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ORIGINAL RESEARCH

Telemedicine Compared to Office-Based Care of Patients With Cardiac Symptoms

Treatment and Outcomes

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ABSTRACT

BACKGROUND An increasing proportion of visits are now delivered via a virtual platform. Virtual visits are limited by the lack of important components of cardiovascular assessment such as physician examination and electrocardiogram.

OBJECTIVES The purpose of this study was to evaluate the quality of care delivered by virtual visits compared to office-based visits among adults who sought care for three common cardiac-related symptoms: dyspnea, dizziness, or palpitations.

METHODS Retrospective cohort study of 992,526 outpatient visits between January 1, 2017, and December 31, 2021, within an integrated health system, including 356,159 visits for dyspnea, 412,913 for dizziness, and 223,454 for palpitations. We compared the differences in patient characteristics associated with telemedicine visits versus in-office visits, evaluated the referral rates for noninvasive cardiac testing, and examined the association between virtual visits and 30-day clinical outcomes.

RESULTS Among 992,526 visits, 71.5% were office visits, 25.8% telephone visits, and 2.7% video visits. Median age was 59 (IQR: 43-72) years, and 63.1% were women. Patient characteristics associated with increased likelihood of virtual visits included younger age, female sex, being non-Hispanic Black, and being from lower-income households. No association was observed between visit types and 30-day cardiovascular hospitalization for patients with dizziness or palpitations. However, for patients with dyspnea, evaluation via virtual visits was associated with a higher risk of 30-day hospitalization for heart failure (aOR: 1.25; 95% CI: 1.16-1.36 for telephone visits; aOR: 1.45; 95% CI: 1.17-1.80 for video visits). Compared to office-based visits, patients with dyspnea were less likely to be referred for echocardiogram with telephone (aOR: 0.73; 95% CI: 0.72-0.75) or video visits (aOR: 0.92; 95% CI: 0.87-0.98).

CONCLUSIONS Virtual visits may be appropriate for some clinical concerns but not all. Optimal alignment of clinical conditions with appropriate care modalities is an important component of a successful telemedicine strategy.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

KPSC = Kaiser Permanente Southern California

There has been a rapid expansion of telemedicine use over the past several years.[1] Video and telephone visits offer tremendous promise to transform the delivery of cardiovascular care by overcoming geographic distance, enhancing access to care, and building efficiencies.[2] Benefits of virtual visits include increased access for appointments to patients with physical, geographical, or transportation barriers.[3,4] Virtual visits are associated with high levels of patient satisfaction.[5] However, there may be disparities in technology use and access, particularly among older patients with limited digital literacy or patients of lower socioeconomic status who lack internet access.[6]

For cardiovascular care, virtual visits do not deliver the full spectrum of services offered by in-office visits. Important elements of cardiovascular examination including auscultation of the heart and lung sounds cannot be easily conducted virtually.[7-9] Comprehensive cardiovascular evaluation relies on many elements, including history, physical examination, vital signs, and cardiac testing such as electrocardiogram or echocardiogram to arrive at the correct diagnosis and management plan. Incomplete physical examination for symptomatic patients may result in emergency department referrals that could have been avoided with an in-office visit. Diagnostic studies in low-risk patients may be ordered to compensate for the lack of physical examination. Lack of vital signs measurements may lead to underdiagnosis and treatment of cardiac risk factors. Early evidence based on an analysis of 125.8 million primary care visits during the COVID-19 pandemic found that assessment of blood pressure declined by 37% and cholesterol levels by 20%, partly because of the significant increase in virtual visits.[10] Whether virtual visits adversely impact the diagnosis and clinical management of patients with cardiac-related symptoms has not been studied. Tracking clinical outcomes is important to show evidence-based value and to demonstrate the effectiveness of a virtual care model.

The goal of this study was to assess telemedicine use and modality among adults presenting with three common cardiac-related symptoms: dyspnea, dizziness, or palpitations. We compared the differences in patient characteristics associated with telemedicine visits versus in-office visits, evaluated the referral rates for noninvasive cardiac testing, and examined the association between virtual visits and 30-day clinical outcomes.

METHODS

This is a retrospective cohort study conducted within Kaiser Permanente Southern California (KPSC). This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.[11] This study was approved by the Institutional Review Board with a waiver of informed consent based on 45 CFR §46.

DATA SOURCE. KPSC is an integrated health care delivery system with over 4.8 million members, 15 hospitals, and more than 200 medical offices. The membership is ethnically and socioeconomically diverse and is representative of the general population of California.[12] Patients enroll through the Kaiser Foundation Health Plan for comprehensive health insurance, including prescription drug benefits. Comprehensive medical information, including demographics, administrative, pharmacy, laboratory, and health care utilization data from ambulatory and inpatient encounters, is prospectively captured electronically through clinical and administrative databases and the electronic health record and stored at a centralized research data warehouse.[13]

STUDY COHORT. We included adults ages 18 and above who completed an outpatient visit between January 1, 2017, and December 31, 2021, at a primary care clinic or a cardiologist clinic with a chief concern of "dizziness," "dyspnea," or "palpitation." The chief concern refers to the reason for the patient's visit, as documented in the medical record by either the intake nurses or physicians, based on the patient's report. We included office visits, telephone visits, and video visits provided by physicians, nurse practitioners, physician assistants, and resident physicians. The analysis was performed at the encounter level, with each clinic visit treated as a distinct event, and the date of visit used as the index date. Patients who were not KPSC members or had less than 1 year of membership prior to the index visit were excluded.

