On-demand telemedicine as an emerging disruptive health technology:
Exploring business models, service utilization, and cost effects among early adopter organizations

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Abstract

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To address increasing demand for convenient and accessible care, many health organizations are adopting on-demand telemedicine solutions. Viewing on-demand telemedicine as a disruptive health technology, my research uses the example of virtual urgent care (VUC), a predominant form of the on-demand service, to study emerging business models, service utilization, and cost effects among early adopter organizations. Results from Article 1 suggest early adopters are deploying Value-adding Process models that appropriately matches resources, processes, and profit formulas to support VUC value propositions; four business strategy areas were found to particularly transform the business model into action: fundamental disruptions to the model of care delivery; outsourcing support; disruptive market strategies; and new and unexpected organizational partnerships. Compared to leading alternative in-person care sites (e.g., physician offices), our results in Article 2 indicate VUC can provide lower cost services without the need for potentially duplicative follow-up care for urinary tract infection and respiratory system diagnoses. Lastly, our Article 3 results suggest low adherence to recommended follow-up services may indicate inefficiencies in current VUC care processes; however, if used when recommended, receipt of follow-up can reduce per person spending among VUC users.

Table of Contents

Chapter 1: Introduction

Background

To address leading challenges, many health organizations are adopting telemedicine solutions [1]. Increasing consumer demand for convenience and accessibility is a key trend propelling telemedicine market growth, making launch of on-demand telemedicine a high priority of adopter organizations [2-3]. On-demand telemedicine provides patient-initiated, around-the-clock access to real-time virtual visits for low-acuity conditions from any location using interactive technologies [4]. My dissertation research views on-demand telemedicine as a disruptive health technology with the potential to bring greater convenience, accessibility, and affordability to healthcare by disrupting incumbent forms of in-person care deliver. Prior on-demand telemedicine research is limited and it has never before been studied through the lens of disruptive health technology. Using both qualitative and quantitative methods, my research uses the example of virtual urgent care (VUC), a predominant form of the on-demand service, to study emerging business models, service utilization, and cost effects associated with on-demand telemedicine among early adopter organizations. To provide an orientation to my original dissertation research (reviewed in Chapters 2-4), the information provided below introduces:

- Key terms and concepts related to my research
- Motivations and research gaps that guide specific dissertation objectives
- Conceptual framework guiding my research

Introduction to telemedicine

For the purpose of my dissertation research, telemedicine is defined as the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status [5]. Telemedicine is typically thought to comprise three categories of service, including: (1) store-and-forward, an asynchronous service that involves a provider sharing patient medical information (e.g., labs, imaging) with another provider at a different location, (2) remote patient monitoring, allowing providers to track a patient's vital signs and other activities at a distance), and (3) real-time virtual visits, involving two-way, real-time interactions between a patient and a provider using audio and/or visual telecommunication technologies.

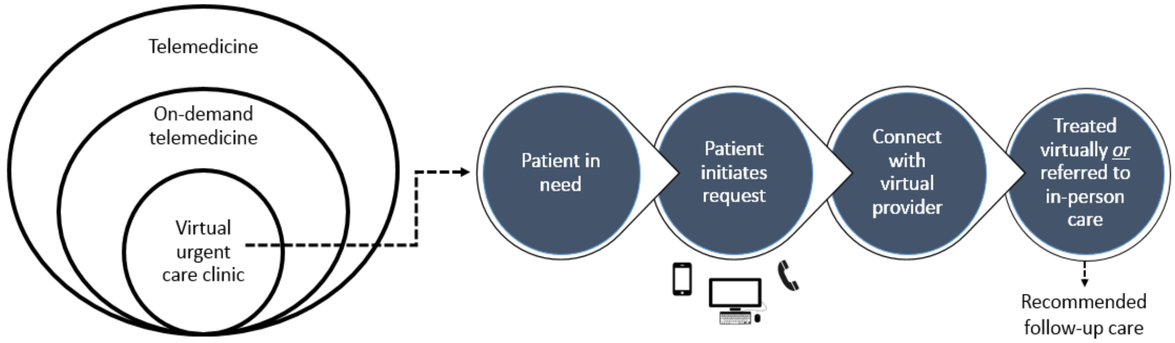
Traditionally, real-time virtual visits are initiated via provider referral, scheduled based on provider availability, and generally involve interactions between a patient and provider that have a previously established relationship. In contrast, on-demand telemedicine is a type of real-time virtual visit that is initiated by the patient, accessed on-demand when and where there is medical need, and not typically associated with a patient's established care provider. This service offers transparent per visit pricing and low out-of-pocket costs for consumers (although insurance reimbursement options are currently limited). Per recent practice guidelines from the American Telemedicine Association, on-demand services are clinically appropriate for the treatment of many non-emergent medical conditions, both episodic (e.g., acute respiratory illnesses) and chronic (e.g., diabetes, behavioral health), and may also be used for consultations regarding prevention and wellness services (e.g., smoking cessation) [4].

More than half of all hospitals and health systems in the U.S. currently offer telemedicine services. [1-2] Among current non-adopters, one-quarter report they are actively looking for telemedicine solutions, and nearly 90% identify investment in telemedicine as a leading organizational priority [1]. While still low relative to overall health service use, telemedicine volumes are growing rapidly and compound annual growth rates for investment range from 18-27% [3]. Increasing consumer demand for convenient, accessible, and affordable services is a key trend propelling telemedicine market growth [1-2], making on-demand telemedicine offerings a particular priority of adopter organizations. While current measurements of on-demand telemedicine adoption rates are limited, a recent national survey of healthcare executives estimates that approximately 10% of health organizations currently offer patient-initiated primary and urgent care on a patient's mobile device [1]. However, among current non-adopters, 70% are highly interested in expanding their telemedicine services to include on-demand offerings in the future [1].

A number of on-demand telemedicine services have emerged (e.g., urgent care, behavioral health, primary care). My dissertation work focuses on VUC, a widely adopted form of the on-demand service that has received growing attention in the peer-reviewed literature, increasing uptake among patients, and rapid rates of adoption by health organizations. Due to this distinction, my research views VUC as a predominant and catalyst form of the on-demand service that can be used to contextual research objectives. VUC provides real-time virtual visits for the treatment of minor illness and injuries, the most common of which include acute respiratory illnesses, urinary tract infections, cold and flu, digestive symptoms, and skin disorders [4]. Health organizations currently offering VUC services represent a diverse group of organizational types [6]. Large, integrated health systems comprise the majority of VUC sponsor organizations. Other identified organization types include insurers, employers, primary care practices, and critical access hospitals. Sponsoring organizations often contract with a third-party telemedicine vendor company to provide the virtual platform and clinical staffing for the VUC services. In other cases, a vendor company will offer VUC services directly to the public.

The diagram in Figure 1 showcases the workflow for a typical VUC visit encounter [6]. A patient will initiate a request for a VUC visit using a web browser, phone, or tablet. A patient may learn about the availability of VUC services via a range of sources, including internet searches, emails or direct mailings from a sponsoring health organization, or radio advertisements, among others. After completing an online intake form, the patient will connect with a virtual provider within 10-15 minutes. Based on chief medical complaint and history, the provider will treat the patient through the virtual visit or, if clinically indicated, triage the patient to a form of in-person care (e.g., office visit, ED, laboratory testing) for future consultation and recommended follow-up. As needed, the provider may prescribe medications or other directives as part of the encounter. Typically, a visit summary is sent to a patient following the encounter. Regarding additional patient contact, sponsoring organizations report varied follow-up care processes.

Figure 1. VUC visit encounter process



Introduction to disruptive health technology

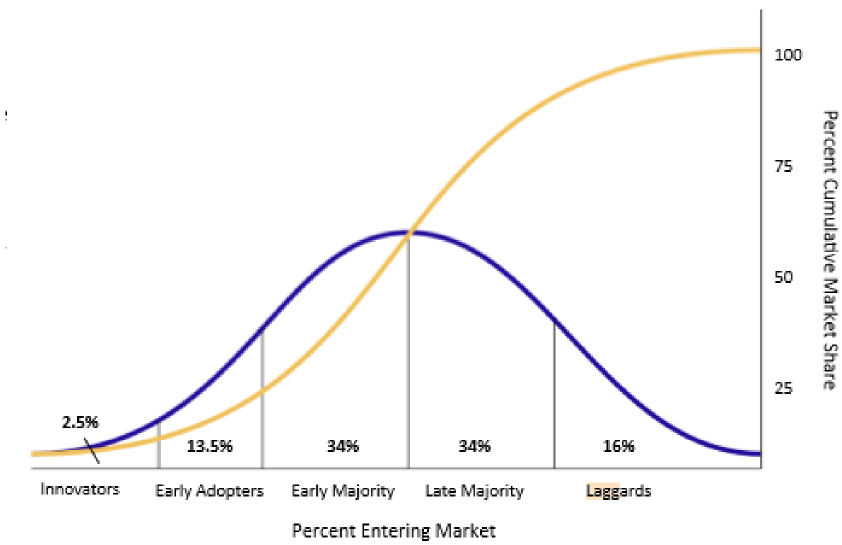
My dissertation research views on-demand telemedicine through the lens of disruptive health technology. The term disruptive technology, first introduced by Clayton Christensen in the late 1990s, describes a process by which "a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors" (Christensen, 1997) [7]. Disruptive technologies take root in low-end and new-market footholds that are overlooked by incumbents. They appeal to overlooked markets by offering products or services that are cheaper, simpler, and more convenient. As disruptor entrants begin to improve the performance of their offerings, they move upstream, attracting more mainstream consumers, and challenging previously dominant incumbents. By comparison, market leaders tend to focus on improving their products and services to meet the needs of profitable high-end consumers [7-8]. But soon those improvements overshoot the needs of the vast majority of consumers – creating space in the market for disruptors. Common examples of disruptive technologies include the personal computer and cellular phone. In the health care sector, coronary angioplasty is considered a leading example. Angioplasty has brought effective treatment to many people at greater convenience and lower cost than open-heart bypass surgery, the incumbent technology at the time. Initially deployed against easy-to-access coronary arteries, over time this minimally-invasive approach improved to the point where fewer and fewer patients needed open-heart bypass surgery.

My research argues that on-demand telemedicine (including VUC) may be viewed as a disruptive technology currently gaining ground across the healthcare delivery sector. By offering low out-of-pocket prices and around-the-clock access to virtual services, on-demand telemedicine aims to disrupt conventional care delivery systems by providing a less expensive, highly accessible, and more convenient alternative to many in-person services (e.g., physician office visits, emergency department (ED)). Aligning with the trajectory of disruptive technologies, VUC and other on-demand offerings currently target the low-end market for common medical needs as well as new patient groups that may not regularly use health services and are not prioritized in traditional care delivery systems (e.g., young professionals, college students) [6]. In-addition, on-demand telemedicine services are making performance improvements that may serve to attract more mainstream consumers: the service is increasingly found to be have safety and quality outcomes comparable to those of in-person services for the treatment of many non-emergent conditions [9-12], and many adopters are beginning to incorporate peripheral devices and at-home diagnostic testing to extend the capability and convenience of the technology [6].

Early adopters and disruptive technologies

My dissertation research focuses on early adopter health organizations of VUC services. The term early adopter refers to Everett Rogers' theory of diffusion of innovation that seeks to explain how, why, and at what rate new ideas and technologies spread [13]. Rogers introduces five categories of adopters, including innovators, early adopters, early majority, late majority, and laggards, that lie along a curve that describes the degree to which an individual, organization, or society adopts an innovation. As represented by the cumulative market share curve in Figure 2, available market shares for a given innovation will vary by adopter category.

Figure 2. Everett Rogers' Diffusion of Innovation curve



Innovators are eager to try new ideas, and is willing to accept the occasional setback when new ideas prove unsuccessful [13]. Early adopters tend to have the greatest degree of opinion leadership in a social system: they provide advice and information sought by other adopters about an innovation [13]. Early adopters are usually respected by peers and have a reputation for successful and discrete use of new ideas. Members of the early majority category will adopt new ideas just before the average member of a social system. Early majority adopters are the link between very early adopters and those that are late to adopt; thus, they play an important part in the diffusion process [13]. Their innovation-decision time is relatively longer than innovators and early adopters, since they deliberate some time before completely adopting a new idea. Seldom leading, early majority adopters willingly follow in adopting innovations. The late majority are a skeptical group, adopting new ideas just after the average member of a social system [13]. They are cautious about innovations, and reluctant to adopt until most others in their social system do so first (often borne out of economic necessity and/or response to increasing social pressure). An innovation must have the weight of system norms behind it to convince the late majority. Lastly, laggards are traditionalists and the last to adopt an innovation. They are likely to be suspicious not only of innovations, but of innovators and change agents as well [13]. An innovation finally adopted by a laggard may already be rendered obsolete by more recent ideas already in use by innovators.

Among current adopter organizations, on-demand telemedicine is in the early adopter stage of technology adoption and diffusion, with the potential trajectory of approaching early majority in the coming years. This can be a precarious position for widespread assimilation of on-demand services, as the inability to bridge the innovation chasm between these stages is known to impact the success of disruptive technologies [14-15]. Therefore, now is an opportune time to discover lessons learned from the experiences of early adopter organizations of on-demand telemedicine that are in the process of navigating these rocky waters. Moreover, existing on-demand telemedicine studies do not speak through the lens of disruptive technology to yield lessons from early adopters.

Research motivations and specific dissertation aims

Disruptive technology and the business model

Although disruptive technologies have brought greater accessibility and affordability to consumers in other industries, the same cannot be widely said for the healthcare delivery sector [16-18]. Prior healthcare research suggests this failure is associated with misalignment between disruptive technologies and the deployed business model [17]. It is well documented that the success of a disruptive technology is closely tied to its business model [19-20]. The business model provides a framework for an organization to create and capture value out of the disruption. According to Johnson et al. (2009) [21], pairing disruptive technologies with the right innovative business model can lead to greater accessibility and affordability. To better avoid the failures encountered by other disruptive technologies in the healthcare delivery sector, new information is needed regarding if and where on-demand telemedicine fits into the general topology of leading business model archetypes.

Further, while useful, identifying a befitting type of business model may not provide the detail needed to inform strategic direction. Leaders in the field, Johnson et al. (2008) understand any given business model as consisting of four interrelated strategic components, including (a) the value proposition, or value created by offering a product or service, (b) key resources and (c) key processes that are needed to deliver the value proposition, and (d) the profit formula that defines how money is made for a deploying organization via delivery [21]. Past disruptive technology research suggests these components must be fit together such that they are appropriately linked to an emerging disruptor for the new technology to succeed when brought to market [19-21]. More information is needed to specify these core components and their linkages in the context of on-demand telemedicine.

While the business model describes the basic means by which an organization creates and delivers value from a disruptive technology, the business strategy is the specific method a deploying organization uses to achieve the proposed value and deal with opportunities and threats posed to the business model [20, 22]. In the technology and innovation management field, little if any attention has been paid to the role of business strategies in association with emerging business models for disruptive technologies. Therefore, more information is needed regarding what these disruptive strategies are and how they impact the path early adopters are taking to harness the potential of on-demand telemedicine.

