2021.01.030
11. Friedman AB, Gervasi S, Song H, et al. Telemedicine catches on: changes in the utilization of telemedicine services during the COVID-19 pandemic. *Am J Manag Care*. 2022;28(1):e1-e6. doi:10.37765/ajmc.2022.88771
12. Koonin LM, Hoots B, Tsang CA, et al. Trends in the use of telehealth during the emergence of the COVID-19 pandemic — United States, January–March 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(43):1595-1599. doi:10.15585/mmwr.mm6943a3
13. Peden CJ, Mohan S, Pagán V. Telemedicine and COVID-19: an observational study of rapid scale up in a US academic medical system. *J Gen Intern Med*. 2020;35(9):2823-2825. doi:10.1007/s11606-020-05917-9
14. Rodriguez JA, Betancourt JR, Sequist TD, Ganguli I. Differences in the use of telephone and video telemedicine visits during the COVID-19 pandemic. *Am J Manag Care*. 2021;27(1):21-26. doi:10.37765/ajmc.2021.88573
15. Patel SY, McCoy RG, Barnett ML, Shah ND, Mehrotra A. Diabetes care and glycemic control during the COVID-19 pandemic in the United States. *JAMA Intern Med*. 2021;181(10):1412-1414. doi:10.1001/jamainternmed.2021.3047
16. Ansari Z, Laditka JN, Laditka SB. Access to health care and hospitalization for ambulatory care sensitive conditions. *Med Care Res Rev*. 2006;63(6):719-741. doi:10.1177/1077558706293637
17. Quinton JK, Ong MK, Sarkisian C, et al. The impact of telemedicine on quality of care for patients with diabetes after March 2020. *J Gen Intern Med*. 2022;37(5):1198-1203. doi:10.1007/s11606-021-07367-3
18. Sharma AE, Khoong EC, Sierra M, et al. System-level factors associated with telephone and video visit use: survey of safety-net clinicians during the early phase of the COVID-19 pandemic. *JMIR Form Res*. 2022;6(3):e34088. doi:10.2196/34088
19. Rodriguez HP, McClellan SR, Bibi S, Casalino LP, Ramsay PP, Shortell SM. Increased use of care management processes and expanded health information technology functions by practice ownership and Medicaid revenue. *Med Care Res Rev*. 2016;73(3):308-328. doi:10.1177/1077558715613233
20. Bishop TF, Shortell SM, Ramsay PP, Copeland KR, Casalino LP. Trends in hospital-ownership of physician practices and the effect on processes to improve quality. *Am J Manag Care*. 2016;22(3):172-176.
21. Bishop TF, Ramsay PP, Casalino LP, Bao Y, Pincus HA, Shortell SM. Care management processes used less often for depression than for other chronic conditions in US primary care practices. *Health Aff (Millwood)*. 2016;35(3):394-400. doi:10.1377/hlthaff.2015.1068
22. Wiley JA, Rittenhouse DR, Shortell SM, et al. Managing chronic illness: physician practices increased the use of care management and medical home processes. *Health Aff (Millwood)*. 2015;34(1):78-86. doi:10.1377/hlthaff.2014.0404
23. Rittenhouse DR, Ramsay PP, Casalino LP, McClellan S, Kandel ZK, Shortell SM. Increased health information technology adoption and use among small primary care physician practices over time: a national cohort study. *Ann Fam Med*. 2017;15(1):56-62. doi:10.1370/afm.1992
24. Zhang T, Mosier J, Subbian V. Identifying barriers to and opportunities for telehealth implementation amidst the COVID-19 pandemic by using a human factors approach: a leap into the future of health care delivery? *JMIR Hum Factors*. 2021;8(2):e24860. doi:10.2196/24860
25. American Diabetes Association. *Standards of Medical Care in Diabetes–2017* abridged for primary care providers. *Clin Diabetes*. 2017;35(1):5-26. doi:10.2337/cd16-0067
26. Miake-Lye IM, Chuang E, Rodriguez HP, Kominski GF, Yano EM, Shortell SM. Random or predictable?: adoption patterns of chronic care management practices in physician organizations. *Implement Sci*. 2017;12(1):106. doi:10.1186/s13012-017-0639-z
27. Hammersley V, Parker R, Paterson M, et al. Telemonitoring at scale for hypertension in primary care: an implementation study. *PLoS Med*. 2020;17(6):e1003124. doi:10.1371/journal.pmed.1003124
28. Schneeweiss S, Maclure M. Use of comorbidity scores for control of confounding in studies using administrative databases. *Int J Epidemiol*. 2000;29(5):891-898. doi:10.1093/ije/29.5.891
29. O'Brien RM. A caution regarding rules of thumb for variance inflation factors. *Qual Quant*. 2007;41(5):673-690. doi:10.1007/s11135-006-9018-6
30. Casalino LP, Wu FM, Ryan AM, et al. Independent practice associations and physician-hospital organizations can improve care management for smaller practices. *Health Aff (Millwood)*. 2013;32(8):1376-1382. doi:10.1377/hlthaff.2013.0205
31. Adler-Milstein J, Jha AK. HITECH Act drove large gains in hospital electronic health record adoption. *Health Aff (Millwood)*. 2017;36(8):1416-1422. doi:10.1377/hlthaff.2016.1651
32. Spencer-Bonilla G, Serrano V, Gao C, et al. Patient work and treatment burden in type 2 diabetes: a mixed-methods study. *Mayo Clin Proc Innov Qual Outcomes*. 2021;5(2):359-367. doi:10.1016/j.mayocpiqo.2021.01.006
33. Khatana SAM, Yang L, Eberly LA, Julien HM, Adusumalli S, Groeneveld PW. Predictors of telemedicine use during the COVID-19 pandemic in the United States—an analysis of a national electronic medical record database. *PLoS One*. 2022;17(6):e0269535. doi:10.1371/journal.pone.0269535
34. Chunara R, Zhao Y, Chen J, et al. Telemedicine and healthcare disparities: a cohort study in a large healthcare system in New York City during COVID-19. *J Am Med Inform Assoc*. 2021;28(1):33-41. doi:10.1093/jamia/ocaa217
35. Campos-Castillo C, Anthony D. Racial and ethnic differences in self-reported telehealth use during the COVID-19 pandemic: a secondary analysis of a US survey of internet users from late March. *J Am Med Inform Assoc*. 2021;28(1):119-125. doi:10.1093/jamia/ocaa221
36. Poon BY, Shortell S, Rodriguez HP. Physician practice transitions to system ownership do not result in diminished practice responsiveness to patients. *Health Serv Res*. 2018;53(4):2268-2284. doi:10.1111/1475-6773.12804