Demographic characteristics, including age, sex, race, and ethnicity, were collected from the electronic medical record. Race and ethnicity were self-reported and categorized into mutually exclusive groups: Asian or Pacific Islander, Black, White, and other (defined as Native American or Alaska Native and multiple or other races and ethnicities). Household income was estimated using the provided home address and the corresponding neighborhood information. We identified baseline medical comorbidities using International Classification of Diseases-10th

Revision codes. Patients were followed for 30 days for clinical endpoints.

NONINVASIVE CARDIAC PROCEDURES. Noninvasive cardiac testing procedures were identified using Current Procedural Terminology codes. We evaluated rates of transthoracic echocardiogram, treadmill stress test, stress echocardiogram, stress nuclear myocardial perfusion imaging with single-photon emission computed tomography (MPI), Holter monitor, and event monitor.

CLINICAL OUTCOMES. The primary outcome was hospitalization for a cardiovascular cause within 30 days after the index visit. Secondary outcomes included 30-day hospitalization for myocardial infarction, heart failure, or atrial fibrillation. Hospitalization for myocardial infarction, heart failure, or atrial fibrillation was defined as hospital discharges with a principal diagnosis of these conditions identified using International Classification of Diseases codes.

STATISTICAL ANALYSIS. Continuous variables were reported as median (IQR). Categorical variables are reported as numbers (%). Differences in categorical data were compared by the chi-square tests. Multivariable logistic regression models were constructed to examine the association between index visit type (office visit, video visit, or telephone visit) and 30-day clinical outcomes. Separate models were constructed for each outcome. Models were adjusted for patient demographics, including age, sex, race or ethnicity, and medical comorbidities. We also examined the association between patient demographic characteristics (age, sex, race, ethnicity, and household income level) and the use of video visit or telephone visit compared to in-person office visits. OR and the associated 95% CI were reported. All analyses were performed using 2-sided tests for significance, and $P < 0.05$ was used as the threshold for statistical significance. Analyses were conducted using Stata 17/MP 17.0 (StataCorp LLC) or SAS version 9.4 (SAS Institute Inc).

RESULTS

STUDY POPULATION. Among 992,526 visits during the study period, 709,998 (71.5%) were office visits, 255,625 (25.8%) were telephone visits, and 26,903 (2.7%) were video visits. In terms of chief complaints for these visits, 356,159 (35.9%) were for dyspnea, 412,913 (41.6%) were for dizziness, and 223,454 (22.5%) were for palpitations. **Table 1** shows the baseline characteristics of the population. Median age was 59 (IQR: 43-72) years, 63.1% were women, 39.3% self-identified as non-Hispanic White, 9.3% non-Hispanic Black, 37.8% Hispanic, and 11.0% non-Hispanic Asian. The majority of visits were provided by clinicians with internal medicine or family medicine training. Cardiologists provided care for 8.5% of these visits. A high proportion office visits were for dizziness.

NONINVASIVE CARDIAC TESTING PATTERNS BY VISIT TYPE. Rates of noninvasive cardiac testing were lower with virtual visits (**Central Illustration**). Among patients with dyspnea, an echocardiogram was ordered in 16.7% of office visits, 11.5% of telephone visits, and 13.1% of video visits (**Figure 1**). Compared to office visits, telephone visits were associated with a lower likelihood of referral for an echocardiogram (aOR: 0.73; 95% CI: 0.72-0.75), stress testing (aOR: 0.55; 95% CI: 0.53-0.56), and cardiac rhythm monitoring (aOR: 0.69; 95% CI: 0.65-0.72) (**Table 2**). Video visits were also associated with a lower likelihood of echocardiogram (aOR: 0.92; 95% CI: 0.87-0.98), stress testing (aOR: 0.66; 95% CI: 0.62-0.71), and cardiac rhythm monitoring (aOR: 0.81; 95% CI: 0.72-0.93).

Among patients who presented with palpitations, cardiac rhythm monitoring was ordered in 20.7% of office visits, 15.2% of telephone visits, and 17.2% of video visits (**Figure 1**). Compared to office visits, patients with palpitations were less likely to be referred for cardiac rhythm monitoring if they had telephone visits (aOR: 0.69; 95% CI: 0.67-0.71) or video visits (aOR: 0.80; 95% CI: 0.75-0.86) (**Table 2**).

PATIENT CHARACTERISTICS ASSOCIATED WITH A TELEPHONE VISIT OR A VIDEO VISIT. Adjusted associations between patient sociodemographic characteristics and utilization of telephone visits or video visits are shown in **Table 3**. Compared to adults ages 18 to 34, adults 50 years and above were less likely to utilize telephone or video visits. Men were slightly less likely than women to utilize telephone visits (aOR: 0.96; 95% CI: 0.95-0.97). Compared to non-Hispanic White patients, non-Hispanic Black patients were more likely to utilize telephone and video visits (telephone: aOR: 1.13; 95% CI: 1.11-1.15; video: aOR: 1.34; 95% CI: 1.28-1.40). Hispanic patients and non-Hispanic Asian patients were also more likely to utilize video visits.

We evaluated the association between estimated household income and virtual visit utilization and observed that patients with lower household incomes were more likely to utilize telephone or video visits.

