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ORIGINAL RESEARCH

Association of Structured Virtual Visits for Hypertension Follow-Up in Primary Care with Blood Pressure Control and Use of Clinical Services

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BACKGROUND: Optimal management of hypertension requires frequent monitoring and follow-up. Novel, pragmatic interventions have the potential to engage patients, maintain blood pressure control, and enhance access to busy primary care practices. "Virtual visits" are structured asynchronous online interactions between a patient and a clinician to extend medical care beyond the initial office visit.

OBJECTIVE: To compare blood pressure control and healthcare utilization between patients who received virtual visits compared to usual hypertension care.

DESIGN: Propensity score-matched, retrospective cohort study with adjustment by difference-in-differences.

PARTICIPANTS: Primary care patients with hypertension.

EXPOSURE: Patient participation in at least one virtual visit for hypertension. Usual care patients did not use a virtual visit but were seen in-person for hypertension.

MAIN MEASURES: Adjusted difference in mean systolic blood pressure, primary care office visits, specialist office visits, emergency department visits, and inpatient admissions in the 180 days before and 180 days after the in-person visit.

KEY RESULTS: Of the 1051 virtual visit patients and 24,848 usual care patients, we propensity score-matched 893 patients from each group. Both groups were approximately 61 years old, 44% female, 85% White, had about five chronic conditions, and about 20% had a mean pre-visit systolic blood pressure of 140–160 mmHg. Compared to usual care, virtual visit patients had an adjusted 0.8 (95% CI, 0.3 to 1.2) fewer primary care office visits. There was no significant adjusted difference in systolic blood pressure control (0.6 mmHg [95% CI, −2.0 to 3.1]), specialist visits (0.0 more visits [95% CI, −0.3 to 0.3]), emergency department visits (0.0 more visits [95% CI, 0.0 to 0.01]), or inpatient admissions (0.0 more admissions [95% CI, 0.0 to 0.1]).

CONCLUSIONS: Among patients with reasonably well-controlled hypertension, virtual visit participation was associated with equivalent blood pressure control and reduced in-office primary care utilization.

KEY WORDS: virtual visit; telemedicine; hypertension; blood pressure control.

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INTRODUCTION

About one in three American adults have hypertension. Only half of those with hypertension have adequate blood pressure control.[1] Hypertension costs the USA $46 billion annually and is the primary or contributing cause of 360,000 deaths each year.[2] Despite advances in treatment over several decades, management of hypertension remains a significant challenge due to non-adherence and challenges accessing care.[3] There are 39 million visits with a primary diagnosis of hypertension each year in the USA, but it is unclear if a traditional in-person visit best serves patients and clinicians.[4]

To improve hypertension care and decompress busy primary care practices, novel, pragmatic interventions are urgently needed. Primary care-based interventions should maintain quality and safety, engage patients, should not rely on adding trained personnel to the primary care workforce, and must not increase healthcare utilization outside of primary care. Many interventions require additional personnel, fail to connect patients to their clinician or primary care practice,[5,6] or increase healthcare utilization.[7]

"Virtual visits" are structured asynchronous online interactions between a clinician and patient that extend contact and medical care beyond the initial office visit with the goal of maintaining blood pressure control and reducing face-to-face office visits. Prior work on the virtual visits platform at hand demonstrated high clinician and patient satisfaction, but clinical outcomes and subsequent utilization of primary and other healthcare remain unknown.[8]

So that clinicians, healthcare leaders, and patients can choose evidence-based tools for healthcare delivery, we conducted a propensity score-matched difference-in-differences comparison of blood pressure control and healthcare utilization between primary care patients who did and did not receive virtual visits.

METHODS

Setting

Partners HealthCare is an integrated health delivery system in Eastern Massachusetts. Among other institutions, Partners HealthCare includes Massachusetts General Hospital and Brigham and Women's Hospital, academic medical centers each with multiple community- and hospital-based primary care clinics.

Data Extraction

We obtained electronic health record data for all patients in the exposure and usual care groups. This included sociodemographic variables (gender, age, language preference, partner status, veteran status, race/ethnicity, BMI, health insurance, and medical conditions), systolic blood pressure (SBP) measurements, and healthcare utilization within the partners system (visits to primary care, specialists, and the emergency department; inpatient admissions).