To address these research gaps, my first dissertation research article (reviewed in Chapter 2) explores the paths early adopter organizations are taking to harness the disruptive potential of on-demand telemedicine. Using qualitative methods and focusing on a study population of early adopter organizations of VUC, this research seeks to:

a. Identify the emerging business model being deployed for VUC.
b. Describe the core components (value proposition, key resources, key processes, and profit formula) of the emerging business model for VUC.
c. Identify disruptive business strategies employed by organizations as they launch VUC.

On-demand telemedicine as a potential replacement for traditional in-person services

A key attraction of VUC for many adopting organizations is to replace traditional in-person services, such as physician office and ED visits, with less expensive virtual visits [26]. This idea aligns with the core definition of disruptive technology as an innovation that displaces established market leaders over time by offering a cheaper, easier, and less expensive alternative. Based on the current state of VUC research, it is unclear to what extent VUC visits may serve as a replacement for in-person services. Care impacts on quality, service utilization, and cost are core dimensions from which to make this assessment.

Because VUC is a relatively new care option, published literature regarding outcomes regarding many of these dimensions, utilization and cost in particular, is lacking. Care quality is of particular concern to adopting organizations, such as whether physicians can provide accurate diagnoses without hands-on physical examinations of patients. Another concern to adopters is whether additional follow-up visits occur after an initial VUC visit as a result of unresolved symptoms. Several studies have demonstrated the quality of telemedicine for low-acuity conditions that fall within the scope of VUC services; these studies generally report high patient satisfaction and other quality outcomes on par with in-person visits regarding misdiagnoses and treatment failures [28-34]. In addition, researchers have generally found similar or lower rates of follow-up visits comparing VUC and in-person care options such as an office visit or the ED. The few studies that have examined healthcare spending outcomes associated with VUC find that an initial VUC visit is usually less expensive than an in-person visit [9-10]. Two published studies have analyzed episode-level costs associated with VUC (including an initial visit and follow-up care); these studies suggest per episode spending is lower for VUC compared to traditional in-person settings [11,27]. Cost per person have received even less attention. One publication found higher per person spending among VUC users with acute upper respiratory infection due to increases in total service utilization with the use of virtual services; however, more recent literature suggests this trend may reverse itself over time [27].

Many research gaps remain regarding the impact of VUC on healthcare utilization and cost. These gaps must be addressed to better understand the potential of VUC as an alternative to in-person services. Only with this knowledge will adopting health organization and policy makers be appropriately informed to make future technology investment and reimbursement decisions to improve healthcare accessibility and affordability. Specifically, prior research has been limited to commercially insured study populations that receive VUC services from independent telemedicine companies not associated with a patients' regular source of care. This limitation likely constrains the generalizability of past findings, particularly as different patient populations increasingly gain knowledge and exposure to VUC and different types of health organizations begin to offer the virtual service (e.g., self-insured health systems). Additionally, the current state of research is largely restricted to aggregated analyses of trends across all clinical diagnoses; little if any diagnosis-specific VUC research exists. New research is needed to understand how differences in spending and service utilization between VUC and in-person services may vary by clinical diagnosis.

To address these research gaps, my second dissertation research article (reviewed in Chapter 3) explores spending and clinical care utilization associated with use of VUC, separately for two leading low-acuity conditions including urinary tract infection and respiratory system disease. Combined, these two diagnoses account for more than half of reported primary diagnoses for VUC visits. Using quantitative methods and focusing on a study population of self-insured patients at VUC early adopter health systems, this research seeks to:

a. Compare differences in spending and service utilization between episodes of care initiated at a VUC versus in-person site (including physician office, urgent care, and ED sites) for urinary tract infection diagnoses.
b. Compare differences in per episode spending and service utilization between episodes of care initiated at a VUC versus in-person site (including physician office, urgent care, and ED sites) for respiratory system disease diagnoses.

On-demand telemedicine as a potential source of care fragmentation

The rise VUC and other forms of on-demand telemedicine can be couched in the “convenient care” revolution of the past decade. These care options encompass a range of consumer-oriented innovations that are available on-demand, easily accessible, and more affordable compared to conventional services such as physician office visits or the ED [36]. The first wave of this revolution is generally thought to include urgent care centers and retail clinics; VUC may be considered part of a second wave of virtual convenient care options.

Many policy makers and health organizations tout the convenience and low-cost of convenient care options, including VUC [9,37-38]. Others raise concerns about their potential to increase fragmentation of care [39-40]. Prior research has justified some of these concerns in the retail clinic and urgent care center context [9,41-42]. Particularly, these studies cite failures to connect patients with follow-up services after an initial visit, indicating lack of continuity with other existing health system structures. As noted above, because VUC is a relatively new care option, published literature regarding outcomes is lacking; its impact on fragmentation remains unclear.

Often used as a proxy measure of adequate clinical resolution, researchers have generally found similar or lower rates of follow-up visits comparing VUC and in-person care options such as physician office visits or ED [9,11]. Regarding continuity with other these follow-up services, preliminary VUC research indicates most early adopter organizations have implemented care processes to connect patients with follow-up after an initial virtual visit (if deemed clinical necessary) [43]. However, the efficacy of such care processes to promote continuity have not yet been studied. My third dissertation article (reviewed in Chapter 4) begins to address this gap by studying patterns of follow-up utilization among VUC users. Using quantitative methods and focusing again on a study population of self-insured patients at VUC early adopter health systems, this research seeks to:

a. Compare differences in users, initial virtual visit characteristics, and healthcare spending between VUC episodes of care that result in follow-up versus episodes that do not, among patients referred to an in-person care site to manage a presenting condition after a VUC index visit.

b. Compare differences in users, initial virtual visit characteristics, and healthcare spending between VUC episodes of care that result in follow-up versus episodes that do not, among patients <u>not referred to</u> an in-person care site to manage a presenting condition after a VUC index visit.

Conceptual Framework

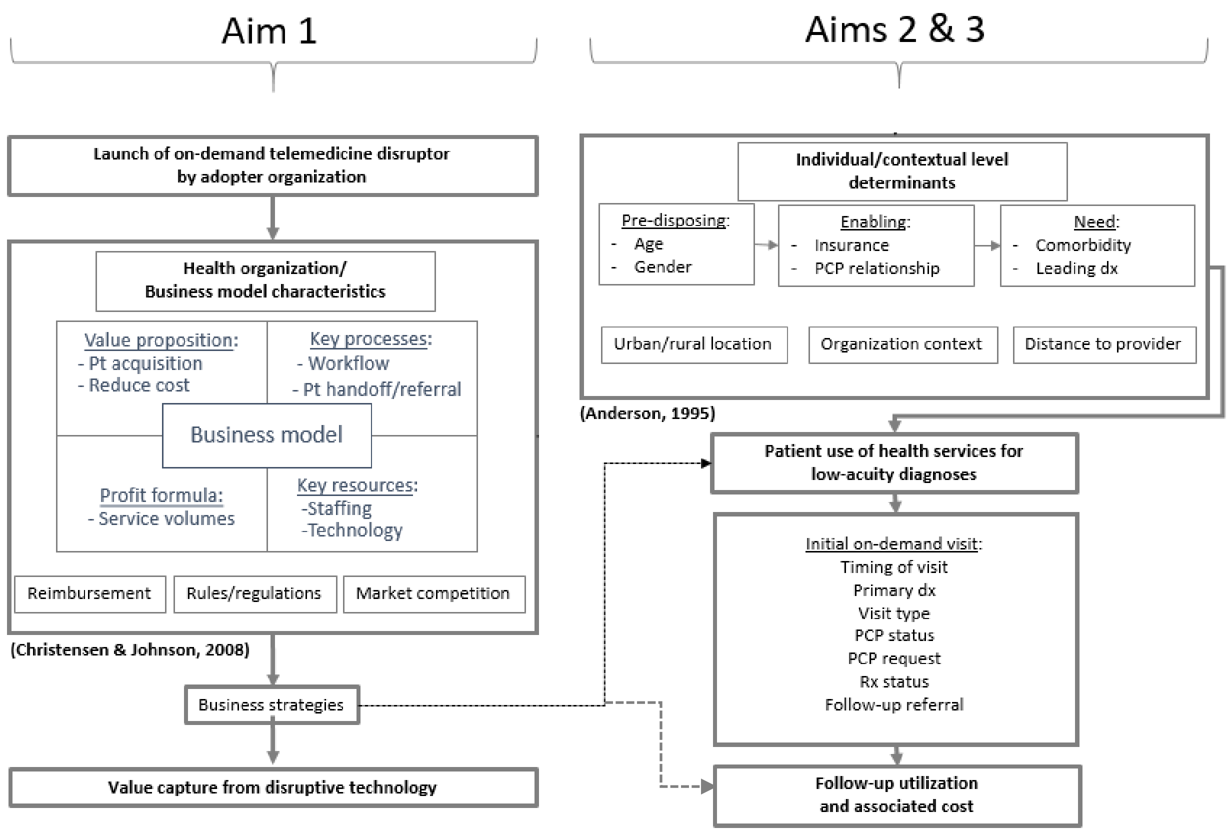
The conceptual framework depicted in Figure 3 describes proposed relationships between concepts associated with each of my specific dissertation research aims. The framework I introduce integrates the Johnson & Christensen business model framework [21] and the Anderson behavioral model of health service use [44]. My first journal article (reviewed in Chapter 2) is guided by the Johnson & Christensen business model framework, a well cited framework that has been previously used to study disruptive technology adoption in healthcare settings. When on-demand telemedicine is launched by an adopter organization, business model components (including value proposition, key resources, key processes, and profit formula) operating within an organization will interact with each other as well as the outer organizational environment (including rules/regulation, market competition, and reimbursement and policy) to drive business strategies and value capture resulting from disruption.

Journal articles two and three (reviewed in Chapters 3-4) are guided by the Anderson behavioral model of health service use. This is one of the most widely acknowledged models that identifies predictors of health service utilization. It is a multilevel model that incorporates both individual and contextual determinants of health service use, dividing components into those that predispose, enable, or suggest need for individual use of health services. Predisposing factors include demographic characteristics, social factors such as education, occupation, ethnicity and social relationships, and mental factors in terms of health beliefs. Financing and organizational factors serve as conditions enabling service utilization. Individual financing factors involve the income and wealth at an individual's disposal to pay for health services and the effective price of health care which is determined by the individual's health insurance status and cost-sharing requirements. Organizational factors entail whether an individual has a regular source of care and the nature of that source. Regarding need factors, Anderson differentiates between perceived need for health services (i.e., how people view and experience their own health) and evaluated need (i.e., professional assessments and objective measurements of patients' health status and need for medical care). My dissertation research focuses on evaluated need.

As modeled in my second and third journal articles, population characteristics, operating at both the individual level (including pre-disposing factor such as age and gender, enabling factors such as household income and insurance coverage, and evaluated need factors such as comorbidities) and the contextual level (including urban/rural location, organizational context, and distance to provider) predict health service use by an individual. For our purposes, health service use involves an initial visit for a low-acuity diagnoses, ultimately informing follow-up service use and associated cost. For my third journal article, we are specifically interested in initial health service use via VUC, as part of our work will be assessing the relationship between follow-up service use and associated cost and a set of individual-level VUC patient (e.g., age, gender) and virtual visit characteristics (e.g., type of virtual modality, primary diagnosis, visit day of week and time of day).

Connecting all three aims, I hypothesize pathways between on-demand telemedicine business model and resulting strategies and health service use by individuals as well as follow-up utilization and associated cost. The results of my dissertation research provide novel insights into these proposed pathways in the context of VUC.

Figure 3. Conceptual framework guiding dissertation research



Chapter 2: Journal Article 1

Journal: Journal of Medical Internet Research (JMIR)

Status: Revise/resubmit status (resubmitted August 11, 2019)

Title: On-demand telemedicine as a disruptive health technology: Exploring emerging business models and strategies among early adopter organizations in the United States

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Abstract

Background:
On-demand telemedicine is increasingly adopted by health organizations to meet patient demand for convenient, accessible, and affordable services. Little guidance is currently available to new entrant organizations as they consider viable business models and strategies to harness the disruptive potential of on-demand telemedicine services (in particular, virtual urgent care clinics (VUC) as a predominant and catalyst form of on-demand telemedicine).

Objective:
We recognize on-demand telemedicine as a disruptive technology to explore the experiences of early adopter organizations as they launch on-demand telemedicine services and deploy business models and strategies. Focusing on VUC service lines, we address the following specific research questions: 1) What is the emerging business model being deployed for on-demand telemedicine? 2) What are the core components of the emerging business model for on-demand telemedicine? 3) What are the disruptive business strategies employed by early adopter organizations as they launch on-demand telemedicine services?

Methods:
Our qualitative study gathered data from 32 semi-structured phone interviews with key informants from 19 VUC early adopter organizations across the United States. Interview protocols were developed based on noted dissemination and implementation science frameworks. We used the constant comparison method to transform study data into stable dimensions that revealed emerging business models, core business model components (value proposition, key resources, key processes, and profit formula), and accompanying business strategies.

Results:
Early adopters are deploying business models that most closely align with a Value-adding Process model archetype. By and large, we find that this general model appropriately matches resources, processes, and profit formulas to support the disruptive potential of on-demand telemedicine. Four business strategy areas were found to particularly contribute to business model success for on-demand disruption among early adopters: fundamental disruptions to the model of care delivery; outsourcing support for on-demand services; disruptive market strategies to target potential users; and new and unexpected organizational partnerships to increase return on investment.

Conclusion:
On-demand telemedicine is a potentially disruptive innovation currently in the early adopter stage of technology adoption and diffusion. On-demand telemedicine must cross into the early majority stage to truly be a positive disruption that will increase accessibility and affordability for healthcare consumers. Our findings provide guidance for adopter organizations as they seek to deploy viable business models and successful strategies to smooth the transition to early majority status. We have presented important insights for both early adopters and potential early majority organizations to better harness the disruptive potential of on-demand telemedicine.

Keywords: telemedicine; disruptive technology; business model; business strategy

Introduction

Healthcare organizations in the United States are operating in a time of high volatility [1-6]. Contributing to current pressures is the rise of consumerism in healthcare, driving patient demand for convenient, accessible, and affordable services. To compete and thrive, many organizations are adopting telemedicine solutions [7]. Telemedicine involves the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status [8]. In 2018, more than 50% of hospitals and health systems reported some form of telemedicine offering [7,9].