CLINICAL OUTCOMES. Among patients evaluated for dyspnea, 0.75% of office visits, 0.82% of telephone visits, and 0.82% of video visits were followed by hospitalization for heart failure within 30 days

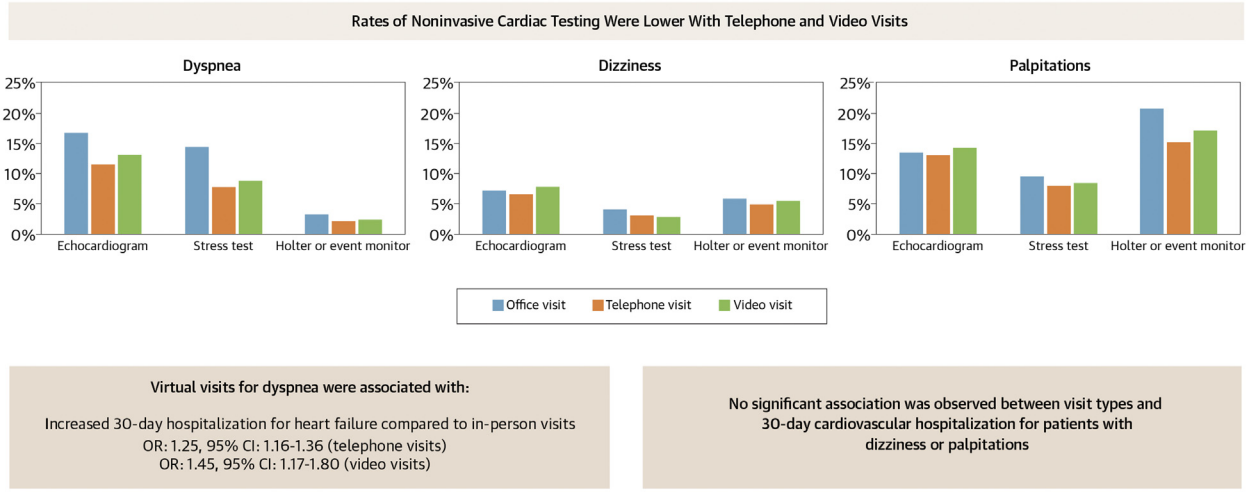
TABLE 1 Baseline Characteristics

	Office Visit (n = 709,998)	Telephone Visit (n = 255,625)	Video Visit (n = 26,903)	Total (N = 992,526)	*P* Value
Age, y					
18-34	91,062 (12.8)	40,002 (15.7)	5,021 (18.7)	136,085 (13.7)	<0.001
35-49	135,224 (19.1)	56,516 (22.1)	7,377 (27.4)	199,117 (20.1)	
50-64	192,098 (27.1)	67,972 (26.6)	6,867 (25.5)	266,937 (26.9)	
65-79	206,581 (29.1)	64,320 (25.2)	5,605 (20.8)	276,506 (27.9)	
≥80	85,033 (12.0)	26,815 (10.5)	2,033 (7.6)	113,881 (11.5)	
Sex					
Male	264,803 (37.3)	91,855 (35.9)	9,848 (36.6)	366,506 (36.9)	<0.001
Female	445,195 (62.7)	163,770 (64.1)	17,055 (63.4)	626,020 (63.1)	
Race/ethnicity					
White	283,682 (40.0)	97,790 (38.3)	8,626 (32.1)	390,098 (39.3)	<0.001
Black	63,649 (9.0)	26,018 (10.2)	2,878 (10.7)	92,545 (9.3)	
Hispanic	264,764 (37.3)	98,976 (38.7)	11,757 (43.7)	375,497 (37.8)	
Asian	80,693 (11.4)	25,472 (10.0)	2,722 (10.1)	108,887 (11.0)	
Other	17,210 (2.4)	7,369 (2.9)	920 (3.4)	25,499 (2.6)	
Insurance type					
Commercial	366,460 (51.6)	141,992 (55.6)	16,154 (60.1)	524,666 (52.9)	<0.001
Medicare	247,978 (34.9)	77,658 (30.4)	6,638 (24.7)	332,274 (33.5)	
Medicaid	38,950 (5.5)	16,199 (6.3)	1,948 (7.2)	57,097 (5.8)	
Other	56,400 (7.9)	19,650 (7.7)	2,145 (8.0)	78,195 (7.9)	
Missing	210 (0.03)	126 (0.05)	18 (0.07)	354 (0.04)	
Income					
>$80,000	356,316 (50.2)	123,647 (48.4)	12,412 (46.1)	492,375 (46.1)	<0.001
$45,001-$80,000	285,703 (40.2)	106,698 (41.7)	11,712 (43.5)	404,113 (40.7)	
≤45,000	65,672 (9.3)	24,783 (9.7)	2,744 (10.2)	93,199 (9.4)	
Unknown	2,307 (0.3)	497 (0.2)	35 (0.1)	2,839 (0.3)	
Specialty					
Cardiology	60,662 (8.5)	20,391 (8.0)	3,502 (13.0)	84,555 (8.5)	<0.001
Family medicine	426,134 (60.0)	163,947 (64.1)	14,744 (54.8)	604,825 (60.9)	
Internal medicine	223,202 (31.4)	71,287 (27.9)	8,657 (32.2)	303,146 (30.5)	
Medical comorbidities					
Hypertension	349,124 (49.2)	118,224 (46.3)	10,809 (40.2)	478,157 (48.2)	<0.001
Hyperlipidemia	401,709 (56.6)	134,416 (52.6)	12,869 (47.8)	548,994 (55.3)	<0.001
Diabetes	166,657 (23.5)	58,380 (22.8)	5,472 (20.3)	230,509 (23.2)	<0.001
Coronary artery disease	36,924 (5.2)	13,052 (5.1)	1,228 (4.6)	51,204 (5.2)	<0.001
Heart failure	62,964 (8.9)	24,658 (9.7)	2,298 (8.5)	89,920 (9.1)	<0.001
Atrial fibrillation	66,955 (9.4)	23,898 (9.4)	2,224 (8.3)	93,077 (8.3)	<0.001
Stroke/TIA	47,621 (6.7)	17,246 (6.8)	1,546 (5.8)	66,413 (6.7)	<0.001
Chronic kidney disease	110,105 (15.5)	36,721 (14.4)	3,132 (11.6)	149,958 (15.1)	<0.001
Liver disease	5,832 (0.8)	1,386 (0.5)	109 (0.4)	7,327 (0.7)	<0.001
COPD/asthma	201,682 (28.4)	78,201 (30.6)	7,754 (28.8)	287,637 (29.0)	<0.001
Obesity	240,644 (33.9)	85,568 (33.5)	9,180 (34.1)	335,392 (34.1)	<0.001
Hypothyroidism	94,136 (13.3)	33,195 (13.0)	2,995 (11.1)	130,326 (13.1)	<0.001
Dementia	12,863 (1.8)	4,482 (1.8)	421 (1.6)	17,766 (1.8)	0.003
Depression	182,718 (25.7)	70,952 (27.8)	7,453 (27.7)	261,123 (26.3)	<0.001
Chief complaint					
Dizziness	311,558 (43.9)	91,847 (35.9)	9,508 (35.3)	412,913 (41.6)	<0.001
Dyspnea	234,993 (33.1)	110,155 (43.1)	11,011 (40.9)	356,159 (35.9)	
Palpitations	163,447 (23.0)	53,623 (21.0)	6,384 (23.7)	223,454 (22.5)	