Visit **ajmc.com/link/89302** to download PDF and eAppendix

**eAppendix**

- **eAppendix Table 1.** Characteristics of the Ten Health Systems
- **eAppendix Table 2.** Patient Analytic Sample Exclusions
- **eAppendix Table 3.** Encounter and Patient Counts, by Practice Ownership
- **eAppendix Table 4.** Descriptive Summary of Practice Characteristics
- **eAppendix Figure 1.** Temporal Trends in Telemedicine Across Ten Health Systems
- **eAppendix Figure 2.** Weekly Encounter Volume for Adults with Diabetes and/or Hypertension Across Ten Health Care Systems

**eAppendix Table 1. Characteristics of the Ten Health Systems**

| Health System | Restricted Practice Sample Count | Physician full-time Equivalents | Physicians per practice | Clinician employment relationships represented in data |
|---|---|---|---|---|
| A | 638 | 2100 | 3.29 | system-employed |
| B | 50 | 100 | 2.00 | medical group |
| C | 14 | 76 | 5.43 | medical group |
| D | 77 | 156 | 2.03 | medical group |
| E | 226 | 1014 | 4.49 | system-employed |
| F | 43 | 550 | 12.79 | system-employed (academic) |
| G | 63 | 235 | 3.73 | medical group |
| H | 55 | 115 | 2.09 | medical group |
| I | 42 | 70 | 1.67 | medical group |
| J | 40 | 240 | 6.00 | medical group |