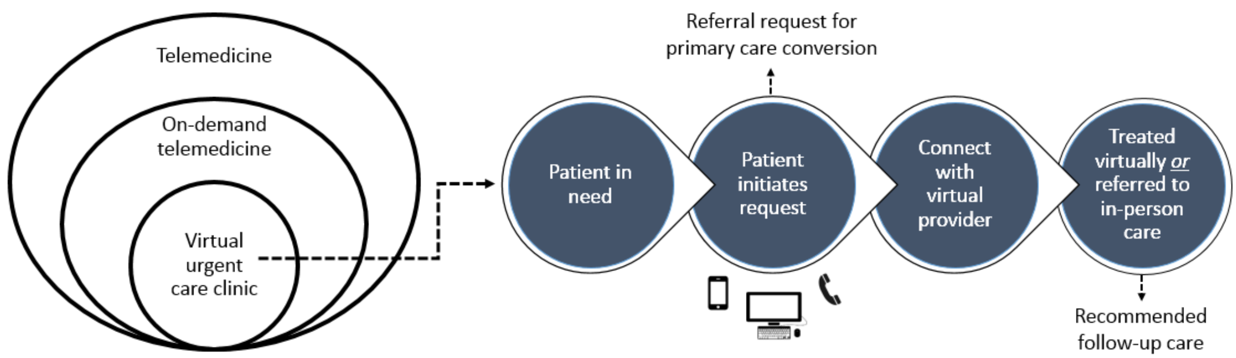
Whether telemedicine should be considered a disruptive technology is a topic of debate. Disruptive technologies are innovations that disrupt and displace established market leaders by offering products and services that are cheaper, simpler, and more convenient than what is currently available [10]. Those that assert telemedicine as a disruptive technology view it as a disruptive model of care delivery that challenges the status quo (i.e., facility-based, in-person services) to create greater access and affordability in healthcare [12]; those in opposition view it as an innovation that improves but ultimately sustains the performance trajectory of traditional market leaders in care delivery [13]. A holistic view of telemedicine as one healthcare service fuels the debate. In practice, telemedicine is not one health service offering, but actually a cadre of potential service lines, each with its own nuances in goals, workflow, stakeholders, and financing – much like in-person care.

Both practice and research may benefit from taking a closer look at forms of telemedicine that stand out as strong disrupter entrants, if we want to successfully harness and leverage the potential of these service lines. It is our position that, in particular, some newer forms of telemedicine create a compelling case that they will disrupt current delivery models of medical care by offering a less expensive, highly accessible, and more convenient alternative to many in-person options. Newcomer service lines often include offerings for "on-demand" telemedicine that are initiated by healthcare consumers [14]. In comparison to traditional modes of facility-based in-person care delivery, on-demand services are patient-initiated and accessible around-the-clock from any location [14]. These potential advantages may attract health organizations operating in high volatility environments seeking ways to manage existing pressures, including the rise of consumerism. Indeed, recent research of telemedicine adoption rates and drivers indicate strong and growing interest for on-demand services that allow patients at home or on the go to reach a clinical provider for a non-emergency consult at a transparent and low-cost fee (typically $30-50) [7].

Riding a tide of increased market growth and uptick in adoption rates among health organizations, on-demand telemedicine may hold great promise as a disruptive technology that will bring greater accessibility and affordability to healthcare. However, little guidance is currently available to new entrants as they consider viable business models and strategies for on-demand services. On-demand telemedicine is in the early adopter stage of technology adoption and diffusion, with the potential trajectory of approaching early majority in the coming years [15]. This can be a precarious position for widespread assimilation of on-demand services, as the inability to bridge the innovation chasm between these stages is known to impact the success of disruptive technologies [15-17]. In general, for a disruptive technology to successfully cross into widespread assimilation, adopter organizations must understand how to navigate viable business models and strategies to expand market potential and encourage adoption among more cautious pragmatists [16-17]. Therefore, now is an opportune time to discover lessons learned from the experiences of early adopter organizations of on-demand telemedicine that are in the process of navigating these rocky waters. Few research studies in the telemedicine or disruptive technology domains provide strategy and practical guidance for those embarking on new telemedicine service lines [18-19]. Moreover, existing studies do not speak through the lens of disruptive technology to yield lessons from early adopters or detail specific forms of telemedicine [18-19].

There are many different forms of on-demand telemedicine, such as for primary care, behavioral health care, and urgent care. The virtual urgent care clinic (VUC) is a widely adopted form of the on-demand service that has received growing attention in the peer-reviewed literature [20-24]. Due to this distinction, our study views VUC as a catalyst form of the disruptive technology that can be used to examine on-demand service launch and business model deployment. VUC provides primary and urgent care services for non-emergent medical conditions that can be managed effectively by telemedicine, such as chronic bronchitis, conjunctivitis, rashes, and upper respiratory tract infections [14]. Figure 1 displays where VUC is situated in the wider context of telemedicine and reviews the general patient encounter process (see Appendix 1 for additional information regarding the encounter process).

Figure 1. VUC encounter process



Disruptive Technology Business Model

Although disruptive technologies have brought greater accessibility and affordability to consumers in other industries, the same cannot be widely said for the healthcare delivery sector [25-27]. Prior healthcare research suggests this failure is associated with misalignment between disruptive technologies and the need for business model innovation [26]. According to Hwang et al. (2008) [26]:

> "Legacy institutions of healthcare delivery are jumbled mixtures of multiple business models struggling to deliver value out of chaos…The healthcare system has trapped many disruption-enabling technologies in high-cost institutions that have conflated two and often three business models under the same roof. The situation screams for business model innovation."

It is well documented that the success of a disruptive technology is closely tied to its business model [28-33]. The business model provides a framework for an organization to create and capture value out of the disruption [28-30]. According to Christensen et al. (2009), pairing disruptive technologies with the right innovative business model can lead to greater accessibility and affordability [28]. Research indicates that business models can be generally categorized into three archetypes: Solution Shops, Value-adding Processes, and Facilitated-user Networks [26-27]. Table 1 provides an overview of these leading archetypes.

Table 1. Overview of leading business model archetypes [26-27]

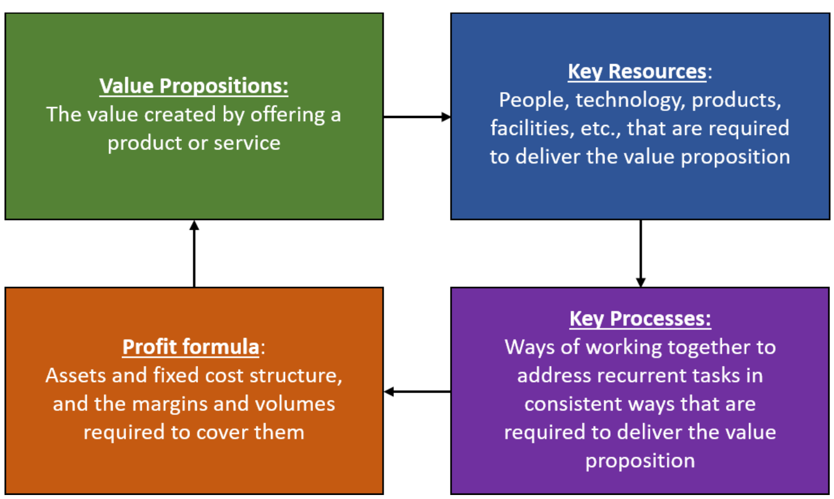
	Business Model Archetypes		
	Solution Shop	Value-adding Process	Facilitated User Network
General model description	Used to diagnose and solve unstructured problems that are unique case to case. Value is derived from employees who diagnose causes and recommend solutions.	Used to transform inputs into outputs of greater value. Value is derived by using standardized inputs and uniform, convenient processes to produce consistent results.	Used for enterprises in which people exchange things with one another. Value is derived by facilitating the effective operation of the network.
Examples of model deployment	- Consulting firms - Advertising agencies - Diagnostic work performed in general hospitals	- Automobile manufacturing - Common medical procedures after definitive diagnosis	- Mutual insurance companies - eBay - Behavioral health support groups

To better avoid the failures encountered by other disruptive technologies in the healthcare delivery sector, new information is needed regarding if and where on-demand telemedicine fits into the general topology of leading business model archetypes. The current landscape of experiences among early adopter health organizations can provide us insight into emerging business models. This leads us to our first research question: *What is the emerging business model being deployed for on-demand telemedicine (specifically, in the form of VUC)?*

Disruptive Technology Business Model Components

While useful, identifying a befitting type of business model does not provide the detail needed to inform strategic direction. Leaders in the field, Johnson et al. (2008) understand any given business model as consisting of four interrelated strategic components (see Figure 2), including (a) the value proposition, or value created by offering a product or service, (b) key resources and (c) key processes that are needed to deliver the value proposition, and (d) the profit formula that defines how money is made for a deploying organization via delivery [28].

Figure 2. Business model framework components (from Johnson et al., 2008 [28] and Hwang et al., 2008 [26])



Once the four components coalesce into an established business model, only value propositions that fit the existing resources, processes, and profit formula can be successfully delivered [20]. Past disruptive technology research suggests these pieces must be fit together such that they are appropriately linked to an emerging disruptor for the new technology to succeed when brought to market [26]. More information is needed to specify these core components and their linkages in the context of on-demand telemedicine. To address this research gap, we propose our second research question: *What are the core components (value proposition, key resources, key processes, and profit formula) of the emerging business model for on-demand telemedicine (specifically, in the form of VUC)?*

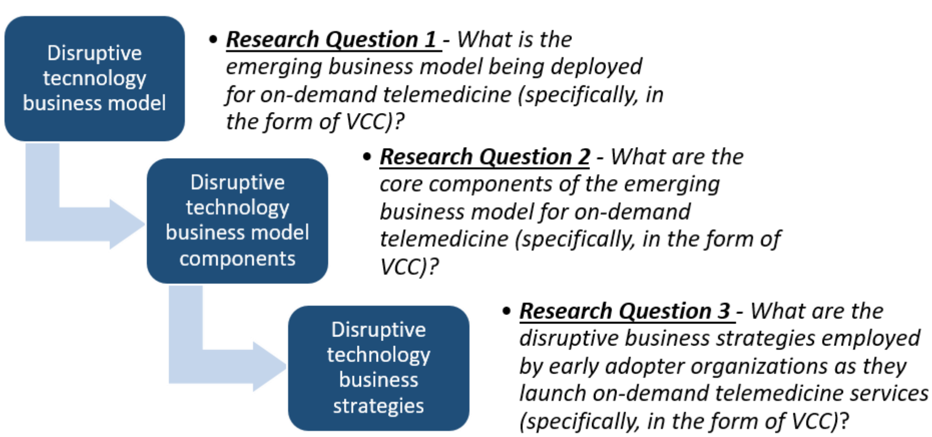
Disruptive Technology Business Strategies

While the business model describes the basic means by which an organization creates and delivers value from a disruptive technology, the business strategy is the specific method a deploying organization uses to achieve the proposed value and deal with opportunities and threats posed to the business model [29]. In the technology and innovation management field, little if any attention has been paid to the role of business strategies in association with emerging business models for disruptive technologies. More information is needed regarding what these disruptive strategies are and how they impact the path early adopters are taking to harness the potential of on-demand telemedicine. This leads us to our third research question: *What are the disruptive business strategies employed by early adopter organizations as they launch on-demand telemedicine services (specifically, in the form of VUC)*?

Study Objective

The objective of this qualitative study is to explore the paths that early adopters are taking to harness the disruptive potential of on-demand telemedicine, using VUC as a dominant instantiation. In doing so, we hope to contribute to disruptive technology research by examining emerging business models and strategies being coupled with on-demand telemedicine services. We also aim to offer practical guidance for adopter organizations as they seek to overcome some of today's leading healthcare challenges using disruptive telemedicine solutions. Our general research framework and specific research questions are depicted in Figure 3. To our knowledge, the components of this framework have never before been studied either collectively or independently in the context of on-demand telemedicine.

Figure 3. General research framework and specific research questions



Methods

Study Population and Data Sources

Our qualitative study focuses on a study population of VUC early adopter organizations nationwide. Participants represent a range of organizational types and geographic service areas from across the United States. Table 2 provides descriptive information regarding participant organizations. Five vendor organizations are represented in our study sample (including many leading vendors among the limited number of companies currently operating in the VUC market). Among non-vendor participants, the majority of organizations contract with vendors to provide some degree of clinical staffing and technology infrastructure to support their VUC programs.

After a 6-month national recruitment effort, we developed points of contact at 25 organizations that offer VUC services; of that total, 19 organizations (76%) agreed to participate in our study. Convenience and purposive sampling were used to identify potential VUC adopter organizations. We targeted potential participant organizations using contact lists from the American Telemedicine Association and National Consortium of Telehealth Resource Centers. We also used internet searches to identify other organizations that may not have been listed (using key word searches for “telemedicine”, “telehealth”, “virtual clinic” and other related terms); internet searches resulted in identification of two additional participant organizations. Overall, early adopter organizations stated they were eager to participate in the confidential interview process; organizations were interested in learning from our collective, de-identified findings in publication as a means of further advancing their VUC program efforts. Among the six organizations that declined to participate, the majority declined due to scheduling constraints among potential key informants.

Data sources included sixty-minute semi-structured phone interviews with key informants from participating organizations and their organization’s VUC-related web and print content. Because staffing titles varied across participating organizations, organizational contacts assisted us to identify key informants for study interviews. To recruit key informants, we targeted organizational roles related to strategy/business development, implementation, marketing, administrative operations, and/or clinical operations.

Two members of the research team conducted 32 phone interviews from September 2017 to December 2018. To promote an open and candid discussion, verbal and written recruiting messages emphasized confidentiality and the ability of the participants to skip questions and to go “off record” with certain comments. Furthermore, at the beginning of each interview, key informants were made aware that all information collected during the interview would be completely confidential: anyone that was refer to during the interview would not be mentioned by name, nor would organizations be identified by name. All interviews were recorded (upon permission from key informants), de-identified, and transcribed prior to analysis. If there were any comments key informants did not wish to have recorded, the interview was postponed until all recording functions were turned off (“off record”). Conversations were fluid with few “off record” requests. Failure to respond to a question was typically due to perceived lack of knowledge or factual detail related to the question; in most cases, a follow-up communication (e.g., email) provided a response or a referral was made to a knowing person.

To provide breathe and depth of coverage, interview protocols were developed based on noted, dissemination and implementation science frameworks that have been widely used to study adoption of technologies in service delivery organizations, namely: Damschroder's Consolidated Framework for Implementation Science Research [34], Greenhalgh's framework for diffusion of innovations in service organizations [35], and Aaron's conceptual model of evidence-based practice implementation in public service sectors [36]. Collectively, these frameworks reflect a broad, socio-technical organizational perspective that shaped our interview questions and allowed for an evidence-based exploration of business model and strategy components. Prior to use among key informants, the interview protocol was reviewed by experienced qualitative researchers familiar with the health information technology field as well as healthcare administrators and clinicians with a connection to telemedicine duties, such as telemedicine directors and virtual providers. Minor refinements were made to the protocol as a result of this expert review. (See Multimedia Appendix 2 to review our general study protocol; this general protocol was adjusted as needed to tailor interview questions and perspective to the type of organization and role of key informant).

*Table 2***.** Characteristics of participating VUC early adopter organizations

	VUC early adopter organization type			
VUC service characteristics	**Health systems (n=12)**	**Primary care practice (n=1)**	**Insurer (n=1)**	**Vendor N=5)**
US geographic coverage:				
West	4	0	1	0
Midwest	4	0	0	0
East	4	1	0	0
National	0	0	0	5
Rural/urban service area:				
Urban	0	0	0	0
Rural	1	0	0	0
Urban/rural	11	1	1	5
Available VUC modalities:				
Only real-time text	0	0	0	2
Only real-time phone	0	1	0	0
Only real-time video (e.g., web, phone-based app)	3	0	0	1
Real-time phone and video	9	0	1	2
Vendor engagement (among non-vendors):				
Clinical staffing and other support services	10	0	1	NA
Non-clinical staffing support	2	0	0	NA
No vendor engagement	0	1	0	NA

Analytic Approach

We used the constant comparison method to analyze qualitative data [37-38]. Interview transcripts and supplementary web and print content were coded independently by one or more research team members. Our team first deductively used noted dissemination and implementation science frameworks to develop an a priori coding schema [34-36]. Researchers met regularly during this process to iteratively discuss initial coding and refine coding categories [39]. Inter-coder disagreements were resolved by consensus resolution, using an external qualitative expert to act as an auditor who makes final determinations as needed. We then carried out axial coding to inductively collapse initial coding categories into aggregate, stable dimensions that revealed emerging business models, strategic components, and accompanying business strategies [39]. Embedded in our interviewing and coding procedures, validity and reliability of study data and interpretation were assessed following Lincoln and Guba's criteria for evaluating interpretive research [40-41]. Reporting of qualitative data were guided by the Consolidated Criteria for Reporting Qualitative Research (COREQ) [42]. We used Dedoose© software for all qualitative data management and analysis [43].