COPD = chronic obstructive pulmonary disease; TIA = transient ischemia attack.

(Table 4). After adjusting for demographics and comorbidities, the likelihood of 30-day hospitalization for heart failure was significantly higher for telephone visits (aOR: 1.25; 95% CI: 1.16-1.36) and video visits (aOR: 1.45; 95% CI: 1.17-1.80). No significant association was observed between visit type and hospitalization for atrial fibrillation or myocardial infarction. All-cause cardiovascular hospitalization

CENTRAL ILLUSTRATION **Telemedicine Compared to Office-Based Care of Patients With Cardiac Symptoms: Treatment and Outcomes**



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within 30 days was higher for telephone visits (aOR: 1.11; 95% CI: 1.05-1.18) and video visits (aOR: 1.25; 95% CI: 1.07-1.46).

For patients evaluated for dizziness or palpitations, no association was observed between visit type and 30-day cardiovascular hospitalization (Table 4).

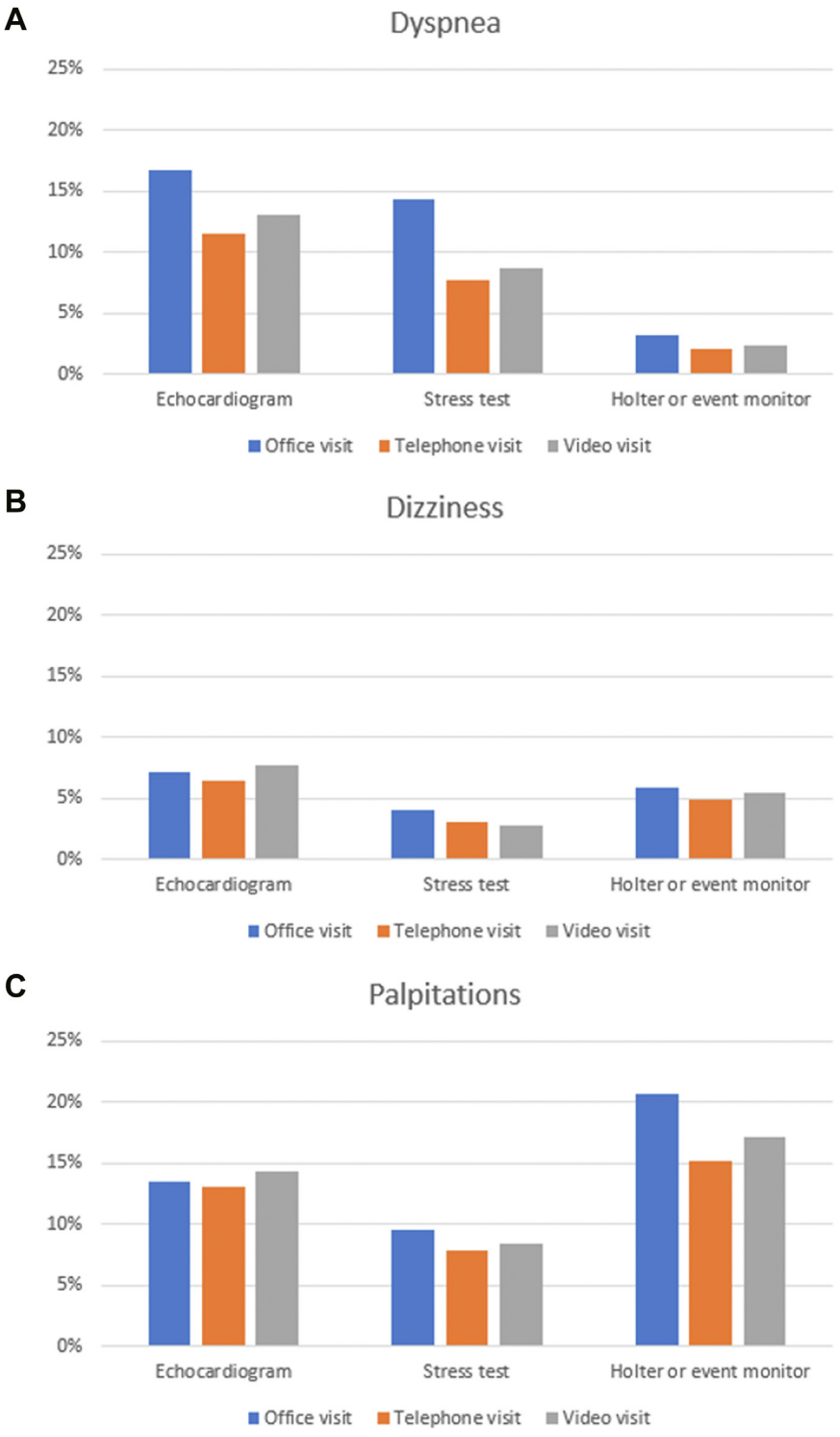
DISCUSSION

Among patients who presented for an outpatient visit for the evaluation of dyspnea, dizziness, or palpitations within an integrated health care system in the United States, approximately one-fourth were assessed through telemedicine. The majority of telemedicine visits were conducted by telephone. Patient characteristics associated with increased likelihood of telemedicine visits included younger age, female sex, being non-Hispanic Black, and being from lower-income households. Compared to in-person visits, referral for noninvasive cardiac testing was significantly lower with virtual visits. Among patients with dyspnea, telephone visits were associated with a 25% increased likelihood of hospital admission for heart failure within 30 days, while video visits were associated with a 45% increased risk compared to in-person visits. For patients with symptoms of dizziness or palpitations, no significant association was observed between visit type and the risk of 30-day cardiovascular hospitalization. These findings suggest telemedicine may not be the ideal visit type for all patients. Patients with certain symptoms, such as dyspnea, might require in-person evaluation and management.

The past few years have seen a rapid increase in ambulatory telemedicine visits.[14] In the post-COVID world, a substantial proportion of patient care continues to be delivered virtually. This increase in virtual care may be a turning point for the delivery of clinical services moving forward, with the potential to transform health care into a model that is more patient-centered, with increased convenience and reduced cost.[15-17] With any new care delivery model, the quality of care delivered needs to be actively evaluated. Tracking clinical outcomes associated with virtual visits is important to demonstrate the safety and effectiveness of a virtual care model. Certain conditions and patient profiles may be particularly well-suited for virtual care. For example, follow-up appointments for chronic conditions, where management focuses on medication adjustments and reviewing lab results, can often be effectively handled through telemedicine.[18-20] Similarly, mental health consultations and psychotherapy have been shown to be as effective when conducted virtually, with the added benefit of offering patient privacy and removing barriers to access.[21,22]