Exposure: Virtual Visits

This virtual visit platform has been described in detail elsewhere.[8] In brief, virtual visits are asynchronous, structured digital exchanges between a patient and a primary care clinician following an in-person encounter. Their purpose is to substitute for a follow-up in-person visit. We assessed virtual visits specifically crafted for hypertension follow-up after an in-person visit. After a visit where hypertension was discussed, clinicians could ask their patients to follow-up online through the virtual visit platform from 21 to 180 days following the initial encounter. The follow-up period from in-person visit to virtual visit was entirely at the discretion of the treating clinician. The virtual visit begins with a notification e-mail which directs the patient to a secure mobile-friendly website. The patient enters up to five blood pressure readings, notes medication adherence through a single binary response, relays medication side effects by free text, and can ask the ordering clinician questions. Once submitted, the clinician reviews the data and can respond with structured treatment decisions via the platform, recommendation for repeat virtual visit, recommendation for follow-up phone call, or request for an in-person appointment. A clinician could offer a virtual visit as s/he saw fit. There was no protocolized standardization of the blood pressure device, calibration, or training.

Virtual visits were first offered to select primary care practices at Massachusetts General Hospital in March 2013. In March 2015, virtual visits were made available to all primary care clinicians at Massachusetts General Hospital and its affiliated clinics. Virtual visits have not been available outside of Massachusetts General Hospital and its affiliated clinics, but they are planned to be rolled out to all of Partners HealthCare.

The exposure group included every patient who had engaged in a virtual visit for hypertension at any of Massachusetts General Hospital's primary care clinics between December 12, 2012 and February 19, 2016 ($n = 1051$). We defined a "pre-visit" time period as 180 days before the in-person visit for hypertension. The "post-visit" time period was 180 days after the in-person visit for hypertension. The virtual visit occurred during this post-visit period.

Usual Care

The usual care group was drawn from all patients with hypertension who presented with principal diagnosis of essential hypertension (ICD9 401.9 or 401.1; shown to be a relatively accurate reflection of the true reason for a visit)[9] to a primary care clinician's office at any of Brigham and Women's network of primary care clinics between December 12, 2012 and February 19, 2016 ($n =$ 28,848). Because Brigham and Women's primary care clinics do not yet have access to virtual visits but otherwise had similar information systems and are planning to implement virtual visits, they made for an uncontaminated usual care group. The pre-visit and post-visit time periods were defined the same as for the exposure group.

Propensity Score Matching Analysis

We used propensity score matching to create comparable cohorts of virtual visit and usual care patients. We used logistic regression modeling to create the propensity score of receiving a virtual visit (as if virtual visits were available at Brigham and Women's network of primary care practices). We propensity score matched using age (continuous), gender (two classes), language preference (four classes), partner status (two classes), veteran status (two classes), smoking (two classes), race/ethnicity (four classes), health insurance coverage (four classes), total number of chronic conditions (continuous; of the 20 conditions considered chronic by the Health and Human Services Office of the Assistant Secretary of Health),[10] visit year (continuous), mean pre-visit SBP (four classes), number of pre-visit antihypertensive medications (continuous), pre-visit primary care visits (continuous), pre-visit specialist visits (continuous), pre-visit emergency visits (continuous), and pre-visit inpatient admissions (continuous). We then used a SAS macro to perform nearest propensity score one-to-one matching with a caliper of 0.02.[11] Unmatched characteristics are available in online eTable 1.

Because after propensity score matching on total number of chronic conditions the prevalence of diabetes was unbalanced in the groups, as a sensitivity analysis, we specifically added

Table 1 Patient Characteristics, Propensity Score-Matched Virtual Visit and Usual Care Cohorts

Characteristic*	Virtual visit ($n = 893$)	Usual care ($n = 893$)†
Age, mean years (95% CI)	61 (60,61)	60 (59,61)
Female (%) (95% CI)	44 (41,47)	42 (39,45)
English language preference (%) (95% CI)	97 (96,98)	97 (96,98)
Partnered (%) (95% CI)	67 (63,70)	66 (62,69)
Veteran (%) (95% CI)	8 (7,10)	9 (7,10)
BMI, mean (kg/m^2) (95% CI)	28 (27,28)	27 (26,28)
Smoking (%) (95% CI)	6 (4,7)	5 (4,7)
Race/ethnicity, *n* (%)		
White	756 (85)	750 (84)
Black	50 (6)	48 (5)
Asian	35 (4)	39 (4)
Latino	21 (2)	23 (3)
Other	31 (3)	33 (4)
Health insurance coverage, *n* (%)		
Private	624 (70)	636 (71)
Medicare	237 (27)	223 (25)
Medicaid	14 (2)	15 (2)
Uninsured	18 (2)	19 (2)
Pre-visit SBP severity, *n* (%)		
SBP < 140 mmHg	701 (79)	708 (79)
SBP 140–160 mmHg	170 (19)	154 (17)
SBP 161–180 mmHg	22 (2)	30 (3)
SBP > 180 mmHg	0 (0)	1 (0)
Pre-visit antihypertensives, mean no. (95% CI)	0.5 (0.5,0.6)	0.6 (0.5,0.6)
Total chronic disease count, *n* (95% CI)	4.8 (4.6,5.0)	4.9 (4.7,5.1)
Chronic diseases (%) (95% CI)		
Hypertension	100 (100,100)	100 (100,100)
Dyslipidemia	67 (63,70)	65 (62,68)
Depression	18 (16,21)	20 (17,22)
Diabetes	14 (12,17)	22 (19,24)
Asthma	11 (9,13)	14 (12,16)
Chronic kidney disease	12 (9,14)	12 (10,14)
Cancer	11 (9,13)	10 (8,12)
Heart failure	5 (4,7)	6 (6,9)
Substance abuse (%) (95% CI)	5 (4,7)	5 (4,6)