Results

Our analysis revealed an emerging business model among VUC early adopters that closely aligns with the Value-adding Process archetype introduced in Table 1. We will first share our findings regarding the general characteristics of this emerging model and detail its four core strategic components. We then describe four business strategies revealed from our data that are particularly indicative of the disruptive potential of VUC services.

The Emerging Business Model Deployed by Early Adopters

Identification of VUC as a Value-adding Process business model archetype was supported in a number of ways. First, interviewees described a general business model focused on delivering a consistent, high quality patient care experience that is quick, convenient, and highly accessibility. According to one interviewee regarding convenience, accessibility, and expediency:

> "First and foremost with [VUC], it's all about the convenience of being able to do it over your phone, your mobile phone, and on-demand. And so I've got a problem…I've got pink eye, I need to get that taken care of, I can open up my mobile phone, open up my app and I can be seen you know in less than 10 minutes."

Regarding an emphasis on consistent high quality patient care, another interviewee commented:

> "We have defined protocols that we create based on the best literature and research out there on the appropriate way to treat patients [virtually]. We've also undertaken to hire very experienced clinicians."

Second, indicative of the Value-adding Process archetype, organizations described a rules-based and uniform encounter process initiated after a VUC provider makes a definitive clinical diagnosis. Third, with few exceptions, interviewees reported having deployed a business model dependent on service volumes to generate profit derived from the VUC encounter process. Service volumes were attributable to the VUC encounter itself and downstream from recommended follow-up care or referrals resulting from the on-demand visit:

> "So the key indicators are numbers of visits, and that includes number of visits to the website, the number of people who start the process, number of people who complete a virtual clinic visit…and then we track people who are appointed with a new primary care doctor in our system… we look at the financial return on visits that we are tracking."

To generate volume, organizations often relied on direct-to-consumer marketing to potential users to raise awareness and drive service uptake. To accommodate the needs associated with increased service volumes, the majority of our participating early adopter organizations relied to some extent on vendor outsourcing to support key resource inputs for the on-demand service, such as VUC clinical staffing and/or technology infrastructure (See Table 2).

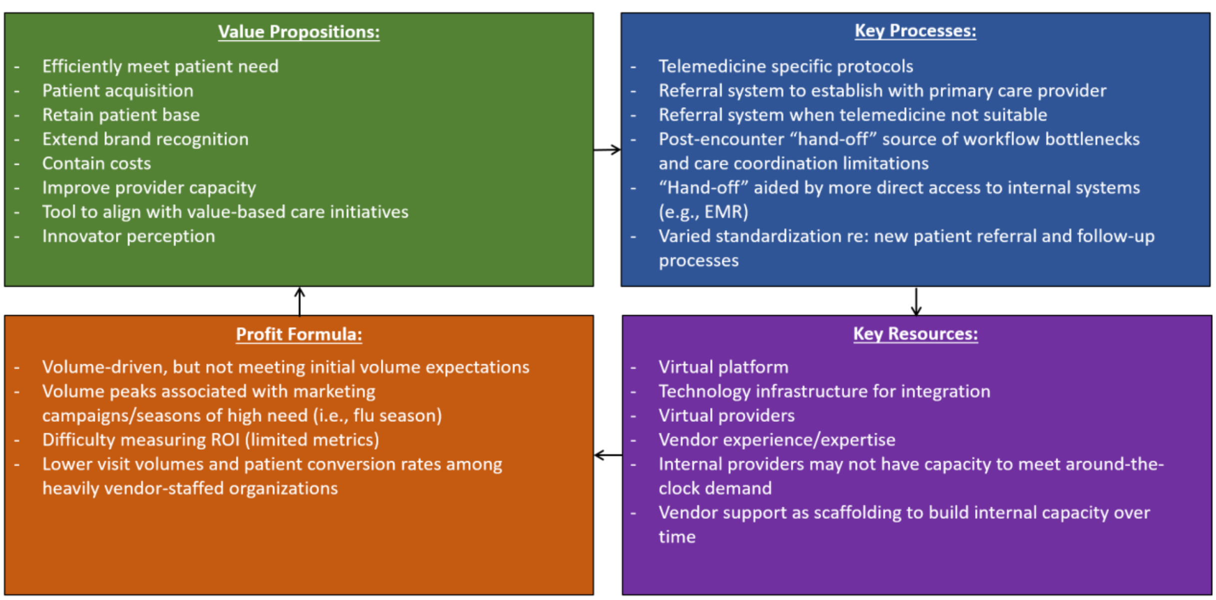
Interestingly, the collective experiences of our interviewees suggest that many early adopters are leveraging their initial investment in VUC services to explore new potential innovations in the on-demand telemedicine space that are using different business model type structures. These newly spawned innovations share elements commonly associated with the User Facilitated Network business model archetype reviewed in Table 1, such as the exchange of communications and data between users, and profit generation via membership or user fees. For example, some participating organizations are cultivating VUC and other on-demand telemedicine patient user networks and technologies to manage the care of many chronic diseases. To illustrate, one interviewee described a diabetes self-management program that uses a phone-based text messaging platform to share and discuss disease management information with a wide patient community in real-time.

Also in alignment with the Facilitated User Network archetype, other participating organizations described emerging strategies to expand their membership-based service operations to increase profit generation. In such arrangements, early adopters contract with outside self-insured entities to offer VUC or other on-demand telemedicine services directly. For the self-insured entity, financial returns are achieved via improved employee health, lower employee absenteeism, and greater employee retention. For the on-demand service provider, financial returns emerge by building a larger client base.

Core Strategic Components of the Emerging Business Model

Figure 4 summarizes selected themes related to the four core strategic components (value proposition, key resources, key processes, and profit formula) that illuminate how VUC early adopter organizations are approaching the emerging business model we have described. We address each of these components below (a complete review of Figure 4 themes is included in Multimedia Appendix 3).

Figure 4. Summary of core strategic components of emerging business model archetype



Value proposition. According to interviewees, a core leading value proposition for on-demand service launch was more efficiently meeting patient need to access care. For example:

> "The value proposition for us, really comes down to better service, easier access, faster access, being mobile, you know, being able to go right where those patients are, rather than having them come to us, and really the big keyword for all of [our goals] came down to access…"

Other common value propositions included patient acquisition, retaining patient base, and extending brand recognition (often facilitated by white labeling of the VUC service by a telemedicine vendor). Regarding patient acquisition, one interviewee stated:

> "It's very expensive to acquire a new patient for health systems and so offering a convenient [virtual] urgent care and other consumer acquired services, it can be a very good way to acquire new patients and develop a new relationship with patients."

Reducing healthcare costs, or cost containment, also emerged as a frequent theme. One interviewee commented:

> "…there is an incentive for the health care system to be seeing patients in this way... I think it saves [the health system] money, it saves on unnecessary costs incurred by patients being seen when they didn't have to be seen or … coming to an emergency room and utilizing resources that could better be utilized for patients who need that sort of in person service."

Some interviewees also identified improved provider capacity as a leading value proposition:

> "For us we are having a real access issue in our small rural county. And so we were using [VUC] as a way to provide services to our community whenever we don't have provider capacity in our primary care clinic."

While less commonly expressed by interviewees, other value propositions also included the use of VUC as a tool to support population health management (in alignment with value-based care initiatives) or to promote an innovator perception to gain competitive advantage over peer organizations. Regarding promotion of an innovator perception, one interviewee commented:

> "…health systems see the value in extending their brand, and being seen as the leader in the market of telemedicine or virtual care, it allows them to differentiate in that manner… they see this as another arm in the overall machine of trying to generate new business for the organization."

Key resources. According to interviewees, common key resources among early adopter organizations include the VUC virtual platform, technology middleware to link clinical and administrative systems, and virtual clinical providers to staff the on-demand service. As reviewed in Table 2, many interviewees indicated that their organizations contract with third-party vendors to source some or all of these resources, particularly clinical staffing. Vendors were seen to provide vast experience and expertise to facilitate a fast and efficient VUC launch. For example, one interviewee explained:

> "I mean if it was just putting up a video chat component that's not that difficult and anyone can do it but there is you know a lot of aspects to it, there's billing, there's claims processing, there is integration to their systems, there is doctor availability, there is managing, training…so when

> you come to us you kind of get that complete package plus the expertise of you know what we have been able to accomplish over the past 10 years."

Many interviewees acknowledged that, for their organizations, pulling together key resources in-house requires extensive internal expertise regarding technology infrastructure and myriad aspects of virtual clinician staffing. While operational and clinical control was often identified as a perceived benefit, interviewees consistently indicated that it was challenging to meet around-the-clock patient demand for VUC with only their internal clinical providers. According to one interviewee:

> "Our intent is to staff it as much as possible with our employed providers. But it just doesn't make economic sense for us and we wouldn't be able to maintain a low cost point if we're having to staff [the virtual clinic] at every low utilization time, for example in the early morning. And then also we wanted to be highly accessible not just in the states where … our patients are, but have it available to those patients as they travel out of state … so we have [a] partner network [with a vendor]."

Key processes. According to interviewees, common processes among early adopters relate primarily to the VUC encounter, including use of telemedicine-specific clinical protocols and systems for primary care referral and triage to in-person services. However, interviewees reported quite varied experiences in post VUC-encounter processes. Among organizations relying primarily on clinically staffing support by vendors, interviewees described a patient hand-off process between the vendor, who provides the virtual encounter, and the adopter organization, who typically handles scheduling for new referrals and follow-up to check on patient progress after the clinical encounter. As one interviewee describes this hand-off process:

> "…I mean right now it's a much more, I would say antiquated process, but the visit summary is sent to our [health information] department and then they are manually filing in that patient's chart in the media tab… So that process of getting [a patient] set up with a primary care provider is outside of the [vendor] process."

According to interviewees, the lack of a standardized and strong hand-off process was associated with workflow bottlenecks and care coordination limitations:

> "Well ideally we would be able to get them in for a [visit] if they were hoping to have a primary care provider in our system. And so usually what ends up happening is we call them and get them on a wait list. It would be ideal if we could have more access and were able to actually pull them into our system."

Among those organizations that do not rely primarily on clinical staffing support by vendors, most interviewees reported that post-encounter processes tend to be more standardized and efficient, greatly aided by more direct access to the internal systems of adopter organizations, especially electronic medical records (EMRs), referral systems, and appointment scheduling software. As one interviewee explains:

> "I think some health care systems are adopting this model and finding it better than hiring a [vendor] simply because having it done internally, people understand the internal process, they are already utilizing the same [electronic medical record] which ends up being a huge problem with hiring a [vendor] sometimes. And so the workflow and the integration and the follow up on

> patient care can be a lot easier when it's done in-house rather than hiring one of these [vendors]."

Profit formula. Overwhelmingly, interviewees described volume-driven profit generating mechanisms for VUC services, dependent on number of VUC encounters and referrals to other in-system services. However, with few exceptions, interviewees reported they are not meeting initial volume related goals.

> "I mean we're satisfied with the quality and the customer satisfaction. We are not terribly satisfied with the volume for the growth trajectory …. We thought it would grow faster than it did last year."

Volume peaks are commonly associated with VUC marketing campaigns and seasonal times of high need (i.e., flu season). In general, interviewees representing organizations that rely heavily on vendor staffing typically reported lower encounter volumes and indicated less success at generating downstream volumes via patient conversion to primary care, compared to peers. As one interviewee explains:

> "[Patient] conversion is lower than what was targeted… I think we may have over projected potentially, initially on conversion. "

Review of Disruptive Business Strategies Employed by Early Adopters

Our qualitative study data revealed four business strategies that seem to particularly dictate the disruptive potential of VUC services, including: 1) fundamental disruptions to the model of care delivery; 2) outsourcing support for on-demand services; 3) disruptive market strategies to target potential users; and 4) new and unexpected organizational partnerships to increase return on investment.

Fundamental disruptions to the model of care deliver: A modern day twist on house calls.

Interviewees' comments regarding strategy focused on patient convenience, expediency, and appropriate level of care, which represents a fundamental disruption to standard models of care delivery. In fact, it can be viewed as a modern-day twist on the traditional house call. As an extension, to better facilitate the delivery of home care, many early adopters are incorporating home-based diagnostic testing and smart-phone based tools and peripheral devices to extend the capabilities and conveniences of VUC services:

> "I think we'll continue to see services evolve more and more to bring the online experience into a connected experience in the home… There are many devices available that you can attach to your Smartphone that would enable the provider to look in an ear or to listen to your heart or to listen to your lungs…and devices for home lab testing. So yeah it's something that we are keeping an eye on and then also thinking of how we can best utilize those to extend our services… [it's] definitely something we are watching."

Regarding displacing traditional models, our data revealed a priority on right fitting care via the VUC care delivery model. One participating organization described placing VUC kiosks near emergency department waiting rooms to help triage patients to appropriate care settings based on medical need and patient choice:

> "We are looking at putting in a ER kiosk for virtual visits in one of our rural hospitals…that leadership team is wanting to have an option for those that really don't need an ER visit that are using it more for primary care, to give them an option of a virtual visit … if it's determined that

> really that patient does not need an ER visit, then they will be given options of seeing an ER physician, a same day appointment with the primary care doctor, urgent care option, or a virtual visit…and they'll be given the cost."

Outsourcing support for on-demand services. As reported by many interviewees, early adopter organizations often outsource to third party vendors to launch, operate, and maintain their VUC services. According to our findings, outsourcing of clinical services is a relatively new and disruptive practice for adopting organizations. Early adopters reported varied and often flexible contracting relationships with vendors, particularly around support for clinical staffing. Although some limitations around the use of vendor services were noted, specifically lack of direct access to the internal EMR and billing systems of adopter organizations, vendor experience and expertise was largely considered a useful and agile resource for early adopters to expediently launch VUC services and to provide virtual clinical provider capacity for their VUC programs.

However, a complete dependency on external virtual clinical providers to staff the service line was not a permanent strategy. Many interviewees reported outsourcing strategies that utilized varying degrees of vendor support to provide important virtual provider scaffolding and increasingly bring the VUC service in-house as internal capacity improves and patient base expands. According to one interview:

> "While we could build it in house, our IT currently doesn't have a skill set to be able to sport something of this magnitude…Now that being said, I know we are currently in discussions and are working on a plan, that hopefully within the next six to 12 months, that will start to combine [vendor] providers with our own."