For the evaluation of cardiac conditions, virtual visits are limited by the lack of a comprehensive physical examination. The importance of physical examination may differ based on the patient's presenting concerns. An important observation of this study was the increased likelihood of hospital

FIGURE 1 Rate of Cardiac Testing Referrals by Visit Type and Chief Complaint



Rates of referrals for echocardiogram, stress tests, and Holter or event monitor stratified by visit types for patients presenting with (A) dyspnea, (B) dizziness, and (C) palpitations.

TABLE 2 Association Between Visit Type and Cardiac Testing Stratified by Chief Complaint

	Office Visit		Telephone Visit			Video Visit		
	Rate per 100 Encounters		Rate per 100 Encounters	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]	Rate per 100 Encounters	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
Dyspnea								
Echocardiogram	16.7	Reference	11.5	0.65 (0.64-0.65)	0.73 (0.72-0.75)	13.1	0.75 (0.71-0.80)	0.92 (0.87-0.98)
Stress test	14.4	Reference	7.7	0.49 (0.48-0.50)	0.55 (0.53-0.56)	8.7	0.56 (0.53-0.60)	0.66 (0.62-0.71)
Holter or event monitor	3.2	Reference	2.1	0.66 (0.63-0.69)	0.69 (0.65-0.72)	2.1	0.77 (0.68-0.87)	0.81 (0.72-0.92)
Dizziness								
Echocardiogram	7.2	Reference	6.5	0.89 (0.87-0.92)	0.88 (0.86-0.91)	7.7	1.06 (0.98-1.15)	1.14 (1.06-1.23)
Stress test	4.0	Reference	3.0	0.73 (0.70-0.76)	0.74 (0.71-0.78)	2.7	0.67 (0.59-0.76)	0.73 (0.64-0.83)
Holter or event monitor	5.8	Reference	4.9	0.85 (0.82-0.88)	0.84 (0.81-0.87)	5.5	0.94 (0.86-1.03)	0.99 (0.91-1.09)
Palpitations								
Echocardiogram	13.5	Reference	13.0	0.96 (0.93-0.99)	0.96 (0.93-0.99)	14.4	1.08 (1.01-1.16)	1.12 (1.04-1.20)
Stress test	9.5	Reference	7.8	0.80 (0.77-0.83)	0.82 (0.79-0.85)	8.4	0.87 (0.80-0.96)	0.94 (0.86-1.03)
Holter or event monitor	20.7	Reference	15.2	0.69 (0.67-0.70)	0.69 (0.67-0.71)	17.2	0.79 (0.74-0.85)	0.80 (0.75-0.86)

[a]Adjusted for age, sex, race and ethnicity, income level, comorbidities (hypertension, diabetes, coronary artery disease, heart failure, atrial fibrillation, chronic kidney disease, stroke or transient ischemic attack, COPD/asthma).

admission for heart failure within 30 days after a virtual visit for dyspnea. This suggests that virtual visits, particularly for evaluating dyspnea, may not adequately identify patients at risk of decompensation or needing immediate intervention that could have prevented hospitalization. In contrast, for symptoms of dizziness or palpitations, virtual visits appeared to be equally effective compared to in-person care in addressing these concerns. These observations may be due to heart failure being an important diagnosis among patients presenting with dyspnea. Physical examination plays a central role in managing patients with heart failure.[23] A comprehensive physical examination allows assessment of patients underlying hemodynamic state so they can be categorized based on their volume status (wet/dry)

