ORIGINAL RESEARCH

The Impact of Telehealth on Primary Care Physician Panel Sizes: A Modeling Study

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Introduction: **Most research on the use of telehealth in lieu of in-office visits has focused on its growth, its impact on access, and the experience of physicians and patients. One important issue that has not gotten much attention is the potential for telehealth to significantly increase physician capacity by reducing non-value adding activities and patient no-shows. We explore this in this article.**

Methods: **We use data from the electronic health records of 2 health care systems and information gathered from family medicine physician focus groups to develop estimates of visit durations and no-show rates for tele-visits. We use these in a simulation model to determine how patient panel sizes could be increased while maintaining high levels of access by substituting tele-visits for in-person visits.**

Results: **We found that tele-visits reduce the nonvalue-added time physicians spend with patients as well as patient no-shows. At current levels of tele-visit utilization, the use of tele-visits may translate into more than a 10% increase in patient panel sizes assuming a modest reduction in visit durations and no-shows, and as much as a 30% increase assuming that half of all visits could be effectively conducted virtually and result in a greater reduction in visit durations and no-shows.**

Discussion: **Our study provides evidence that a major benefit of using telehealth for many routine encounters is a reduction in wasted physician time and a substantial increase in the number of patients that a primary care physician can care for without jeopardizing access to care. (J Am Board Fam Med 2022;00:000–000.)**

Keywords: **Family Medicine, Health Services Accessibility, No-Show Patients, Primary Care Physicians, Primary Health Care, Simulation Model, Telemedicine, Workforce**

Introduction

Primary care is critical to improving health and lowering costs, but many patients experience difficulty in obtaining timely access to care. Although much has been written about the need to increase the supply of primary care physicians (PCPs), less attention has been paid to making the delivery of care more efficient and accessible. The COVID-19 pandemic has revealed a path forward for doing so.

Virtual care has been available to PCPs for many years. However, its value has become more apparent over the past months of the pandemic. Many types of physician/patient interactions do not require an office visit, but rather can be effectively performed via a tele-visit. Examples include routine check-ins for monitoring a well-controlled chronic disease such as hypertension or diabetes, screening for acute illnesses like UTIs and ear infections, and follow-up visits for recently discharged hospital patients. A meta-analysis of 93 studies conducted by Flodgren et al.[1] showed that the use of telehealth for managing conditions such as diabetes and heart disease appeared to result in similar or better outcomes. During the height of the pandemic, many health systems reported that 70% or more of all outpatient visits were performed virtually. Although that

This article was externally peer reviewed.

Submitted 31 October 2021; revised 25 January 2022 and 3 May 2022; accepted 11 May 2022; *Ahead of Print Publication* 15 September 2022; *Final Publication* 00 XXX 2022.

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Funding: There was no external funding for this study.

Conflict of interest: The authors have no conflicts of interest.

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fraction has decreased to a national average of between 15% and 20%, this still represents a significant shift from the pre-COVID era when the national level was at most 1 to 2% and many physician practices had no telehealth offerings. Both physicians and patients have become more educated and comfortable with telehealth, and government agencies and private payers have waived regulatory and payment restrictions that have historically been obstacles to its growth. Many of these waivers are likely to remain in place, particularly if the clinical and financial benefits of telemedicine are increasingly established.

Green et al.[2] demonstrated that changes in physician practices, including the use of teams, nonphysicians, and electronic communication, could eliminate primary care physician (PCP) shortages. In this article, we show that the expansion of tele-visits can further increase the productivity and hence capacity of primary care physician practices by reducing waste associated with nonvalue-adding activities and patient "no-shows." By incorporating more tele-visits into their practices, physicians can care for a greater number of patients and/or have more frequent interactions with more complex patients potentially reducing ED visits and hospitalizations.