Disruptive market strategies to target potential users. Due to the patient-initiated nature of VUC and other on-demand telemedicine services, direct-marketing to potential users emerged as a central and disruptive theme in the business strategies described by early adopters. Collectively, interviewees reported that VUC marketing strategies were largely new and uncharted terrain for their staff, distinct from the marketing needs for facility-based care delivery of in-person services:

> "Getting the name out there that was something we've never really had to do before. Because usually it's just our name since healthcare is usually a new office, and [patients] already know what that healthcare is, [they] already know what an office does we don't have to really educate or re-educate. [However, this was] a brand new product, brand new service, we had to get our name out there and educate [potential users] on what the product was and how it worked."

Interviewees overwhelmingly commented on the importance of "direct-to-consumer" marketing strategies to raise service awareness among potential users and ultimately drive service utilization and uptake. According to one interviewee:

> "We talk to clients about marketing all the time! Keeping that in their ear because, when it comes down to the bottom line, that's what really drives utilization… Always, on our agenda every week we ask, what's your marketing, what discussions are you having, this did not work so what can we do differently to make sure it works."

Early adopters reported the use of varied marketing strategies, both traditional (e.g., billboards, radio) and digital (e.g., search engine optimization, websites). Interviewees reported marketing success when they prioritized funding and staffing for marketing efforts during initial VUC implementation as well as on an on-going basis and utilized diverse marketing strategies, both traditional and digital. We further identified the value of marketing campaigns to specific seasons (e.g., flu season) or opportunities of need (e.g., part of information packets sent to new and relocated employees).

New and unexpected organizational partnerships. To increase opportunities for return on investment from VUC service launch and to drive profit generation, many early adopters described new and often surprising partnerships with organizations outside of traditional healthcare delivery sector circles. For example, as discussed above, some interviewees commented on future plans to expand membership operations by partnering and contracting with self-insured organizations to offer VUC services directly and at a fee. According to one interviewee:

> "[Health systems are looking to] expand to a member program or a direct to employer program… there's a huge opportunity there where a health system can go out and sell their brand name to these other organizations within the area."

As another example of the unique partnerships undertaken by early adopters, one interviewee discussed contracting with a nationwide hotel chain to offer VUC services to guests and employees. These new partnership strategies are innovative for the healthcare delivery sector and appear to be supporting many early adopters in their attempts to leverage value from their VUC services.

Discussion

Our qualitative study used the dominant instantiation of VUC to explore the paths that early adopter organizations are taking to harness the disruptive potential of on-demand telemedicine. In the coming years, this arguably disruptive form of telemedicine will seek to attract an early majority category of adopters. In turn, our findings contribute to literature by providing insight for researchers and organizations considering launch or expansion of on-demand services to leverage what early adopter organizations have learned along the way regarding business model deployment. We also offer practical lessons learned regarding key strategy choices for adopter organizations as they launch on-demand services and encounter hurdles to value capture and delivery via deployed business models.

Insights into the Emerging Business Model for On-demand Telemedicine

Health organizations have traditionally faced many struggles in aligning disruptive technologies with innovative business models [25-27]. To better understand whether organizations launching disruptive on-demand telemedicine services will meet a similar fate, this study explored emerging business models in the context of VUC early adopter organizations. With few exceptions, our study data suggest that current VUC early adopters are deploying Value-adding Process models that appear to appropriately match resources, processes, and profit formula to support value propositions for on-demand telemedicine.

By disentangling the reports from our interviewees regarding various business model archetypes, we were able to see a visionary progression of innovation among early adopters. Our findings demonstrate that business models archetypes and model components may evolve as organizations encounter challenges and opportunities related to the disruptive technology. In our study, we see many VUC early adopters that originally deployed a Value-adding Process model archetype beginning to transition to the use of a User-facilitated Network model to better capture market share. To continue riding the wave of disruptive innovation and expansion spawned by on-demand telemedicine, early adopters are not staying stagnant: they are continuing to evolve their business models and recalibrate their core model components and strategies as new challenges and opportunities arise. Future research should pay particular attention to the deployment of User-facilitated Networks, as many of the early adopters participating in our current study indicated increasing use of this archetype as they explore new potential on-demand telemedicine innovations within their organizations.

Strategic Direction: Strategy Helps to Transform the Business Model into Action

We identified four strategy areas that seem to particularly dictate the disruptive potential of VUC services, including innovations in care delivery, outsourcing support, marketing strategies, and unique organizational partnerships. Below we review lessons learned for each of these strategy areas to help guide future practice for VUC and other forms of on-demand telemedicine.

Innovations in care delivery. Through much of the early 1900s, roughly half of all clinical visits involved a doctor coming into a patient's home [44]. As health care systems grew larger, more specialized, and complex over the next century, the practice of the traditional house call became nearly non-existent; facility-based, more expensive and often time-consuming models of care delivery, such as the physician office visit and emergency department, moved in to take its place [44]. On-demand telemedicine represents a fundamental change in the model of care delivery for patients – a modern-day re-envisioning of the traditional house call. Today, VUC and other on-demand telemedicine services are pointing back to home care as a low-cost way to reduce time constraints, improve convenience and accessibility, and engage in shared decision making with patients to "right fit" care for common non-emergent conditions.

This new delivery model presents clear gains in convenience and accessibility for the treatment of many common, non-emergent medical conditions. However, when follow-up services are required to check on patient progress or to schedule patient appointments after the on-demand visit, our findings identified workflow bottlenecks and care coordination limitations within the post-encounter process for many early adopter organizations. This may indicate a struggle to integrate home-based services into the larger continuum of care when patient contact and care coordination services are needed beyond the initial virtual visit.

There is limited guidance in the current research literature regarding this integration process to inform decision making among adopting health organizations. However, lessons learned from our participating early adopters suggest that clinical integration of virtual visits into patient EMRs and other electronic systems to help track patient history and facilitate care coordination needs may be an important step to strengthen post-encounter processes and the new care delivery model as a whole. Recently proposed policy by the Centers for Medicaid and Medicare Services (CMS) – that will give patients access to their own downloadable health data [45] – may have implications that will break down barriers to the exchange of EMR data in the near future. The proposed initiative will potentially circumvent the EMR to empower healthcare consumers to share their health data with whomever they wish, including virtual providers.

Outsourcing support. Among early adopters, outsourcing to third-party telemedicine vendors emerged as a key strategy to increase speed to market, gain access to technical infrastructure without taxing internal resources, and extend clinical staffing coverage for the on-demand service. While interviewees described a variety of outsourcing contract arrangements, those that balanced internal resources with important scaffolding support from vendors appeared best suited to meet proposed value propositions. Outsourcing clinical services is still a relatively new concept to the healthcare delivery sector, and as such there is limited guidance to inform future outsourcing decisions from telemedicine and healthcare sources. However, findings from the wider literature may prove instructive in the context of on-demand telemedicine [46-60]. Evidence-based guidance from the general outsourcing literature suggests adopter organizations should consider outsourcing a service in the context of low internal resources (particularly human resources) [49-50], the desire to increase flexibility regarding resources, operations, and other strategic elements [51], high internal costs (relative to expected costs of outsourcing) [52-53], and if other competitors are already outsourcing a given service [54]. In contrast, evidence suggests organizations should shy away from outsourcing a service in the context of high levels of market uncertainty [55], heavy integration of the service into internal systems [56-57], high level of service complexity [58], and if the service is considered a core competency to the service line [59-60]. We call VUC organizations and ensuing research to consider this evidence-based outsourcing guidance from other domains in exploring future strategies.

Marketing strategies. Recent healthcare trends indicate overall telemedicine use is growing fast among patients, but remains low overall [61]. This trends was echoed in what we heard from early adopters in our study, where the majority of interviewees indicated that though their VUC service volumes were increasing they were not meeting initial projections. Low utilization does not seem to be associated with usability issues [62-63] or dissatisfaction [64], which have been identified as some of the more common barriers to technology adoption and use. In fact, many of our participants used patient satisfaction surveys as a means to measure satisfaction as an outcome, and reported that patients that used VUC services were very satisfied. Upon investigating the few reports of dissatisfaction, the most often indicated underlying cause was the patient not receiving a prescription for antibiotics when they wanted one.

Instead, with few exceptions, early adopters connected their lower than expected VUC volumes to challenges around raising awareness for the service among potential users; to address awareness, interviewees often commenting on the importance of "direct-to-consumer" marketing efforts. The importance of raising awareness of a new innovation is not new to disruptive technology research: awareness and knowledge generation is considered the first step in deciding whether to use a new innovation [15]. Not addressing awareness issues can impeded adoption of consumer health technologies [65]. Increased awareness is often driven by the intersection of need recognition and marketing communications [15].

However, as was recognized in our study data, VUC marketing is largely new and uncharted terrain for early adopter organizations; according to one interviewee: "Getting the [VUC] name out there that was something we've never really had to do before. Because usually it's just our [organization] name since healthcare is usually a new office, and [patients] already know what that healthcare is…" VUC marketing efforts seem to have a threefold purpose: a) to provide the health consumer with understanding about the availability of VUC b) educate the health consumer about the medical situations when VUC is a good option, and c) "sell" the health organization as this is where a strong link needs to be created for the health consumer to turn to the health system's VUC offering among other options. Regarding education, as with some other early innovations (e.g., Linkedin), potential adopters may not understand all of the uses and potential of VUC.

Marketing in the form of health system "branding" is still relatively new, and marketing direct-to-consumer services like VUC are even newer. In cases of one-time or episodic care similar to VUC (where the patient may not always interact with the same provider), research suggests that the presence of tight bonds between patients and a sponsoring organization, or even organizational representatives, is a key facilitating factor for successful telemedicine service interactions [62]. This finding has important potential implications for organizations as they market their VUC services. First, organizations should consider directing their marketing efforts not only toward potential virtual patients but also organizational representatives (i.e., primary care providers, other staff) who may share their existing close bonds with their patients and can function as pseudo-brand ambassadors to raise awareness of VUC services. We also learned in our conversations with interviewees of some limited activity in this area, particularly in regard to adopter organizations asking physicians to post VUC advertisements in their offices. Second, it indicates that as health organizations continue to expand and strengthening their "health organization branding," they should leverage their organizational brand in their marketing efforts to raise awareness for VUC; they should consider marketing VUC not as a separate product, but instead as an available service offered by an organization that patients already know and trust to manage their medical care. Building this type of patient-organization connection is still relatively new and evolving, as patients are generally more welded to individual providers rather than to health organizations. Adopting provider organizations, such as health systems, may have an advantage in leveraging patient-organization relationships to raise VUC awareness because of their potential role as a regular source of in-person care for patients and as a well-known healthcare institution in local communities. We see that some early adopters are already engaging in this activity by working with vendors to white-label their VUC services so that they may present the service with strong health system branding.

However, early adopter organizations should also recognize important externals factors that may present challenges to ongoing marketing efforts to raise VUC awareness and drive utilization; namely, limited telemedicine reimbursement that may prevent penetration to certain patient markets (e.g., Medicare patients), and provider credentialing and other regulations that may prevent organizations from providing services across state lines [67-68]. While recent policy changes have reduced these limitations [69], policy barriers are not completely eliminated; those still exist challenge the capabilities of health organizations adopting VUC to expand virtual service offerings and grow their patient volume.

While in our study we identified a number of strategies that led to greater marketing success among VUC early adopters to drive uptake (e.g., using both traditional and digital strategies), there is little additional evidence-based guidance to inform future strategic decision making in the healthcare marketing literature, creating an opportunity for future work. Future research efforts may be informed by research exploring factors to help organizations design, manage, and market service delivery interactions for medical video conferencing, a different form of telemedicine [66].

Unique partnerships. According to interviewees, adopter organizations are particularly motivated to explore innovative relationships with external entities to increase opportunity for return on investment and profit generation related to on-demand telemedicine services. Reviewed above, a prominent example of this involves early adopter health systems contracting with self-insured organizations to offer VUC services directly. Examining other emerging and unexpected partnerships between healthcare and business entities, such as the recent formation of a healthcare company between Amazon, Berkshire Hathaway, and JPMorgan, may help to shed some light on how will these innovative organizational relationships will influence the direction of VUC and other telemedicine services in the future. With the goal of improving healthcare services and cutting costs for more than 1.1 million employees, the Amazon partnership is predicted to disrupt the healthcare marketplace by using technology solutions to develop innovative treatments and modernize delivery system processes [70]. Similarly, new partnership arrangements related to VUC and other on-demand telemedicine solutions also have the potential to disrupt healthcare. Moving forward, it remains to be seen how these new organizational relationships may impact the use of various business model archetypes and strategies for new technologies in healthcare.

Study limitations

Our focus on a narrow study population of VUC early adopter organizations may limit the generalizability of our study findings. As a result, some findings may not be applicable to other forms of on-demand telemedicine, such as for behavioral health. In addition, we did not study non-adopters or organizations with failed VUC adoption experiences; learning about the experiences and challenges faced by these organizations may have provided additionally meaningful insights to address our research objective. Our use of a convenience and purposive sampling approach may also present limitations to study generalizability. Although we targeted organizations in different geographic areas and of varying size and type, it is possible the perspectives of some VUC early adopters are not represented in our study dataset. It is also possible that given time constraints, lack of knowledge, or hesitancy to discuss business information, key informants may not have shared some details of potential interest to researchers. However, key informants were generally very open and forthcoming during study interviews, thus reducing concerns that important themes may not have been revealed. Lastly, we specifically targeted "early adopters," representing only a minority of potential adopters along Rogers' DOI curve [15]. However, the purpose of our study is to offer guidance to new organization entrants as they consider viable business models and strategies for on-demand telemedicine, necessitating an exclusive focus on early adopters.

Conclusion

Current trends suggest health organizations will increasingly use on-demand telemedicine as a means to meet patient demand for convenient, accessible, and affordable services and address other leading healthcare challenges. Here we have presented on-demand telemedicine as a potentially disruptive innovation in the early adopter stage of technology adoption and diffusion. For the research community, we contributed a new level of contextualization to disruptive innovation research targeted to the health information technology space. For early adopters, the insights we have shared can help organizations navigate evolving opportunities and address challenges to leverage their position of early entry. However, to truly be a positive disruption that will increase accessibility and affordability for healthcare consumers, on-demand telemedicine must cross into the early majority stage of widespread assimilation. For potential early majority organizations that are considering launch of on-demand services, insights from this study provide an opportunity to leverage what early adopters have already learned along the way to mitigate unknowns and risks as they deploy innovative business models and make strategy choices to harness the disruptive potential of on-demand telemedicine.

Chapter 3: Journal Article 2

Journal: Health Services Research Journal (HSR)

Status: Submitted August 19, 2019

Title: Virtual Doc-in-a-Box: Evaluating Spending and Clinical Care Associated with Use of Virtual Urgent Care for Two Common Low-acuity Diagnoses

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Abstract

Objective: To compare differences in spending and clinical care utilization between virtual urgent care (VUC) and in-person services for two common low-acuity diagnoses: urinary tract infection (UTI) and respiratory system diseases (RSD).

Study setting: Two health systems in the Midwest offering VUC as a covered benefit to self-insured plan members.

Study design: Cross-sectional, retrospective analysis to estimate spending and any clinical follow-up per episode of care for UTI and RSD, comparing VUC initiated episodes versus in-person initiated episodes (i.e., office, urgent care, emergency department). Episodes were defined as an index visit and all outpatient and emergency department visits within 28-days with the same primary diagnosis (including prescriptions). Inverse probability of treatment weighting employed to balance baseline characteristics between cohorts.