BMI body mass index, CI confidence interval, SBP systolic blood pressure

*Percents may not sum to 100 due to rounding. Groups were significantly different only for diabetes ($p < 0.01$) and asthma ($p = 0.045$)

†Propensity matched on age (continuous), gender (m/f), language (four classes), partnered (y/n), veteran (y/n), smoking (y/n), race/ethnicity (four classes), insurance coverage (four classes), pre-visit SBP severity (four classes), total chronic disease count (continuous), visit year (continuous), pre-visit antihypertensives (continuous), pre-visit primary care visits (continuous), pre-visit inpatient admissions (continuous), pre-visit emergency visits (continuous), and pre-visit specialist visits (continuous). See the "Methods" section for details

diabetes to the propensity score. This did not change any of our findings (online eTable 2).

Outcomes

For SBP, we calculated the mean mmHg of all SBPs obtained in the pre-visit and post-visit periods. SBPs included both in-person and virtual visits, where applicable. The change in SBP was pre minus post. We also examined in binary whether or not SBP decreased ("improved") by at least 1 mmHg pre versus post.

For pre- versus post-utilization measures including primary care visits, specialist visits, emergency department visits, and inpatient admissions, we counted the number of each in-person event in the pre-visit and post-visit periods. We also examined in binary whether or not utilization changed by at least one event pre versus post.

Subgroup Analysis

Because many patients in the exposure group had well-controlled blood pressure, we performed a subgroup analysis that examined only patients without satisfactory blood pressure control (SBP > 140 mmHg).

Statistical Analysis

We compared patients' sociodemographic characteristics with Fisher exact tests for categorical variables and *t* tests for continuous variables.

We developed a multivariable linear regression model to examine the difference-in-differences in SBP change, primary care visits, specialist visits, emergency department visits, and inpatient admissions from the pre to the post period between virtual visit and usual care patients. We also assessed the count outcomes using negative binomial regression, but there were no substantive differences in the results, so we present the linear regression findings for ease of interpretability.

We fit additive (linear) probability models of change in SBP, primary care visit, specialist visit, emergency visit, and inpatient admission (the dependent variables).[12–14] A regres-

Table 2 Adjusted Outcomes for Virtual Visit and Usual Care Patients

Outcome*	Virtual visit		Usual care		Adjusted difference-in-differences†
	Pre	Post	Pre	Post	
SBP (mmHg) (95% CI)	134.8 (133.6,136.0)	133.4 (132.3,134.6)	131.1 (130.2,132.0)	130.3 (129.2,131.4)	0.4 (− 1.8,2.6)
Primary care visit, mean no. (95% CI)	2.20 (1.98,2.43)	1.80 (1.60,2.00)	2.22 (2.06,2.37)	2.60 (2.29,2.90)	− 0.8 (− 1.2,− 0.3)
Specialist visit, mean no. (95% CI)	0.91 (0.77,1.04)	0.85 (0.69,1.02)	1.00 (0.87,1.13)	0.94 (0.79,1.09)	0.0 (− 0.3,0.3)
Emergency visit, mean no. (95% CI)	0.10 (0.07,0.13)	0.06 (0.03,0.08)	0.13 (0.09,0.16)	0.08 (0.06,0.11)	0.0 (− 0.1,0.1)
Inpatient admission, mean no. (95% CI)	0.03 (0.01,0.04)	0.02 (0.00,0.03)	0.03 (0.02,0.05)	0.04 (0.01,0.06)	0.0 (0.0,0.0)

CI confidence interval, SBP systolic blood pressure

*Each outcome is per patient

†Each adjusted difference-in-differences is the result of a multivariable additive (linear) probability model that accounts for and expresses between-group differences over time

sion coefficient of an additive probability model can directly be interpreted as differences in the probability of technology use for a one-unit increase in the covariate corresponding to that coefficient. The additive models included an indicator variable for receipt of a virtual visit, an indicator for the pre and post period, and the interaction of receipt of a virtual visit with the pre and post period. The interaction term directly estimates the difference-in-differences, interpreted as the difference in outcome in the pre and post period between those with and without a virtual visit. We fit additive probability models for each outcome (five models).