Our analyses use estimates of tele-visit use relative to office visits that are largely based on the recent experience of two provider organizations – Crystal Run Health care (CRH) in New York and Lehigh Valley Health Network (LVHN) in Pennsylvania. Focus groups with family medicine physicians in these health care systems revealed that many routine office visits include a physical examination, testing and/or imaging which may be unnecessary and a result of outdated norms, patient expectations and payment incentives. Choosing Wisely (https://www.choosingwisely.org/), a campaign that was begun in 2012 to help identify and eliminate waste in health care, lists many specific instances in which physical exams, procedures and tests are not supported by evidence and may cause more harm than benefit. By transitioning such patient visits from in-office to tele-visits, there is an opportunity to reduce this wasted time. In addition, because virtual visits eliminate many obstacles associated with patient no-shows, unused appointment slots can be substantially reduced. The combined impact can make health care more accessible and affordable for patients and create more physician capacity that can be used to focus on needier patients.

Study Data and Methods

The major vehicle for our study is a queueing-based simulation model that determines maximum patient panel sizes that are consistent with a high degree of patient access (that is, 75% of patients able to get same-day appointments. This model is similar to one used in.[2] We focus on 3 specific model inputs to assess the potential impact of telehealth on patient panel sizes: (1) the fraction of all PCP visits that can effectively be performed using telehealth; (2) the average physician visit time for a tele-visit versus for an office visit; and (3) the rate of patient no-shows for both in-person and tele-visits. We use data from the electronic medical records of family medicine physicians at CRH and LVHN collected between May 2020 and April 2021, discussions with CRH and LVHN physicians, as well as data from the literature to develop a feasible range of these inputs, and use the simulation to analyze the impact of substituting tele-visits for in-person visits on PCP capacity.

CRH is a physician-owned, physician-led multispecialty group that consists of more than 400 providers across 16 locations in the lower Hudson Valley of New York State. Before the COVID-19 pandemic, CRH did not have a virtual health presence. Over the course of two weeks in March 2020, the organization established a telehealth program using Zoom as its platform . In less than a month, CRH averaged approximately 1800 tele-visits/day, which represented approximately 50% of overall visits. Just focusing on primary care, 60 to 65% of all visits were virtual during the peak of the pandemic, with approximately 90% of these being audiovisual and the remainder phone based. Over the period of March–December 2020, the average fraction of primary care telehealth appointments at CRH was 23%.

LVHN is an integrated health system with 10 hospital campuses and numerous health centers, physician practices, urgent care sites and other outpatient facilities serving patients in 7 eastern Pennsylvania counties. Unlike CRH, LVHN has been using telehealth across many of their services for almost 20 years. In the year before the COVID-19 pandemic, telehealth visits represented less than 1% of all visits. Since March 2020, this has increased to an average of approximately 16% of all visits and, in April 2020, at the peak of the pandemic, it rose to more than 60%. For primary

care, the average fraction of visits that have been virtual since the onset of the pandemic has been approximately 21% with a peak of more than 90%.

The main goal of our study is to quantify the potential effects of a wider use of telehealth on patient panel size, that is, the number of patients associated with a physician in a typical practice. We use the term "typical practice" as more of a convenient model for analysis rather than a reflection of any actual practice. Our aim is not to represent any specific practice but rather to demonstrate the potential effect of telehealth on panel sizes. However, although our analysis focuses on a typical or "average" full-time PCP, our methodology can be easily applied to any specific practice by adjusting the model parameters.

Our simulation model is based on several assumptions concerning patient demand for and physician supply of primary care capacity. Specifically, we assume:

1. The number of requested appointments each day is generated by a Poisson probability distribution and is proportional to the panel size. The assumption of Poisson arrivals is the most commonly used assumption in modeling service systems, particularly health systems, and has been empirically verified as appropriate. (see, e.g. Green[3] and references therein)
2. The average number of annual primary care visits per adult is 2.3 (based on data from CRH and LVHN) and that this rate is identical for in-person and tele-visits. In the last section of this paper, we discuss the potential impact of assuming an increased number of tele-visits visits due to ease of access. The demand for primary care from individual patients on a physician's panel are independent of each other.
3. Each patient appointment is assigned to the tele-visit category with some fixed probability that can be interpreted as the fraction of all visits that are virtual.
4. There is a fixed probability that a patient with an appointment is a "no-show." For each "no-show," there is a fixed probability the patient will make a new appointment.
5. Each physician provides care for 8 hours (480 minutes) each day, 5 days per week and works for 47 weeks each year (corresponding to 235 working days). For simplicity, we assume that the physician is operating as a solo practitioner. As described in the discussion section, these assumptions are likely to result in an underestimate of the potential increases in panel size due to telehealth.
6. The amount of time a physician spends with a patient is fixed and depends on whether it is an in-person encounter or a tele-visit.