Data collection: Data collected from hospital claims, beneficiary enrollment files, and virtual encounter files for FY2015-2018.

Principal findings: Spending was lower for VUC versus in-person initiated episodes for both UTI and RSD diagnoses. VUC episodes were less likely to result in any follow-up for UTI and RSD.

Conclusions: Compared to leading alternative in-person sites, results indicate VUC can provide lower cost services without the need for potentially duplicative follow-up care for both UTI and RSD diagnoses.

Key words: telemedicine, virtual urgent care, health care costs, service utilization

Introduction

The rise of consumerism in healthcare is driving patient demand for convenient, accessible, and affordable services.[1-3] To compete and thrive, many health organizations are launching telemedicine solutions. In 2018, more than 50% of health systems and hospitals reported having adopted some form of telemedicine.[4-5] Newly launched telemedicine services often include virtual urgent care (VUC) programs (sometimes also called direct-to-consumer-telemedicine) for low-acuity conditions that can be managed effectively via telemedicine.[6] Compared to traditional modes of facility-based in-person care such as an office visit, VUC is patient-initiated and accessible 24-hours per day by phone or video in real-time from any location. Despite rapid adoption by health systems, little empirical data is available regarding the impact of VUC on healthcare use and spending outcomes.

Because VUC is a relatively new care option, published literature regarding outcomes is lacking. Care quality is of particular concern, such as whether physicians can provide accurate diagnoses without hands-on physical examinations of patients. Another concern is whether additional follow-up visits occur after an initial VUC visit as a result of unresolved symptoms. Several studies have demonstrated the quality of telemedicine for low-acuity conditions that fall within the scope of VUC services; these studies generally report high patient satisfaction and other quality outcomes on par with in-person visits regarding misdiagnoses and treatment failures.[7-11] In addition, researchers have generally found similar or lower rates of follow-up visits comparing VUC and in-person care options such as an office visit or the emergency department (ED).[12-13] The few studies that have examined healthcare spending outcomes associated with VUC find that an initial VUC visit is usually less expensive than an in-person visit.[11] Two published studies have analyzed episode-level costs associated with VUC (including an initial visit and follow-up care); these studies suggest per episode spending is lower for VUC compared to traditional in-person settings.[13-14] However, many remaining gaps in research must still be addressed to understand the impact of VUC on healthcare use and spending.

Prior research in this space have been limited to commercially insured study populations that receive VUC services from independent telemedicine companies (e.g., Teledoc, Doctor on Demand) not associated with a patients' regular source of care. This limitation likely constrains the generalizability of past findings, particularly as different patient populations increasingly gain knowledge and exposure to VUC and different types of health organizations, particularly health systems, begin to offer the virtual service. Our research helps to address this by leveraging a unique dataset that combines claims and virtual encounter data from two self-insured health systems that provide VUC services as a covered benefit to their plan members.

Additionally, the current state of research is largely restricted to aggregated analyses of trends across all clinical diagnoses; with the exception of acute respiratory illnesses[13], little if any diagnosis-specific VUC research exists. The scope of low-acuity diagnoses that can be treated via VUC are wide ranging, including but not limited to colds and sore throats, flu, rashes, and urinary tract infections. New research is needed to understand how differences in spending and service utilization between VUC and in-person services may vary by clinical diagnosis. To help address this, we focus our analysis on two common VUC diagnoses, including urinary tract infection (UTI) and respiratory system diseases (RSD). Combined, UTI and RSD diagnoses account for more than half of reported primary diagnoses for VUC visits[12-13] and are of high relevance to due to the potential for inappropriate antibiotic prescribing practices related to their treatment.[15-17] Inappropriate antibiotic prescribing is a leading cause for concern among clinician and policy makers, as over-prescribing is associated with increased antibiotic resistance, adverse drug reactions, and increased cost of care.[15] There is concern that treatment of low-acuity conditions such as UTI and RSD via VUC may lead to higher rates of follow-up care and associated costs compared to in-person visits due to challenges around making an accurate diagnoses without a physical exam or on-site laboratory testing.[12-13]

Focusing on a study population of self-insured patients receiving services for UTI and RSD diagnoses, the objective of our study is to compare differences in spending and clinical care utilization between episodes or care initiated at a VUC visit versus episodes of care initiated at an in-person visit (including office, urgent care, and ED sites). Our research contributes to the limited VUC outcomes literature by offering diagnosis-specific insights among novel patient populations and organizational settings. The results generated from this work can be used by health organizations at different stages of engagement with VUC to improve clinical practice, resource allocation, and cost-savings, as well as to inform future coverage and technology investment decisions by policy makers.

Methods

Study population and data sources

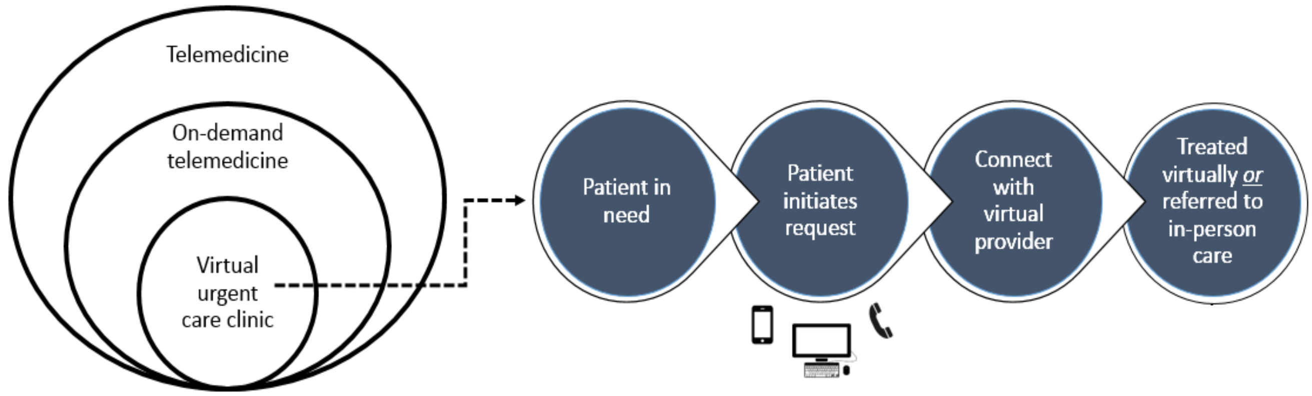
Our study population includes continually enrolled members of two self-insured health systems that offer VUC as a fully-covered plan benefit. We collected data on this population from two large 501-c3 nonprofit health systems operating in the Midwest and a leading third-party telemedicine vendor that contracts with each health system to support their VUC programs. Combined, participating health systems provide VUC as a covered benefit to approximately 50,000 employees and dependents. During the study period, both health systems contracted with the vendor to clinically staff and operate VUC services and provide organization-specific branding (i.e., white labeling) of user interfaces and marketing materials. These specific organizations were targeted for study participation due to a research collaboration between the telemedicine vendor and the University of Washington (UW) through the Center for Health Organization Transformation (CHOT). CHOT is an industry-university cooperative research center funded by the National Science Foundation and health organizations to conduct research supporting major management, clinical, and information technology innovations in healthcare.

Data sources collected from participating organizations included retrospective patient-level information from hospital claims, beneficiary enrollment, and virtual encounter files from June 2015 to July 2018. With these data sources, we are able to describe self-insured enrollees' healthcare utilization and associated costs for first 12-18 months of VUC program implementation as well as 12-months prior to launch. Additionally, we linked county-level population and economic data from the Area Health Resource File (AHRF), a publically available database from the Health Resources and Services Administration (HRSA) that includes data on population demographics and socioeconomic characteristics, among other categories, at the county, state, and national level from over fifty sources.[18]

How VUC visits are provided

The diagram in Figure 1 showcases the workflow for a typical VUC encounter, per description from prior research among participating health systems.[19] A patient will initiate a request for a VUC visit using a web browser, phone, or tablet. After completing an online intake form, they will connect with a virtual provider within 10-15 minutes. Based on chief medical complaint and history, the provider will treat the patient through the virtual visit or, if clinically indicated, triage the patient to a form of in-person care (e.g., office visit, ED, laboratory testing) for immediate consultation or recommended follow-up. A visit summary is sent to a patient following the encounter. Regarding additional patient contact, health organizations report varied post-encounter care processes.

Figure 1. Introduction to virtual urgent care

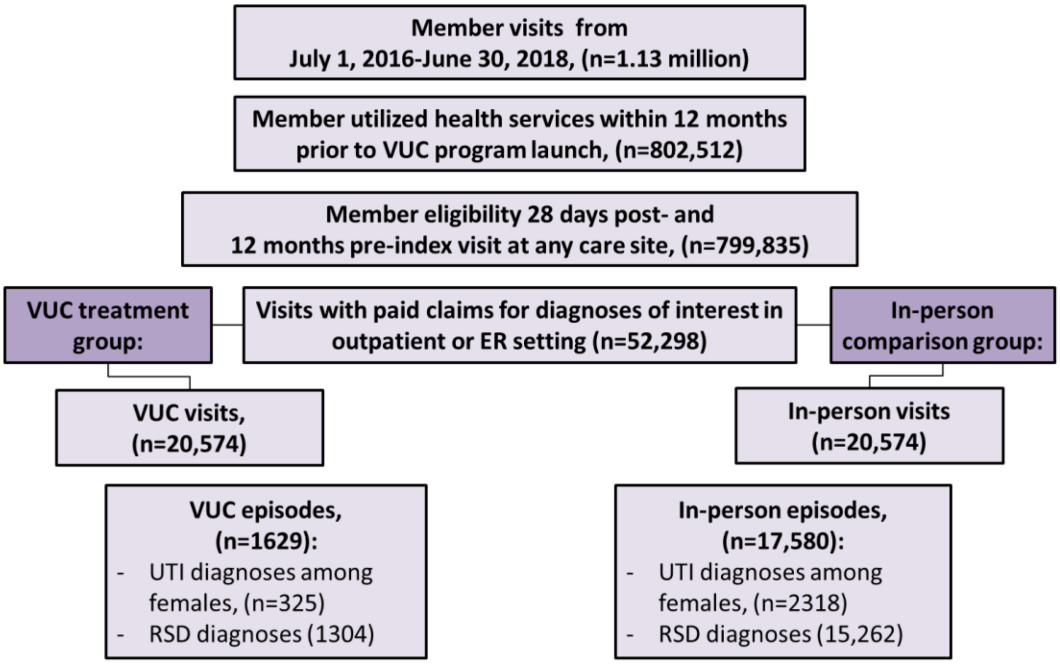


Defining study sample and cohorts

Our study sample, reviewed in Figure 2, was restricted to visit dates for outpatient or ED services in the post-VUC program launch period with primary diagnosis codes listed for UTI and RSD (See Appendix A for ICD-CM-10 codes). We excluded UTI diagnoses among males; compared to females, the infection is rare among men, and when it does develop is more likely to be considered complicated.[15] We further restricted the sample to include visits among plan members who utilized any health services within the 12 months prior to VUC program launch in order to account for trends in service utilization at baseline.

For both diagnoses of interest, cohort groups were composed of episodes of care initiated with an initial visit (index visit) in a VUC versus in-person care setting. In-person index visits included ED, office, and urgent care settings. Episodes of care consisted of an index visit and any outpatient (in-person or VUC) and ED follow-up visits within 28 days with the same primary diagnosis as the index (including laboratory testing, imaging, and pharmacy). We excluded all inpatient hospitalizations and care received at ambulatory surgical centers, as this care was unlikely to be related to low-acuity conditions within the VUC scope of clinical service A conservative 28 day follow-up period was selected to account for appointment scheduling wait times and average treatment periods for UTI and RSD (if a medication is prescribed). If a patient had more than one potential index visit on the same day, the following hierarchy was used to differentiate between an index and follow-up visit: VUC, office, urgent care, ED (VUC visits were always given first priority, and ED visits last priority). We used episode of care as our unit of analysis. Visit dates were only included in the analytic sample if patient data were available for 12 months prior to an index visit and 28 days post-index. The final analytic sample included 19,209 total episodes of care: 1629 VUC episodes (325 for UTI and 1304 for RSD) and 17,580 comparison in-person episodes (2318 for UTI and 15,262 for RSD).

Figure 2. Sample selection and cohort construction



Variables

We considered two outcome variables, including cost per episode of care and a binary measure of any clinical follow-up within an episode of care after the index visit. Outcomes were estimated separately for each diagnosis of interest. For cost, we considered total paid amount per episode (including pharmacy spending). Paid amount (furthermore referred to as cost) included the sum of plan payments plus any member cost-sharing. Our key explanatory variable was a binary measure of whether an episode of care was initiated in a VUC or in-person setting, referred to as the "treatment." Covariates included patient age, gender, rural status, and comorbidity score. Patient gender and rural status were treated as binary measures, with male and urban status as the reference categories. Rural status was based on dichotomized Rural-Urban Commuting Area (RUCA) codes that classify US census tracts using measures of population density, urbanization, and daily commuting.[26] Comorbidity scores were calculated using coding algorithms for Charlson Comorbidities.[27] We selected the Charlson index because it can be derived using diagnosis information in claims data (unlike some other indices) and is commonly used by investigators focusing on healthcare utilization outcomes.[27]

Analytic Approach

For our observational study, we used inverse probability of treatment weighting (IPTW) to address potential biases resulting from baseline differences between cohort groups. IPTW is a common propensity score method that reduces selection bias and leverages the full analytic sample to increase power.[22-23] We first estimated a propensity score by predicting the likelihood of a VUC episode of care conditional on the values of the observable baseline covariates introduced above. We then used weights based on the propensity score to create a synthetic sample such that the distribution of measured covariates is independent of treatment assignment. After applying IPTW, standard differences for almost all covariates were below 10%, suggesting a balanced distribution between our treatment and comparison groups.[24]

We estimated treatment effects for outcomes of interest using generalized linear models (gamma family and log link). Model specification and precision were assessed using standard goodness-of-fit tests.[25] We compared spending and clinical follow-up outcomes for VUC episodes versus in-person episodes. Comparisons considered VUC episodes versus all in-person episode types, as well as separately for in-person episodes originating in office, urgent care, or ED sites. In order to control for correlation in standard errors, the error term was clustered by repeated episode of care observations among the same plan member.

Sensitivity analyses were performed to estimate unadjusted treatment effects in the unweighted sample using ordinary least squares regressions. Due to the range of respiratory system diagnoses included in our RSD category, additional sensitivity analyses were performed in the weighted sample to estimate adjusted treatment effects for RSD sub-categories (our main effects analysis considers all RSD diagnoses combined). RSD sub-categories included: acute respiratory infections (i.e., acute sinusitis), other diseases of the upper respiratory tract (i.e., allergic rhinitis), chronic lower respiratory disease (i.e., asthma), influenza and pneumonia, and other symptoms and signs involving the circulatory and respiratory system (i.e., nasal congestion, cough). (See Appendix A for ICD-CM-10 codes).