**eAppendix Table 2. Patient Analytic Sample Exclusions for the Main Sample**

| | Number of Encounters | % of Total Eligible Encounters |
|---|---|---|
| Total Encounters in 2020 | 4,172,354 | 100.0% |
| Encounter analytic sample | 3,016,761 | 72.3% |
| **Exclusions:** | | |
| Encounters that were outside the March-December study period | 609,845 | 14.6% |
| Encounters not attributed to any practice | 361,745 | 8.7% |
| Encounters in practices with total patients less than 50 | 184,003 | 4.4% |

Notes: Total eligible encounters are restricted to established adult patients with utilization and diagnoses during the 2019 period. We limited the analytic sample to patients with at least one physician visit and at least one diagnosis of diabetes and/or hypertension between January 1, 2019 and March 12, 2020.

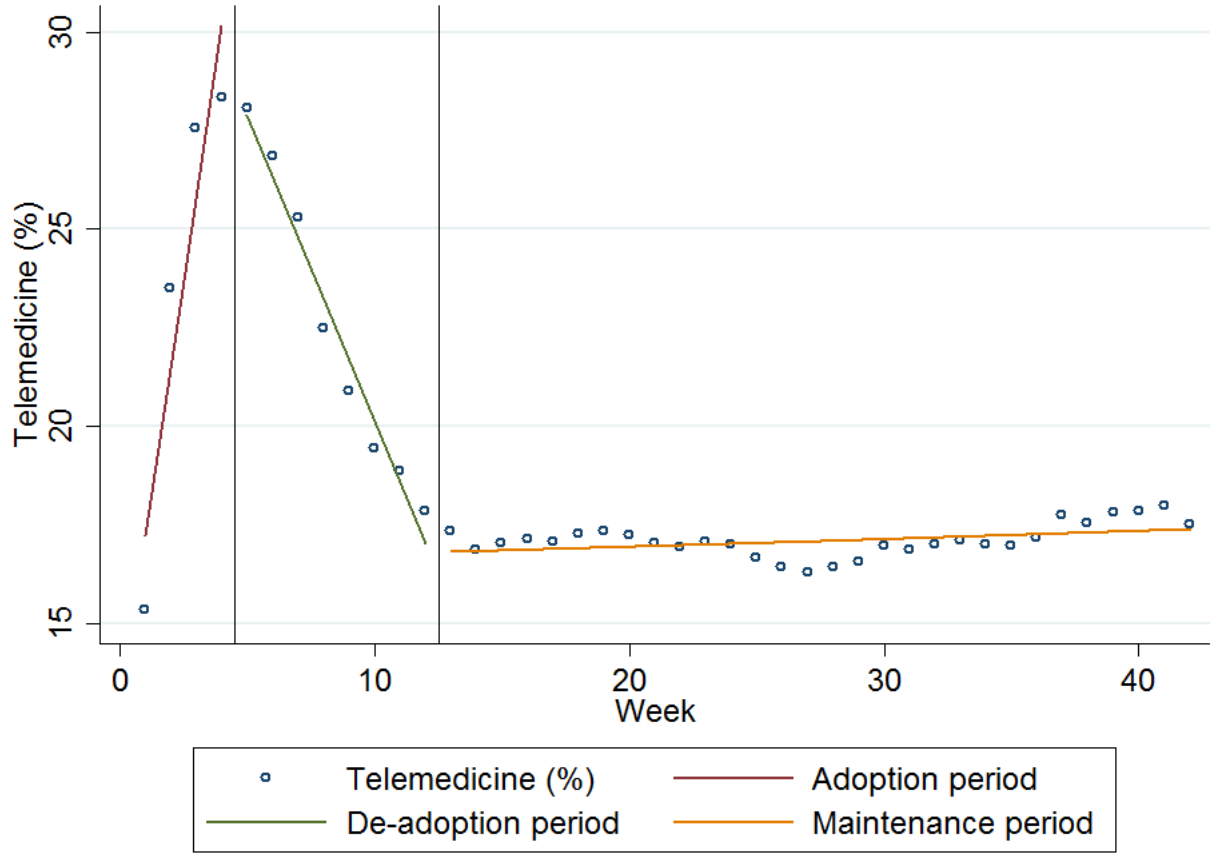
**eAppendix Table 3. Encounter and Patient Counts, by Practice Ownership**