The simulation assumes a given patient panel size and works on a day-by-day basis. Each simulated day begins with a queue of patients which is composed of arrivals of requests for appointments for that day plus any requests from the previous day that were not able to be served that day. "No-shows" do not join the queue. We assume that a physician provides care for patients in the appointment queue, one patient at a time, till the end of the physician's working day (8 hours, or 480 minutes). For each served patient, the wait time in the appointment queue is recorded. At the end of each working day, the appointment requests in the appointment queue that were not served join the queue for the next day. After each simulation step, the sample mean for the fraction of patients that are served within 1 day of joining the appointment queue is calculated. These simulation steps are repeated until the mean standard error for the distribution of this fraction drops below 0.001. We incrementally adjust the patient panel size and rerun the simulation until we identify the largest patient panel size that results in this fraction being 75%. Further details of our simulation are presented in the online Appendix.

To estimate the potential impact of telehealth on patient panel sizes, we performed sensitivity analyses focused on varying the parameter values described in assumptions 3, 4, and 6; that is, the fraction of visits performed virtually, the fraction of no-shows, and the duration of the tele-visit relative to an in-person visit. In the discussion section, we address the potential effect of changing other parameters.

For each set of input parameters, described above, the simulation calculated the maximum number of patients that a physician can care for while assuring "timely access" for care, which we define as 75% of patients being able to get a same-day appointment. This level is consistent with the original concept of "advanced access" as offering a same-day appointment to anyone who wants 1 and with data that indicate that approximately 25% of patients do not desire a same-day appointment.[4]

The values for the fraction of tele-visits observed within CRH and LVHN as well as reported values from many other health systems indicate that this fraction can be significant. For example, Kaiser Permanente, a pioneer in telehealth, reported that in the month before the COVID-19 pandemic, 38% of their ambulatory visits were virtual.[5] This increased to 87% at the peak of the pandemic. Furthermore, conversations with family medicine physicians as well as estimates reported in the literature[6] indicate that many types of primary care visits can be effectively conducted virtually and that the use of telehealth is likely to grow in the coming years. To estimate the impact of telehealth, we consider a "base case" where no visits are virtual and compare that with cases we designate as moderate (25%) and high (50%) levels of tele-visit appointments.

To get a sense of the effect of tele-visits on physician practice and hence the simulation parameter estimates, we first conducted a focus group with 4 experienced family medicine physicians at CRH who had been using tele-visits for several months to obtain their insights on the potential efficiencies associated with this modality. They agreed that for established patients and "routine" follow-ups, physical exams and some testing usually conducted during office visits were not generally necessary. They also noted that their interactions with patients were more efficient for tele-visits. In addition, they could sometimes "double book" patients as it was easier to switch between patients and they could "squeeze in" more tele-visits into their schedules. Informal discussions with LVHN physicians yielded similar observations. The consensus was that tele-visit durations were, on average, shorter than in-person visits.

We collected data from both the LVHN and CRH electronic medical records for all family medicine physicians for the period from May 2020 to April 2021 to try to estimate the physician times associated with both in-person and virtual visits. Though the CRH data did not allow for accurate estimates of the durations of physician visits, it did indicate that physicians were able to see approximately 10% more patients per hour using tele-visits relative to in-office visits. The LVHN records had time stamps associated with the start and end times for the physician portion of a patient visit for both modalities. For in-person visits, the average duration was almost 24 minutes whereas for tele-visits, it was 16 minutes, a 30% reduction in duration. Rao et al.[7] reported that nationally, the average duration of the face-to-face part of an in-person PCP visit in 2015 was 21.6 minutes. Based on these estimates, in our simulation we use a base case duration of 22 minutes for in-person visits and consider the impact of several different levels of reduced durations associated with tele-visits.