Results

Table 1 compares key characteristics of the 1629 VUC and 17,580 comparison in-person episodes before IPTW. The highest proportion of VUC episodes occurred among patients 18-34 years (33%). In contrast, patients <18 years accounted for the highest proportion of in-person episodes originating in an office (24%) or urgent care (33%) site, and patients 50-64 years accounted for the highest proportion of in-person episodes originating in the ED (31%). The majority of patients in all groups were female, resided in urban settings, and had a low disease burden (as indicated by a comorbidity score of zero). A lower proportion of VUC episodes were initiated on weekdays (75%) versus in-person episodes originating in an office site (92.5%) and the ED (83%); similar to VUC episodes, a lower proportion of urgent care index visits were initiated on weekdays (74%). A higher proportion of VUC episodes resulted in a medication fill (43%) compared to in-person episodes originating in an office, (38%), urgent care (23%), or ED (29%) site. In addition, VUC episodes had a lower mean number of follow-up visits per episode (0.39) compared to in-person episodes originating in an office (0.68), urgent care (0.48), or ED (0.40) site.

One of the participating health systems contributed the majority of episodes to the sample (due to an earlier program launch date), including 67.3% of VUC episodes and 60.0% of in-person episodes. The distribution of UTI and RSD diagnoses across the two participating health systems was proportional to the full sample.

Table 1. Baseline characteristics comparing treatment and comparison groups

	VUC treatment group (n=1629)	**In-person comparison group (n=17,580)**		
Characteristics		Office (n=14,699)	Urgent care (n=1783)	ED (n=1098)
Age*, mean (SD)	34.7 (16.6)	**34.7 (20.9)**	**29.3 (19.3)**	**38.5 (20.2)**
Age categories, n (%):				
<18 year	278 (17.1)	**3970 (27.0)**	**580 (32.5)**	**199 (18.1)**
18-34 years	540 (33.1)	**3464 (23.6)**	**536 (30.2)**	**277 (25.2)**
35-49 years	462 (28.4)	**2668 (18.2)**	**316 (17.7)**	**198 (18.0)**
50-64 years	328 (20.2)	**3595 (24.5)**	**270 (15.1)**	**341 (31.1)**
65+ years	21 (1.3)	**1002 (6.8)**	**81 (4.5)**	**83 (7.6)**
Female*, n (%)	912 (56.0)	9828 (66.9)	**1256 (70.4)**	**741 (67.5)**
Rural*, n (%)	297 (18.2)	**2733 (18.6)**	**65 (3.7)**	192 (17.5)
Comorbidity score*, n (%)				
0	1615 (99.1)	**14,509 (98.7)**	1752 (98.3)	1072 (97.6)
1	14 (0.86)	**176 (1.2)**	29 (1.6)	24 (2.2)
2+	0 (0.0)	**14 (0.09)**	2 (0.1)	1 (0.09)
RSD diagnosis, n (%)	1304 (80.1)	**12,689 (86.3)**	**1580 (89.6)**	**993 (90.4)**
Weekday visit, n (%)	1217 (74.7)	**13,597 (92.5)**	1321 (74.1)	**907 (82.6)**
Any medication filled, n (%)	798 (43.1)	**5630 (38.3)**	**412 (23.1)**	**318 (29.0)**
Follow-up visits per episode, mean (SD)	0.39 (0.04)	**0.68 (0.06)**	**0.48 (0.05)**	**0.40 (0.06)**

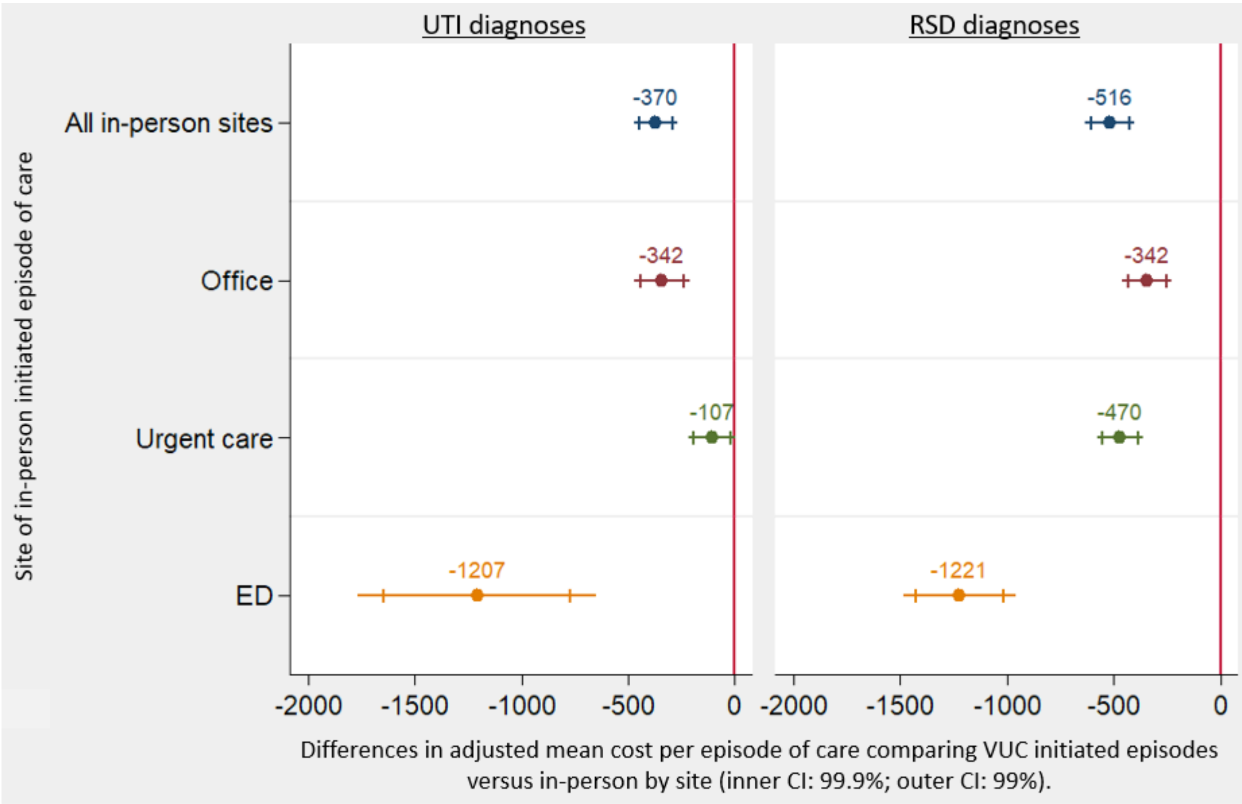
*Differences (p<0.01) between VUC versus in-person episodes. **Included as covariate in propensity score model (standardized differences <10% for most covariates).

Cost per episode of care

Figure 3 reviews our findings regarding costs per episode. For both UTI and RSD diagnoses, adjusted average costs per episode of care were lower for VUC initiated episodes versus in-person. Overall episode costs were lower for UTI compared RSD diagnoses. For UTI, average adjusted per episode spending was $39 for VUC, $380 for office sites, $147 for urgent care, and $1247 for ED. Among UTI diagnoses, adjusted average costs for VUC initiated episodes were $410 lower compared to in-person, inclusive of office, urgent care, and ED sites (95% CI: -$431, -$310; p-value<0.001). Looking at in-person sites individually, VUC initiated episode spending was $342 (95% CI:-$420, -$264; p-value<0.001), $107 (95% CI: -$172, -$42; p-value=0.001), and $1207 (95% CI: -$1537, -$878; p-value<0.001) lower compared to office, urgent care, and ED sites, respectively.

For RSD diagnoses, average adjusted per episode spending was $129 for VUC, $471 for office sites, $599 for urgent care, and for $1350 for ED. Among RSD diagnoses, adjusted average costs for VUC initiated episodes were $516 lower compared to in-person initiated episodes (95% CI: -$585,-$448; p-value<0.001); VUC episode spending was $342 (95% CI: -$412, -$273; p-value<0.001), $470 (95% CI: -$534, -$405; p-value<0.001), and $1221 (95% CI: -$1378 -$1064; p-value<0.001) lower compared to office, urgent care, and ED sites, respectively.

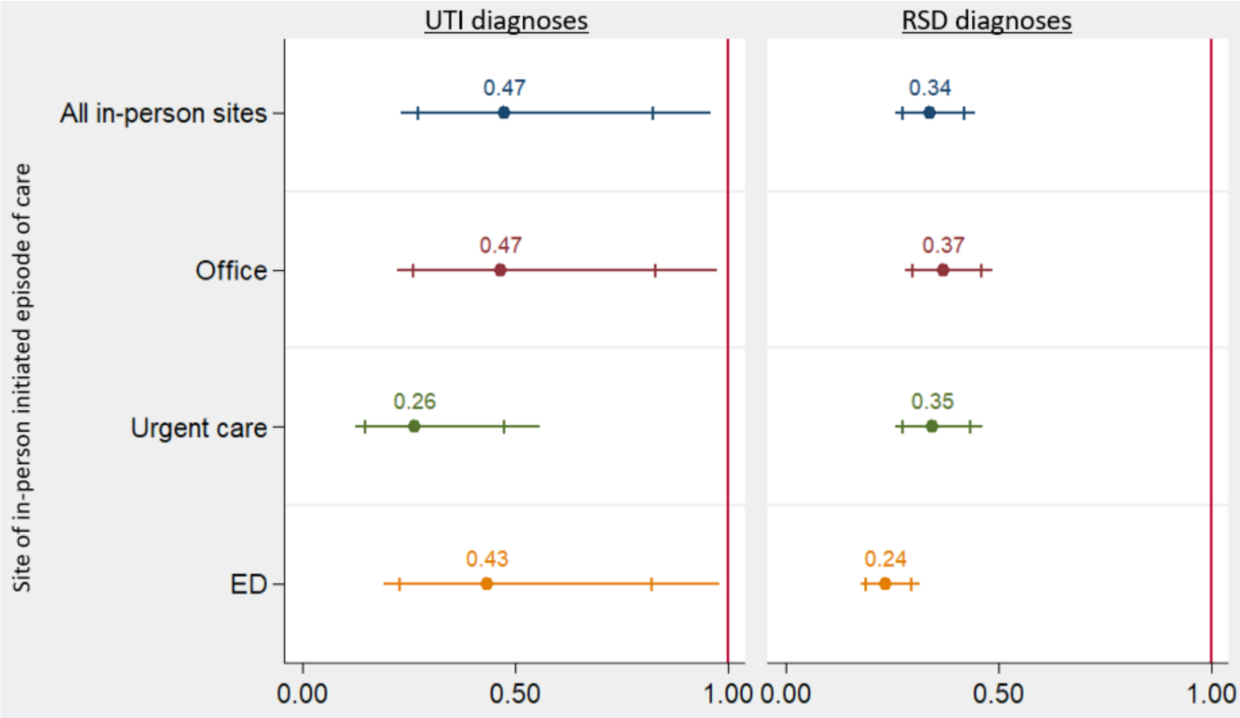
Figure 3. Differences in adjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites.



Clinical follow-up per episode of care

Figure 4 reviews our findings regarding follow-up per episode. For both UTI and RSD diagnoses, VUC initiated episodes were less likely to result in any follow-up after an initial index visit compared to in-person initiated episodes, regardless of care site. For UTI diagnoses, VUC initiated episodes were 53% less likely to result in follow-up compared to any in-person setting (OR=0.47; 95% CI: 0.31, 0.72; p-value=0.001), and 53%, 73%, and 57% less likely for office (OR=0.47; 95% CI: 0.30, 0.72; p-value=0.001), urgent care (OR=0.26; 95% CI: 0.17, 0.41; p-value<0.001), and ED sites (OR=0.43; 95% CI: 0.27, 0.70; p-value=0.001). For RSD diagnoses, VUC initiated episodes were 66% less likely to result in follow-up compared to any in-person setting (OR=0.34; 95% CI: 0.29, 0.39; p-value<0.001), and 63%, 65%, and 76% less likely for office (OR=0.37; 95% CI: 0.32, 0.44; p-value<0.001), urgent care (OR=0.35; 95% CI: 0.29, 0.41; p-value<0.001), and ED sites (OR=0.24; 95% CI: 0.20, 0.28; p-value<0.001).

Figure 4. Adjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites.



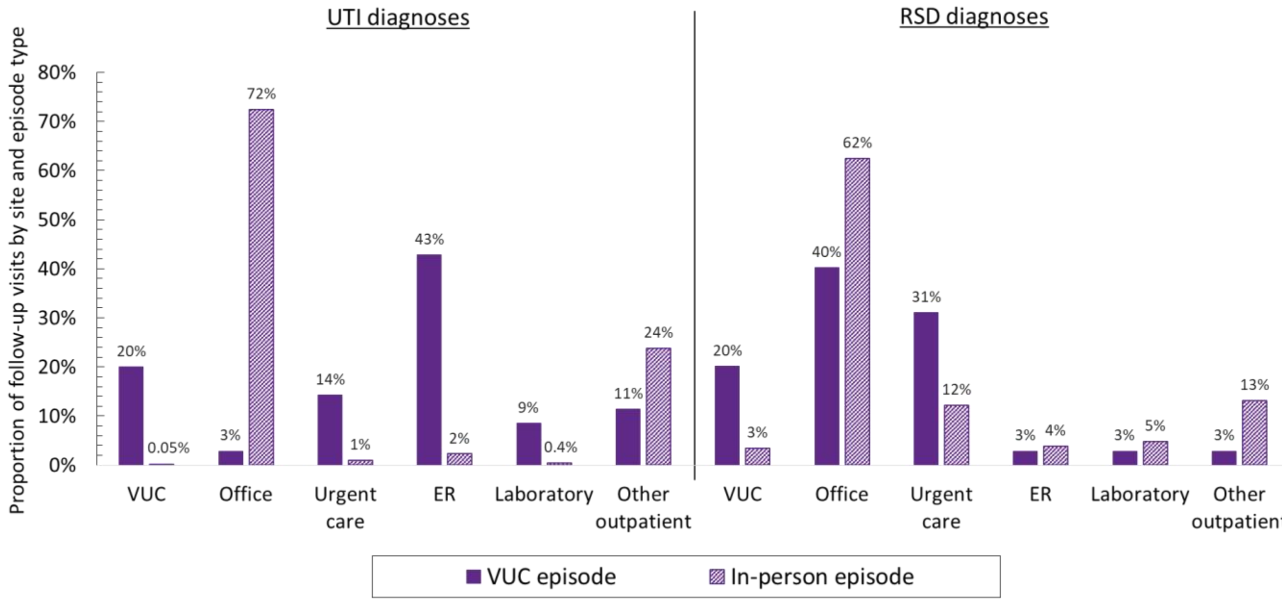
Adjusted odds ratios predicting differences in any clinical follow-up comparing VUC initiated episodes of care versus in-person by site (inner CI: 99.9%; outer CI: 99%).

Site of clinical follow-up visits

For episodes that included follow-up visits, we found that healthcare sites where patients sought follow-up varied widely by diagnosis of interest and episode type. (See Figure 5). VUC as a site of follow-care was more often seen for VUC initiated episodes (20% for UTI and RSD) versus in-person. For in-person initiated episodes, follow-up visits occurred most frequently in an office setting (72% for UTI and 62% for RSD). For UTI diagnoses, the majority of follow-up visits for VUC initiated episodes occurred in the ER (43%), followed by VUC visits (20%), urgent care visits (14%), other outpatient service visits (11%), laboratory testing (9%), and office visits (3%). In the case of UTI diagnoses for in-person initiated episodes, the majority of follow-up visits occurred in an office setting (72%), followed by other outpatient service sites (24%), the ER (2%), urgent care (1%), and laboratory testing and VUC settings (<1%).