TABLE 3 Patient Characteristics Associated With Use of Telephone or Video Visits

	Telephone Visits		Video Visits	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
Age, y				
18-34	Reference	Reference	Reference	Reference
35-49	0.95 (0.94-0.97)	0.96 (0.94-0.97)	1.00 (0.97-1.04)	1.01 (0.98-1.05)
50-64	0.82 (0.81-0.83)	0.83 (0.81-0.84)	0.69 (0.66-0.72)	0.71 (0.68-0.73)
65-79	0.73 (0.72-0.74)	0.74 (0.72-0.75)	0.54 (0.52-0.56)	0.57 (0.55-0.59)
≥80	0.74 (0.73-0.75)	0.75 (0.73-0.76)	0.47 (0.45-0.50)	0.51 (0.48-0.53)
Sex				
Female	Reference	Reference	Reference	Reference
Male	0.94 (0.94-0.95)	0.96 (0.95-0.97)	0.99 (0.96-1.01)	1.04 (1.01-1.06)
Race/ethnicity				
White	Reference	Reference	Reference	Reference
Black	1.17 (1.15-1.19)	1.13 (1.11-1.15)	1.42 (1.36-1.48)	1.34 (1.28-1.40)
Hispanic	1.07 (1.06-1.09)	0.99 (0.98-0.99)	1.43 (1.39-1.47)	1.22 (1.19-1.26)
Asian	0.91 (0.90-0.93)	0.89 (0.87-0.90)	1.13 (1.09-1.18)	1.07 (1.02-1.11)
Other	1.21 (0.18-1.25)	1.11 (1.08-1.14)	1.66 (1.54-1.77)	1.36 (1.27-1.46)
Income				
>$80,000	Reference	Reference	Reference	Reference
$45,001-$80,000	1.07 (1.06-1.08)	1.04 (1.03-1.05)	1.15 (1.12-1.18)	1.06 (1.04-1.09)
≤45,000	1.08 (1.06-1.10)	1.04 (1.03-1.06)	1.17 (1.12-1.22)	1.06 (1.02-1.11)

[a]Adjusted for age, sex, race or ethnicity, and income.

TABLE 4 Rates and Odds Ratio of 30-Day Clinical Outcomes Comparing Telephone Visits and Video Visits With Office Visits Stratified by Chief Complaint

	Office Visit		Telephone Visit			Video Visit		
Dyspnea	**(n = 234,993)**	**OR (95% CI)**	**(n = 110,155)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)[a]**	**(n = 11,011)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)[a]**
Myocardial infarction	437 (0.19)	Reference	195 (0.18)	0.95 (0.80-1.13)	1.13 (0.95-1.34)	15 (0.14)	0.73 (0.44-1.23)	0.96 (0.57-1.61)
Heart failure	1,768 (0.75)	Reference	901 (0.82)	1.09 (1.00-1.18)	1.25 (1.16-1.36)	90 (0.82)	1.09 (0.88-1.34)	1.45 (1.17-1.80)
Atrial fibrillation	423 (0.18)	Reference	196 (0.18)	0.99 (0.83-1.17)	1.18 (0.99-1.40)	12 (0.11)	0.61 (0.34-1.07)	0.81 (0.46-1.45)
Cardiovascular hospitalization	4,019 (1.71)	Reference	1,796 (1.63)	0.95 (0.90-1.01)	1.11 (1.05-1.18)	178 (1.62)	0.94 (0.81-1.10)	1.25 (1.07-1.46)
Dizziness	**(n = 311,558)**		**(n = 91,847)**			**(n = 9,508)**		
Myocardial infarction	177 (0.06)	Reference	64 (0.07)	1.23 (0.92-1.63)	1.13 (0.85-1.51)	6 (0.06)	1.11 (0.49-2.51)	1.25 (0.55-2.82)
Heart failure	284 (0.09)	Reference	103 (0.11)	1.23 (0.98-1.54)	1.05 (0.83-1.32)	12 (0.13)	1.38 (0.78-2.47)	1.42 (0.79-2.55)
Atrial fibrillation	199 (0.06)	Reference	74 (0.08)	1.26 (0.97-1.64)	1.18 (0.91-1.55)	9 (0.09)	1.48 (0.76-2.89)	1.71 (0.87-3.35)
Cardiovascular hospitalization	1,648 (0.53)	Reference	544 (0.59)	1.12 (1.01-1.23)	1.05 (0.96-1.16)	58 (0.61)	1.15 (0.89-1.50)	1.30 (0.99-1.70)
Palpitations	**(n = 163,447)**		**(n = 53,623)**			**(n = 6,384)**		
Myocardial infarction	67 (0.04)	Reference	21 (0.04)	0.96 (0.59-1.56)	0.94 (0.57-1.53)	1 (0.02)	0.38 (0.05-2.75)	0.38 (0.05-2.71)
Heart failure	165 (0.10)	Reference	42 (0.08)	0.78 (0.55-1.09)	0.73 (0.52-1.03)	9 (0.14)	1.40 (0.71-2.73)	1.41 (0.71-2.81)
Atrial fibrillation	198 (0.12)	Reference	63 (0.12)	0.97 (0.73-1.29)	0.92 (0.69-1.22)	5 (0.08)	0.65 (0.27-1.57)	0.70 (0.29-1.71)
Cardiovascular hospitalization	779 (0.48)	Reference	245 (0.46)	0.95 (0.83-1.11)	0.94 (0.81-1.08)	29 (0.47)	0.95 (0.66-1.38)	1.00 (0.69-1.46)