Another potential source of increasing physician care capacity associated with tele-visits relates to the reduction of last-minute cancelations and patient no-shows. When a no-show occurs, the appointment slot goes unused and, if the patient reschedules the appointment, an additional appointment slot must be allocated. This combination of no-shows and rescheduled appointments increases appointment waiting times for patients. Consequently, by substantially reducing no-shows, physicians can increase patient panel sizes without compromising timely access to care. By eliminating travel times and obstacles due to transportation, childcare issues, weather, etc., the increased use of telehealth is likely to result in a reduction in these sources of wasted physician capacity.

For in-person visits, the literature reports PCP no-show rates ranging from 15% to 50% (see, for example,[8] and[9] and references therein). Both CRH and LVHN reported levels closer to the low end of this range. Though neither CRH nor LVHN had accurate data for no-show levels associated with tele-visits, anecdotal evidence supported the hypothesis of fewer no-shows. Studies reported in[10]

Table 1. Patient Panel Sizes Assuming 75% of Patients Receive Same-Day Appointments

		Fraction of tele-visits		
Rescheduled No-Show Frequency for tele-visits = 0.25		0%	25%	50%
Tele-visit duration	22 minutes	1569	1569	1569
	19 minutes	1569	1650	1713
	16 minutes	1569	1707	1850

Table 2. Patient Panel Sizes Assuming 75% of Patients Receive Same-Day Appointments

		Fraction of tele-visits		
Rescheduled No-Show Frequency for tele-visits = 0.15		0%	25%	50%
Tele-visit duration	22 minutes	1569	1618	1670
	19 minutes	1569	1697	1817
	16 minutes	1569	1749	1948

and[11] demonstrated substantial reductions in no-shows for tele-visits relative to those for in-person. In our simulation study, we use a base level of 25% for rescheduled no-shows for in-office visits and study the impact of different levels of reduction of this value for tele-visits based on the levels reported in[10] and.[11]

Results

Tables 1-3 focus on patient panel size assuming the timely access of care standard of 75% of patients receiving same-day care under varying levels and durations of tele-visits. Table 1 assumes the rescheduled no-show frequency for tele-visits is the same 25% as for in-person visits, whereas this fraction is set at 15% in Table 2, and 5% in Table 3.

As Tables 1–3 show, the base-case panel size of around 1570 patients can be expanded to around 2030 patients, a 30% increase, if tele-visits result in a reduction of physician time from 22 to 16 minutes and of the rescheduled no-shows from 25% to 5%, provided that the practice can shift 50% of all patient visits to the virtual mode.

Discussion

In this article, we demonstrated that, by eliminating unneeded care and reducing no-shows, telehealth has the potential to significantly increase PCP capacity assuming conventional appointment scheduling and workdays. By assuming a "typical" practice, our study is meant to be illustrative. The impact of telehealth on any specific PCP practice will likely be affected by many factors including patient and physician demographics, physician practice style, geographic considerations, technology infrastructure, cultural issues, insurance, etc.

It is important to note, that in assuming a solo practitioner setting and a conventional 8-hour workday (assumption 5), we have likely underestimated the potential increase in patient panel sizes. For example, telehealth facilitates balancing patient demands across locations, resulting in substantial economies of scale. The ability of physicians to attend to patients in geographically distant locations and across state lines, as has been generally allowed through license waivers during the pandemic, increases physicians' ability to flexibly schedule appointments on short notice. In addition, because virtual visits can be initiated anywhere, physicians can more easily extend the working day, as has been reported by physicians in our focus group. All these factors increase physician capacity and make telehealth a critical component in addressing PCP shortages.

The addition of telehealth as an option allows physicians to tailor the modality, frequency and duration of visits to better accommodate various types of patients and services. Because of the substantial savings in time and the convenience associated with the ability to engage in a virtual visit almost anywhere, telehealth is more attractive to patients, particularly for routine visits and for patients living in rural and other underserved areas. Patients who

Table 3. Patient Panel Sizes Assuming 75% of Patients Receive Same-Day Appointments

		Fraction of tele-visits		
Rescheduled No-Show Frequency for tele-visits = 0.05		0%	25%	50%
Tele-visit duration	22 minutes	1569	1657	1758
	19 minutes	1569	1738	1907
	16 minutes	1569	1784	2033

might otherwise put off follow-up care can often easily participate in a telehealth visit from their office or home.