| | Practices with ≥ 50 Attributed Patients | | |
|---|---|---|---|
| | Diabetes (with or without hypertension) | Hypertension (without diabetes) | Total |
| **Encounters** | 1,253,540 | 1,763,221 | 3,016,761 |
| Encounters by Ownership | | | |
| System | 951,437 (76.0%) | 1,343,522 (76.2%) | 2,294,959 (76.1%) |
| Medical Group | 15,395 (1.2%) | 21,028 (1.2%) | 36,423 (1.2%) |
| Independent | 286,708 (22.9%) | 398,671 (22.6%) | 685,379 (22.7%) |
| **Patients** | 279,676 | 484,845 | 764,521 |
| Patients by Ownership | | | |
| System | 213,051 (76.2%) | 370,434 (76.4%) | 583,485 (76.3%) |
| Medical Group | 3,899 (1.4%) | 6,485 (1.3%) | 10,384 (1.4%) |
| Independent | 62,726 (22.4%) | 107,926 (22.3%) | 170,652 (22.3%) |
| Number of practices | - | - | 1,207 |

**eAppendix Table 4. Descriptive Summary of Practice Characteristics**

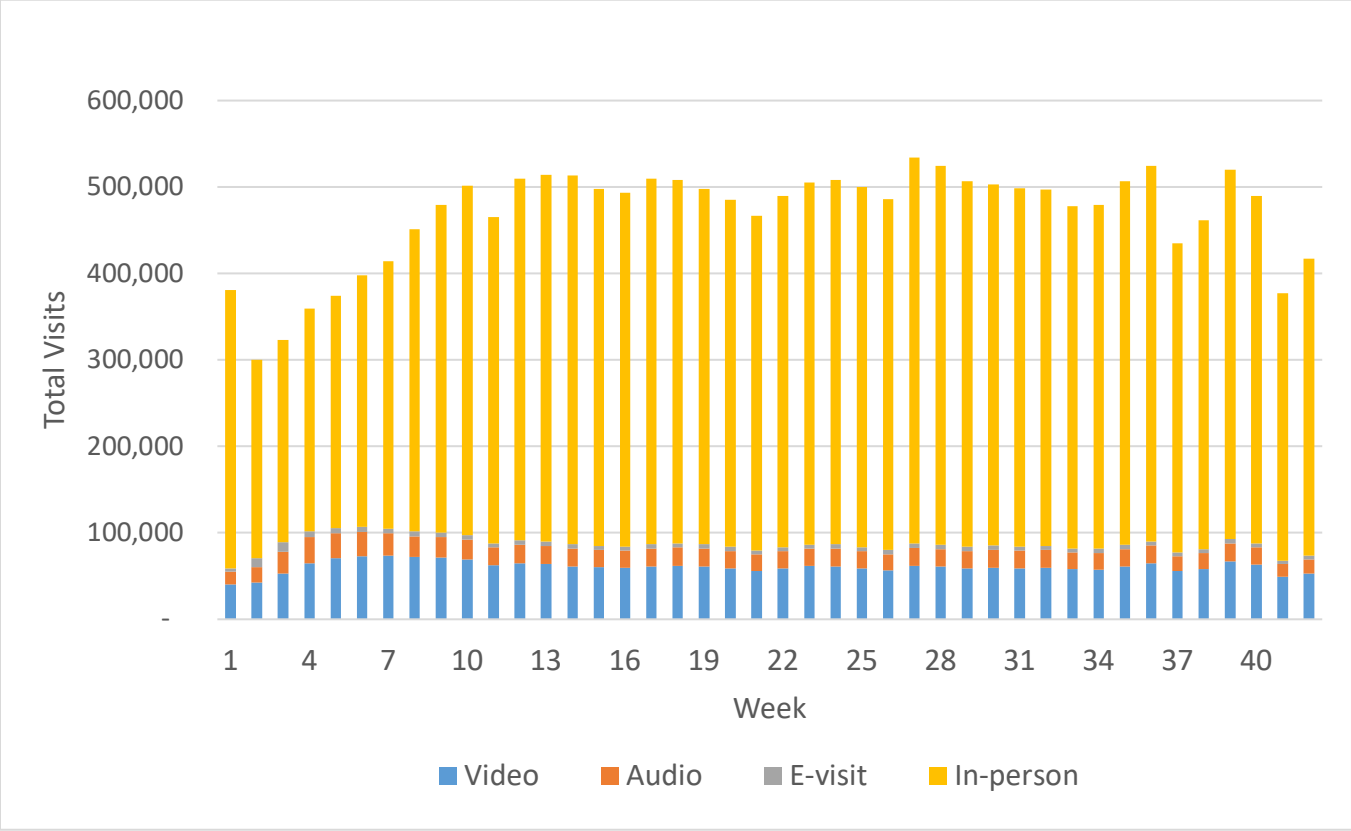
| | Practices in Analytic Sample (≥50 attributed Patients) | Practice Locations Excluded due to <50 attributed Patients | All Practice Locations |
|---|---|---|---|
| **Practice n** | 1,207 | 10,441 | 11,648 |
| **Practice Characteristics** | | | |
| Advanced Practice Clinicians (Mean, SD) | 2.9 (9.8) | 2.5 (6.7) | 2.5 (7.1) |
| Size (%) | | | |
| Small, 0 to 1 physician | 28.1 | 35.9 | 35.1 |
| Medium, 2 to 3 physicians | 30.2 | 27.0 | 27.3 |