[a]Adjusted for age, sex, race and ethnicity, income level, comorbidities (hypertension, diabetes, coronary artery disease, heart failure, atrial fibrillation, chronic kidney disease, stroke or transient ischemic attack, COPD/asthma).

and perfusion status (warm/cold).[24] Volume assessment, including evaluation of jugular venous distention, hepatojugular reflux, and square-wave response in blood pressure to the Valsalva maneuver, can be difficult to ascertain at a virtual visit. Perfusion assessment, including determining if a patient's extremities are warm versus cold can also be difficult over the telephone or video. In office-based visits, accurate classification of a patient's volume status and perfusion state allows the implementation of appropriate therapy. Patients who are volume overloaded require diuresis for decongestion. With the risk of heart failure admission being tightly coupled to filling pressure, the importance of intervention guided by hemodynamic assessment cannot be overemphasized.[25]

In this cohort, referral for noninvasive cardiac testing was lower with virtual visits. Several potential reasons may be considered. It is possible that the physical examinations performed during in-office visits allowed clinicians to uncover findings such as heart murmurs or irregular heart rhythms, prompting further evaluation with additional cardiac testing. Electrocardiograms, which are easily performed during in-office visits, may show abnormalities such as Q waves or other changes that necessitate downstream testing. Additionally, clinicians might feel more compelled to order additional tests during in-office visits because the patient had made the effort to come to the office. By ordering tests, both the clinician and the patient might feel that something concrete is being done to address the patient's concerns.

Technology advancements could play a crucial role in overcoming some of the challenges associated with virtual visits. Digital stethoscopes allow remote auscultation of the heart and lungs.[26] Wearable cardiac monitors enable recording of cardiac rhythms and electronic sharing of the recording with physicians.[27] Systems that monitor oxygen saturation, heart rate, and walking information can be used to evaluate an individual's cardiopulmonary condition, similar to a 6-minute walk test.[28] Although the technology to provide additional data for virtual care is already available, it is not yet widely utilized. Efforts to effectively integrate these technologies within virtual care practices will likely enhance the quality of care. As these technologies continue to evolve, the potential to address the gaps in virtual health care delivery becomes increasingly feasible.

In our cohort, certain patient demographics were more likely to adopt virtual care: younger individuals, women, non-Hispanic Black patients, and those from lower-income households. These patterns may reflect health care access issues, with virtual care possibly offering a more accessible option to those facing barriers to in-person care, such as time constraints, transportation difficulties, or financial difficulties. Other studies have also found older age to be

associated with lower telemedicine use.[29] Engaging in virtual visits may be challenging for older adults due to impaired hearing, vision, and motor skills.[30] Designing telemedicine devices focusing on improving usability in the geriatric population is an important area that deserves investments. We observed a higher rate of telephone visits compared to video visits in our study population. For video visits, patients and clinicians were required to install and use software that complies with Health Insurance Portability and Accountability Act regulations. The need to install a new software may have introduced an extra hassle factor for patients, making the process cumbersome for some patients who opted for the convenience of telephone visits instead.

The finding that non-Hispanic Black patients and those from lower-income households had higher adoption rates is different from what others have observed.[29,31] When telemedicine was first introduced, there were concerns that decreased accessibility to broadband internet and reliable cellphone services may exacerbate health care disparities.[31] This study's finding is reassuring, suggesting that the technology challenges are not insurmountable, and telemedicine may, in fact, improve access by allowing patients to be evaluated without needing to take time off from work. Similarly, for women who bear a disproportional burden of childcare responsibilities, telemedicine provides a platform to access health care services without the added stress of arranging care for their children.

STUDY LIMITATIONS. First, our findings may not be generalized to all patients as our cohort represents an insured population with access to comprehensive health care. Therefore, our findings may not apply to uninsured patients, or those residing outside of the United States. Second, patient comorbidities and patient outcomes were limited by the information captured in the electronic medical records. We were not able to capture patient-reported outcome measures such as patient assessment of their symptoms, well-being, and functional status. Third, this study primarily focused on patient clinical outcomes. We were not able to assess the clinicians' experience with virtual care. Fourth, although we observed that referral rates for cardiac testing were lower for virtual visits, we were not able to determine whether the ordered tests were clinically appropriate. However, the low rate of echocardiogram ordering and the higher rate of subsequent admission for heart failure raised the possibility that testing may have allowed more timely identification of patients with heart failure, allowing intervention that may have prevented a hospital admission. Finally, given the observational nature of this study, the association of virtual visits with higher event rates should not be interpreted as causative.

CONCLUSIONS

While virtual visits have emerged as an important component of modern health care delivery, their application must be thoughtful, targeted, symptom-specific, and condition-specific to ensure patient safety and optimal outcomes.

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PERSPECTIVES

COMPETENCY IN PATIENT CARE AND PROCEDURAL SKILLS: In this study that evaluated 992,526 visits for three common cardiac symptoms (dyspnea, dizziness, or palpitations), the effectiveness of telemedicine differed based on symptoms. For patients with dizziness or palpitations, the type of visit (virtual versus in-person) had no significant impact on the rate of cardiovascular hospitalization within 30 days. In contrast, patients evaluated for dyspnea via telephone or video had a significantly higher likelihood of being admitted for heart failure.

TRANSLATIONAL OUTLOOK: While telemedicine is appropriate for many patients, patients with certain cardiac symptoms, such as dyspnea, where physical examination represents an important component of diagnostic evaluation, may require in-person visits to ensure optimal care. Further research is needed to confirm the results in external cohorts.

REFERENCES

1. 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;61:434–438.