Several caveats are in order. In our analyses, we assumed that telemedicine is mature. Specifically, during this initial phase of the adoption or scaling of tele-visits, there have been reports of both physicians and patients experiencing difficulties with using an unfamiliar technology as well as some technological glitches. These are clearly transient. We have also assumed that almost all patients have access to the appropriate technology and are open to using it. Although the former may take some time and resources, the latter seems to be supported by several recent patient surveys. Of course, telehealth will not survive as a viable option unless financial, payment and regulatory barriers are removed or modified. Telehealth is clearly more likely to expand under value-based and capitated payment systems. Most of these factors are currently the subject of discussions at both the state and federal levels.

We also note that telehealth will likely expand as health care IT capabilities continue to increase, for example, enhanced video, more and better sensors to check vitals, etc. At the same time, telehealth is clearly not appropriate for all patients or all situations. People with cognitive issues, language difficulties, certain physical limitations, etc. will best be served by in-person encounters. And situations requiring procedures/immunizations, or which are complex and require decision making based on a physical examination (eg, chest pain, abdominal pain) should be handled by in-person visits. It is possible that the expansion of telehealth may create a disincentive for patients to see physician for certain types of preventative care, for example, vaccinations and might result in some erosion in the physician-patient relationship. On the other hand, tele-visits that are used in conjunction with remote monitoring may improve quality in some situations by allowing for, for example, more frequent and reliable blood pressure readings.

Telehealth may not result in larger patient panel sizes if it increases the demand for visits by removing obstacles to access, contrary to assumption 2. For example, if the introduction of tele-visits increases primary care demand by 10%, the corresponding value of the patient panel size that a physician can care for will be reduced by the same fraction. However, if these visits represent real unmet needs, that should result in better clinical outcomes and perhaps savings in downstream costs of care, for example, ED visits, hospitalizations. Proper triage at time of appointment should screen out most unnecessary care or issues that can be readily dealt with by a non-physician professional.[12]

Much more research is needed to learn more about the potential benefits and difficulties associated with telehealth. These include obtaining better estimates on potential time savings and the impact on no-shows; the impact on clinical outcomes, patient satisfaction, physician satisfaction, overall costs, and access to care.

Though this article has focused on primary care, clearly telehealth has impacted many other areas of care such psychiatry, obstetrics, dermatology and rehabilitative medicine. Each of these areas will need to be studied as well.

The authors would like to thank Joe Tracy, VP Connected Care and Innovation, LVHN, Stephen Klein, MD, Crystal Run Healthcare, Sophia Lee, MD, Crystal Run Healthcare, Riaz Ruhmann, MD, Crystal Run Healthcare, Laura Nicol, MD, Crystal Run Healthcare, Lori Yackanicz, MBA, CPHIMS, LVHN.

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Appendix.

In simulating the dynamics of appointment scheduling/patient care, on any day t=0, 1, …., we assume the following sequence of events:

1. The system starts with A_t patients in the appointment queue, with k-th patient's appointment request, T_t^k belonging to either e-visit or in-office type:

$$T_t^k = \begin{cases} 1, & if\ it\ is\ a\ "e-visit", \\ 0, & if\ it\ is\ an\ "in-office"\ visit, \end{cases}$$

   k=1, …, A_t.

2. The number of patients, out of A_t, that is served on day t (of duration Δ=480 minutes) is determined as

$$S_t = \max\left(k \in (1,\ldots,A_t) \middle| \sum_{j=1}^{k} \left(T_t^j \tau_e + \left(1 - T_t^j\right)\tau_i\right) \le \Delta\right).$$

3. The number of patients remaining in the appointment queue at the end of day t is A_t - S_t.
4. The new appointment requests arrive and join the appointment queue. The number of patients requesting an appointment on day t=0, D_t is generated using the Poisson distribution with mean given by $\frac{2.3\times N}{235}$, where N is the size of patient panel.
5. For each patient l=1,…, D_t, we simulate the type of appointment request,

$$T_t^l = \begin{cases} 1, & if\ it\ is\ a\ "e-visit", \\ 0, & if\ it\ is\ an\ "in-office"\ visit, \end{cases}$$

   using the Bernoulli random variable ("coin toss") with probability f_e.

   On day t=0, we start with the "empty" system, with no waiting patients (A_0 = 0).