We considered two-sided p values of less than 0.05 to be significant. We performed all analyses in SAS v9.4 (Cary, NC, USA). The Partners HealthCare Human Research Committee deemed this study exempt from review.

RESULTS

Patient Characteristics

Unmatched groups differed most notably by race/ethnicity, insurance coverage, pre-visit SBP severity, and total chronic disease count (online eTable 1). Of the 24,848 usual care patients and 1051 virtual visit patients, we matched 893 virtual visit patients to 893 usual care patients (Table 1; for pre-match cohort characteristics, see online eTable 1). After matching, patients in both groups were about 61 years old, 44% female, 97% English-speaking, 67% partnered, 85% White, and had about five chronic conditions. Most (79%) had a mean SBP < 140 mmHg and took one antihypertensive or less in the pre-visit period. The groups differed significantly for diabetes prevalence: 14% of virtual visit patients had diabetes compared to 22% of usual care patients ($p < 0.01$; see online eTable 2 for sensitivity analysis that specifically matches on diabetes but does not significantly change any of the ensuing results).

Virtual visit patients completed a mean of 2.1 (95% CI, 2.0 to 2.3) virtual visits. The mean interval between in-person and virtual visit was 43 days (95% CI, 40 to 46).

Changes in Systolic Blood Pressure Before and After Virtual Visits

Patients in the virtual visit group had a mean of 2.4 (95% CI, 2.2 to 2.6) blood pressure measurements in the 180 days leading up to the in-person visit and 2.5 (95% CI, 2.3 to 2.7) in the 180 days after the in-person visit. Patients in the usual care group were similar prior to the in-person visit (2.4 [95% CI, 2.2 to 2.6]) and slightly increased in the 180 days after the in-person visit (3.0 [95% CI, 2.7 to 3.2]).

Mean SBP improved in 56% (95% CI, 51% to 61%) of virtual visit patients compared to 52% (95% CI, 48% to 56%) of usual care patients. In the virtual visit group, the unadjusted mean SBP changed from 134.8 mmHg (95% CI, 133.6 to 136.0) to 133.4 mmHg (95% CI, 132.3 to 134.6); the usual care mean SBP changed from 131.1 mmHg (95% CI, 130.2 to 132.0) to 130.3 mmHg (95% CI, 129.2 to 131.4). In adjusted difference-in-differences analysis, participation in a virtual visit was associated with a 0.4 mmHg (95% CI, − 1.8 to 2.6) increase in SBP (Table 2).

Changes in Utilization Before and After Virtual Visits

Visits to primary care decreased in 44% (95% CI, 41% to 47%) of patients in the virtual visit group, compared to 41% (95% CI, 38% to 44%) in the usual care group. In the virtual visit group, primary care visits decreased from 2.20 (95% CI, 1.98 to 2.43) to 1.80 (95% CI, 1.60 to 2.00) versus 2.22 (95% CI, 2.06 to 2.37) to 2.60 (95% CI, 2.29 to 2.90) in the usual care group. In adjusted difference-in-differences analysis, patients in the virtual visit group had 0.8 (95% CI, − 1.2 to − 0.3) fewer primary care visits than usual care patients (Table 2).

Among virtual visit participants, we observed no adjusted difference-in-differences in specialist visits (0.0 more visits [95% CI, − 0.3 to 0.3]), emergency department visits (0.0 more visits [95% CI, 0.0 to 0.1]), or inpatient admissions (0.0 more visits [95% CI, 0.0 to 0.1]).

In the subgroup analysis examining only patients with unsatisfactory SBP control, patients in the virtual visit group had 1.4 (95% CI, 0.3 to 2.5) fewer primary care visits than usual care patients. All other findings were the same as in the whole sample analysis.