2. Gagnon MP, Duplantie J, Fortin JP, Landry R. Implementing telehealth to support medical practice in rural/remote regions: what are the conditions for success? *Implement Sci*. 2006;1:18.

3. Kehle SM, Greer N, Rutks I, Wilt T. Interventions to improve veterans' access to care: a systematic review of the literature. *J Gen Intern Med*. 2011;26(Suppl 2):689–696.

4. Reed ME, Huang J, Graetz I, et al. Patient characteristics associated with choosing a telemedicine visit vs office visit with the same primary care clinicians. *JAMA Netw Open*. 2020;3:e205873.

5. Kruse CS, Krowski N, Rodriguez B, Tran L, Vela J, Brooks M. Telehealth and patient satisfaction: a systematic review and narrative analysis. *BMJ Open*. 2017;7:e016242.

6. 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 Inf Assoc*. 2021;28:33–41.

7. Takahashi EA, Schwamm LH, Adeoye OM, et al. An overview of telehealth in the management of cardiovascular disease: a scientific statement from the American heart association. *Circulation*. 2022;146:e558–e568.

8. Chowdhury D, Hope KD, Arthur LC, et al. Telehealth for pediatric cardiology practitioners in the time of COVID-19. *Pediatr Cardiol*. 2020;41:1081–1091.

9. Yager PH, Clark ME, Dapul HR, Murphy S, Zheng H, Noviski N. Reliability of circulatory and neurologic examination by telemedicine in a pediatric intensive care unit. *J Pediatr*. 2014;165:962–966.e1-5.

10. 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:e2021476.

11. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med*. 2007;147:573–577.

12. Derose SF, Contreras R, Coleman KJ, Koebnick C, Jacobsen SJ. Race and ethnicity data quality and imputation using U.S. Census data in an integrated health system: the Kaiser Permanente Southern California experience. *Med Care Res Rev*. 2013;70:330–345.

13. Chen W, Xie F, McCarthy DP, et al. Research data warehouse: using electronic health records to conduct population-based observational studies. *JAMIA Open*. 2023;6:ooad039.

14. Zachrison KS, Yan Z, Schwamm LH. Changes in virtual and in-person health care utilization in a large health system during the COVID-19 pandemic. *JAMA Netw Open*. 2021;4:e2129973.

15. Hays RD, Skootsky SA. Patient experience with in-person and telehealth visits before and during the COVID-19 pandemic at a large integrated health system in the United States. *J Gen Intern Med*. 2022;37:847–852.

16. Patel KB, Turner K, Alishahi Tabriz A, et al. Estimated indirect cost savings of using telehealth among nonelderly patients with cancer. *JAMA Netw Open*. 2023;6:e2250211.

17. de Jong MJ, Boonen A, van der Meulen-de Jong AE, et al. Cost-effectiveness of telemedicine-directed specialized vs standard care for patients with inflammatory bowel diseases in a randomized trial. *Clin Gastroenterol Hepatol*. 2020;18:1744–1752.

18. Baughman DJ, Jabbarpour Y, Westfall JM, et al. Comparison of quality performance measures for patients receiving in-person vs telemedicine primary care in a large integrated health system. *JAMA Netw Open*. 2022;5:e2233267.

19. Wakefield BJ, Holman JE, Ray A, et al. Effectiveness of home telehealth in comorbid diabetes and hypertension: a randomized, controlled trial. *Telemed J E Health*. 2011;17:254–261.

20. Chongmelaxme B, Lee S, Dhippayom T, Saokaew S, Chaiyakunapruk N, Dilokthornsakul P. The effects of telemedicine on asthma control and patients' quality of life in adults: a systematic review and meta-analysis. *J Allergy Clin Immunol Pract*. 2019;7:199–216.e11.

21. Zarate CA Jr, Weinstock L, Cukor P, et al. Applicability of telemedicine for assessing patients with schizophrenia: acceptance and reliability. *J Clin Psychiatry*. 1997;58:22–25.

22. Wilcock AD, Huskamp HA, Busch AB, et al. Use of telemedicine and quality of care among medicare enrollees with serious mental illness. *JAMA Health Forum*. 2023;4:e233648.

23. Thibodeau JT, Drazner MH. The role of the clinical examination in patients with heart failure. *JACC Heart Fail*. 2018;6:543–551.

24. Nohria A, Tsang SW, Fang JC, et al. Clinical assessment identifies hemodynamic profiles that predict outcomes in patients admitted with heart failure. *J Am Coll Cardiol*. 2003;41:1797–1804.

25. Stevenson LW, Zile M, Bennett TD, et al. Chronic ambulatory intracardiac pressures and future heart failure events. *Circ Heart Fail*. 2010;3:580–587.

26. Silverman B, Balk M. Digital stethoscope-improved auscultation at the bedside. *Am J Cardiol*. 2019;123:984–985.

27. Sana F, Isselbacher EM, Singh JP, Heist EK, Pathik B, Armoundas AA. Wearable devices for ambulatory cardiac monitoring: JACC state-of-the-art review. *J Am Coll Cardiol*. 2020;75:1582–1592.

28. Li SH, Lin BS, Wang CA, Yang CT, Lin BS. Design of wearable and wireless multi-parameter monitoring system for evaluating cardiopulmonary function. *Med Eng Phys*. 2017;47:144–150.

29. 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:e2031640.

30. Narasimha S, Madathil KC, Agnisarman S, et al. Designing telemedicine systems for geriatric patients: a review of the usability studies. *Telemed J e Health*. 2017;23:459–472.

31. Aziz K, Moon JY, Parikh R, et al. Association of patient characteristics with delivery of ophthalmic telemedicine during the COVID-19 pandemic. *JAMA Ophthalmol*. 2021;139:1174–1182.

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