| Medium, 4 to 6 physicians | 20.5 | 18.2 | 18.4 |
| Large, 7 or more physicians | 21.2 | 18.9 | 19.2 |
| Specialty Mix (%) | | | |
| No Specialists | 72.5 | 75.1 | 74.8 |
| Low Specialty | 9.2 | 7.0 | 7.2 |
| Moderate Specialty | 9.1 | 9.1 | 9.1 |
| High Specialty | 9.2 | 8.8 | 8.9 |
| Ownership (%) | | | |
| System | 76.9 | 75.5 | 75.6 |
| Medical Group | 5.2 | 9.1 | 8.7 |
| Independent | 17.9 | 15.4 | 15.6 |

**eAppendix Figure 1. Temporal Trends in Telemedicine Across Ten Health Systems for Adults with Diabetes and/or Hypertension**




Notes: The figure depicts the actual weekly overall trends (empty dots) in telemedicine use compared to an estimated linear trend in telemedicine use for each of the three periods.

**eAppendix Figure 2. Weekly Total Encounter Volume for Adults with Diabetes and/or Hypertension Across 10 Health Care Systems**




Notes: Total weekly encounter volume for adults with diabetes and/or hypertension across the ten health care systems is presented, differentiating in-person and telemedicine (video, audio, e-visit) volume. Weeks that contain the following holidays are weighted by the total number of non-holidays in that week. Week 11: Memorial Day; Week 17: Independence Day; Week 26: Labor Day; Week 37: Thanksgiving Day; Week 42: Christmas Day and New Year's Eve