DISCUSSION

In a propensity-matched and difference-in-differences adjusted cohort of primary care patients with relatively well-controlled hypertension, exposure to virtual visits was associated with equivalent blood pressure control and reduced in-office primary care utilization, without increased utilization of specialists, the emergency department, or inpatient admissions. Those with poorly controlled SBP had even further reduced in-office primary care utilization. Virtual visits may offer the potential to improve the efficiency of the primary care clinician and make scarce office visits more available.

To our knowledge, there are few, if any, evaluations of online structured asynchronous clinician-provided care for hypertension in the primary care setting that places a patient and her/his continuity clinician on a common platform. Most telehealth interventions occur via a non-clinician healthcare team member, a clinician unfamiliar with the patient's care, or without any human touch.[15–18] Conflicting evidence exists as to these various interventions' ability to improve outcomes. Few interventions address a chronic disease like hypertension, instead focusing on urgent care, often without continuity.[19]

Other telehealth interventions in primary care have shown increased or unchanged utilization of in-person visits.[7,20–22] In contrast, virtual visits were able to substitute a typically resource-intensive follow-up visit with a more time-efficient virtual visit. In previous work evaluating this specific platform, virtual visits required a mean 3.7 min of clinician time per visit and were associated with high patient and clinician satisfaction.[8] This may be due to the structured content of the virtual visit, which obviates the need for an in-person encounter. This decrease in office visits for patients with hypertension may unburden primary and specialty clinics to meet other demands that truly require in-person care.

Both exposure and usual care patients had reasonably well-controlled blood pressure throughout the study. This is likely due to the pragmatic nature of virtual visit implementation but deserves further study to understand the reason for a virtual visit. It may be that physicians chose to use virtual visits for their stable patients, and this still reduced in-person visits. Perhaps these were patients anxious about their blood pressure control or who requested quick follow-up that was not available. Better understanding of the rationale for virtual visits may inform their implementation in the future, with the goal of optimizing their use for high value care.

Several barriers exist to scaling interventions like virtual visits.[23] Reimbursement for asynchronous visits is limited in traditional fee-for-service and is governed at the state level. For example, licensure requirements, particularly the need to have state-level credentials, preclude clinicians from providing virtual visits to their out-of-state patients. Availability and usability of an Internet-equipped device and an Internet connection are required and may exacerbate a socioeconomic "digital divide."[24]

Our study has limitations. First, our use of a quasi-experimental design precludes causal inference, despite use of propensity score analysis and further difference-in-differences adjustment. For example, we could not control for a patient's communication mode preference, access to the Internet, literacy, computer literacy, access to home blood pressure monitoring, or reasons why a patient was chosen for a virtual visit. The pragmatic implementation of the virtual visit also precluded standardization, calibration, or training with a blood pressure device. The inclusion of home-based blood pressure, often lower than office-based blood pressure, could have biased results toward the exposure group. Of note, it is unlikely that patients chose a MGH practice based on the presence or absence of virtual visits due to the slow, geographically sporadic, and unpublicized roll-out. Second, our cohort was from a one-region network of clinics and was mostly middle-aged, White, and privately insured, precluding broad generalizability of virtual visits' impact to other socioeconomic groups. Further testing will be required in more diverse populations. Of note, due to enterprise-wide contracting, changes in insurance plans would affect patients equally. Third, we cannot comment on how virtual visits might impact patients with very poorly controlled blood pressure, as our sample size of patients with very poor control was small ($n = 21$). We performed a subgroup analysis of those without satisfactory blood pressure control and found an even more pronounced association on primary care utilization. Fourth, we do not have data on patients who were offered and refused a virtual visit. Fifth, we did not capture telephone visits as part of utilization, but even if increased, they offer a more efficient point of contact than an in-person office visit.[25,26]

CONCLUSIONS

In this propensity-matched, difference-in-differences adjusted cohort of primary care patients with reasonably well-controlled hypertension, exposure to a virtual visit was associated with equivalent blood pressure control and reduced in-office primary care utilization without increasing other utilization.

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Author Contributions *David Levine had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.*
Study concept and design: Levine and Linder.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Levine and Dixon.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Levine.
Administrative, technical, or material support: Levine.
Study supervision: Linder.

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Compliance with Ethical Standards:

Prior Presentations: *This work was presented as an oral presentation at the 2017 National Meeting of the Society of General Internal Medicine in Washington DC.*

Conflict of Interest: *Dr. Dixon is the developer of the virtual visit program. Partners HealthCare and Massachusetts General Hospital Department of Population Health Management supported the development and implementation of the virtual visit platform. Neither Dr. Dixon, Partners HealthCare, nor Massachusetts General Hospital funded this study.*
All remaining authors declare that they do not have a conflict of interest.

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