For RSD diagnoses, the majority of follow-up visits for VUC initiated episodes occurred in the office (40%), followed by urgent care visits (31%), VUC visits (20%), and the ER, laboratory testing, and other outpatient services (3%). In the case of RSD diagnoses for in-person initiated episodes, the majority of follow-up visits occurred in an office setting (62%), followed by other outpatient service sites (13%), urgent care visits (12%), laboratory testing (5%), the ED (4%) and VUC settings (3%).

Figure 5. Proportion of follow-up visits per episode of care by site and episode type.



Sensitivity analyses

In our unadjusted and unweighted analysis, average costs per episode of care were lower for VUC initiated episodes versus in-person for RSD diagnoses (-$520; 95% CI: -$644, -$398; p-value<0.001) and UTI diagnoses (-$369; 95% CI: -$725, $13; p-value=0.042). For both UTI and RSD diagnoses, VUC initiated episodes were less likely to result in any follow-up after an initial index visit compared to in-person episodes: VUC episodes were 84% less likely to result in follow-up among UTI diagnoses (OR=0.17; 95% CI: 0.12, 0.24; p-value<0.001) and 68% less likely to result in follow-up among RSD diagnoses (OR=0.32; 95% CI: 0.27, 0.38; p-value<0.001).

Our sensitivity analysis estimating treatment effects for five sub-categories of RSD diagnoses showed consistent relative cost differences and odds ratios between VUC initiated and in-person episodes of care as our main RSD analysis, except for non-significant odds of follow-up for chronic lower respiratory disease, influenza and pneumonia, and other symptoms and signs involving the circulatory and respiratory system. Our analysis of acute respiratory infection alone, the largest RSD sub-category, revealed more extreme differences between VUC and in-person services and suggests our main effects analysis may be conservative. For acute upper respiratory infection alone, VUC initiated episodes were -$631 lower compared to all in-person episodes (95% CI: -$724, -$538; p-value<0.001) and were 83% less likely to result in follow-up (OR=0.17; 95% CI: 0.11, 0.24; p-value<0.001). The acute upper respiratory infection sub-category accounted for 52% of all RSD diagnoses.

For other diseases of the upper respiratory tract alone, VUC initiated episodes were -$526 lower compared to all in-person episodes (95% CI: -$668, -$384; p-value<0.001) and were 84% less likely to result in follow-up (OR=0.17; 95% CI: 0.11, 0.24; p-value<0.001). For chronic lower respiratory disease alone, VUC initiated episodes were -$989 lower compared to all in-person episodes (95% CI: -$1347 -$631; p-value<0.001); there were no significant differences in odds of follow-up between VUC initiated and in-person episodes. For influenza and pneumonia alone, VUC initiated episodes were -$610 lower compared to all in-person episodes (95% CI: -$846, -$376; p-value<0.001); there were no significant differences in odds of follow-up between VUC initiated and in-person episodes. For other symptoms and signs involving the circulatory and respiratory system, VUC initiated episodes were -$299 lower compared to all in-person episodes (95% CI: -\$325, -\$103; p-value<0.001); there were no significant differences in odds of follow-up between VUC initiated and in-person episodes. (See Appendix B for additional sensitivity analysis details).

Discussion

Our cross-sectional, retrospective analysis of downstream spending and clinical service utilization demonstrates that VUC initiated episodes of care were less expensive for health systems and patents compared to in-person initiated episodes for two common low-acuity conditions. We observed lower per episode spending comparing VUC to all in-person sites as well as individually compared to office, urgent care, and ED in-person settings. This trend was likely driven by the fact that VUC index visits were less expensive than in-person index visits, and VUC initiated episodes experienced fewer follow-up visits per episode. Our cost related findings align with the limited body of existing literature that similarly indicates lower costs for VUC initiated episodes compared to in-person.[13-14] Further, our diagnosis-specific work builds from past research that has primarily focused on aggregate diagnoses; our findings suggest that the lower cost trend for VUC initiated episodes also holds for UTI and RSD diagnoses individually, the two most common diagnoses categories for VUC services.

Our analysis also demonstrates that VUC initiated episodes are less likely to result in any follow-up visits compared to in-person initiated episodes. Lower rates of follow-up were observed for both UTI and RSD diagnoses as well as all originating sites of in-person care. In contrast to these findings, the limited number of prior VUC studies that investigated this outcome (and use a similar definition for episode of care) reported little or less extreme difference in rate of follow-up comparing VUC and in-person care at the episode-level.[12-13] Additional research will be needed to better determine to what extent this difference is related to the diagnosis-specific nature of our work. More complicated medical diagnoses with less clear clinical guidelines, such as management of chronic conditions, may experience different rates of clinical follow-up after an initial VUC visit. It is also unclear from our current analysis whether lack of follow-up is a good or bad outcome for patient care. Future research should examine the true extent of clinical resolution related to VUC initiated episodes of care. Our study does not piece apart whether lack of follow-up care is an indication of high rates of clinical resolution after an initial VUC visit, and thus fewer potentially duplicative follow-up visits to in-person settings, or in contrast, an indication unmet medical need among VUC patients. This is an important future area of study, but will require a detailed analysis of follow-up trends among VUC users.

Our findings regarding low rates of clinical follow-up associated with VUC services may also be attributed to the organizational context of our study. We examine this outcome in the context of self-insured health systems that offer VUC services as a covered benefit to their plan members. In contrast, other VUC studies have targeted study populations with access to virtual visits only via independent online telemedicine companies with little if any connection to a patient's primary source of care, which is often a health system. Prior research regarding other forms of telemedicine have linked patient adoption and use of virtual services with the presence of enduring ties to and trust in the provider organization.[26] Thus, there is a foundation of evidence to suggest that patient care seeking behavior, including follow-up after an initial VUC visit, may be different depending on the relationship between the patient and the provider organization. In the case of self-insured health systems such as those included in our study, a patient may have an established relationship with the organization and use it as a regular source of care for other health services, potentially suggesting a stronger patient-organization link compared to other types of health organizations that offer VUC services (including independent online telemedicine companies). Additional research is needed to better understand differences in key outcomes associated the type of health organizations offering VUC programs. Future findings in this area may have significant implications as organizations make the decision to launch VUC programs and develop market strategies to build trust between potential patient users and the provider organization that offers the service.

Limitations

While our study focuses on data collected from only two health systems using one VUC product, we constructed a relatively robust analytic sample in terms of size and low-acuity conditions and have no particular reason to believe VUC services would have been performed differently by other health systems. Second, we are unable to conclusively determine whether follow-up visits and associate costs are related to an index visit and part of the same episode of care. However, much of this challenge relates to inherent limitations of claims information that may not provide a full record of care. Third, we assessed clinical service utilization and spending among a study population of self-insured patients with access to VUC as a covered insurance plan benefit. It is possible that patterns of service use and associated spending may be different among patients with high deductible plans, high co-payments, or no insurance. Yet, adoption of VUC is growing rapidly among self-insured health systems, making this a patient population well-deserving of study in its own right. Fourth, our analysis focused only on UTI and RSD diagnoses. However, the relatively low uptake of VUC services among patients makes it challenging to conduct diagnosis-specific analyses beyond these two leading categories due to small sample sizes. Our sensitivity analysis of five RSD sub-categories helps to provide a slightly more granular look at diagnosis-specific trends.

Conclusion

Current trends suggest health systems will increasingly use VUC and other telemedicine offerings as a means to meet patient demand for convenient, accessible, and affordable services and address other leading healthcare challenges. Here we have demonstrated that, compared to leading alterative in-person sites, VUC can provide lower cost services without the need for potentially duplicative follow-up care for both UTI and RSD diagnoses. For the research community, our study expands the limited pool of knowledge regarding effects on downstream spending and utilization of clinical care associated with VUC use to a specific set of low-acuity diagnoses and new patient populations and organizational settings. For health organizations in various stages of engagement with VUC programs, our findings help to inform decision making around scope of clinical practice, resource allocation, and cost-saving opportunities. Specifically for self-insured health systems, our research suggests these organizations may already have a leg up in developing a strong patient-organization relationship to potentially facilitate more favorable healthcare spending and utilization outcomes. For policy makers, the results generated from this study offer valuable insights to inform future coverage decisions and investment into healthcare technologies. To build on our work, we encourage future VUC studies to focus on a wider range of clinical diagnoses (both low-acuity and chronic) and health organizations to better understand spending and utilization patterns associated with VUC and other emerging telemedicine services.

Chapter 4: Journal Article 3

Journal: Journal of Telemedicine & e-Health

Status: To be submitted in September 2019

Title: Evaluating trends in follow-up care utilization and spending among users of virtual urgent care

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Abstract

Background: To address rising consumer demand for convenience and competition for patients, many US health organizations are launching convenient care options, including Virtual Urgent Care (VUC).

Introduction: There is concern VUC will lead to care fragmentation when follow-up services are needed after an initial virtual visit. To better understand patterns in follow-up care among VUC users, our study objective was to determine if there are major differences in user demographics, virtual visit characteristics, and healthcare spending depending on whether follow-up occurs.

Materials and Methods: We collected hospital claims, beneficiary enrollment files, and virtual encounter files for FY2015-2018 from two health systems that offer VUC as a covered benefit to self-insured plan members. Dividing our sample into two VUC episode types depending on whether follow-up care was recommended at an initial virtual visit, we conducted a cross-sectional, retrospective cohort analysis to describe VUC user and visit characteristics, identify predictors of follow-up, and estimate per person spending, comparing episode cohorts that result in follow-up or not.

Results: Among 3453 total VUC episodes, 1360 received a recommendation for follow-up and 2093 did not. When recommended, follow-up occurred among approximately 15% of episodes. Predictors of follow-up included: patient age, rural residence status, length and virtual modality of virtual visit, and prescriptions for antibiotics and other medications. For follow-up recommended episodes, follow-up was associated with $186 lower adjusted mean spending per person.

Conclusion: Low adherence to recommended follow-up may indicate inefficiencies in current VUC follow-up care processes; however, if used when recommended, follow-up can reduce per person spending among VUC users.

Introduction

More than one billion medical visits are made in ambulatory care settings each year, accounting for one-third of total healthcare spending in the United States.[1-2] While the majority of these visits occur in physician offices and emergency departments (EDs), patients are increasingly seeking care in non-traditional sites such as retail clinics and urgent care centers, and most recently, virtual urgent care (VUC) clinics. These non-traditional care options encompass a range of consumer-oriented "convenient care" innovations that are available on-demand, easily accessible, and more affordable compared to conventional services.[3-4] Many policy makers and health organizations tout the convenience and low-cost of these new care options[5-6]; others raise concerns about their potential to increase fragmentation of care.[7-8] Prior research has justified some of these concerns in the retail clinic and urgent care center context. Particularly, these studies cite failures to connect patients with follow-up services after an initial visit, indicating lack of continuity with other existing health system structures.[9-10] Because VUC is a relatively new convenient care option, its impact on fragmentation remains unclear.

VUC (sometimes also referred to as direct-to-consumer telemedicine) is an emerging form of telemedicine that provides patient-initiated, on-demand virtual visits for low-acuity conditions that are accessible around-the-clock in real-time from any location.[11] Promising even greater convenience and accessibility compared to first wave convenient care options, VUC programs are experiencing rapid rates of adoption by health organizations and increasing use by patients. Several studies have demonstrated the quality of telemedicine for low-acuity conditions that fall within the scope of VUC services; these studies generally report high patient satisfaction and other quality outcomes on par with traditional in-person visits regarding misdiagnoses and treatment failures.[12-15] Often used as a proxy measure of adequate clinical resolution, researchers have also generally found similar or lower rates of follow-up visits comparing VUC and in-person care options such as physician office visits or ED.[16-17] Regarding continuity with other existing healthcare structures, our research indicates most VUC programs have implemented care processes to connect patients with follow-up after an initial virtual visit (if deemed clinical necessary).[18] However, the efficacy of these care processes has not yet been studied; we begin to address this gap by studying patterns of follow-up utilization among VUC users.

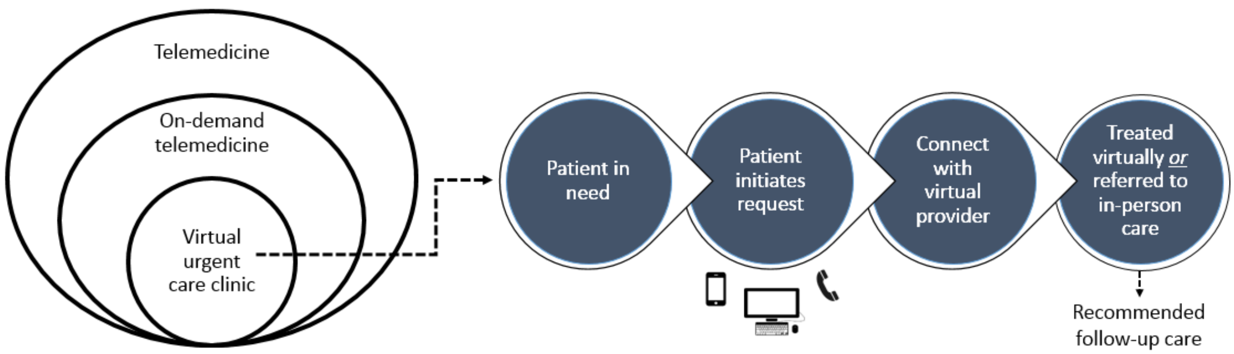
Our objective for this paper was to determine if there are major differences in users, initial virtual visit characteristics, and healthcare spending depending on whether follow-up occurs among VUC users. To carry out our research, we describe the experiences of two Midwest self-insured health systems that provide VUC services as a covered benefit to their plan members. We focus on patients that complete a VUC visit and then track their service utilization and associated costs for a related condition over the course of a 28-day episode of care. Informed by prior literature, we anticipate that follow-up will be more likely to occur among children, patients with more comorbidities, patients with a history of high service utilization and healthcare spending, and patients with more urgent diagnoses[19-21]; we also anticipate to see higher healthcare spending when follow-up occurs, due to higher overall service utilization.[22-23] The results generated from this work can be used by health organizations that provide VUC services to identify opportunities for process improvements, target specific patient groups that may need special attention to connect them with other health services, and quantify cost effects associated with follow-up.

Methods

How VUC visits are provided

The diagram in Figure 1 showcases the workflow for a typical VUC visit encounter, per description from prior research among participating health systems.[18] A patient will initiate a request for a VUC visit using a web browser, phone, or tablet. A patient may learn about the availability of VUC services via a range of sources, including internet searches, emails or direct mailings from the sponsoring health organization, or radio advertisements, among others. After completing an online intake form, the patient will connect with a virtual provider within 10-15 minutes. Based on chief medical complaint and history, the provider will treat the patient through the virtual visit or, if clinically indicated, triage the patient to a form of in-person care (e.g., office visit, ED, laboratory testing) for future consultation and recommended follow-up. For the VUC product used by health systems participating in our study, at the conclusion of the visit the provider will enter an "outcome assessment" into the VUC patient record, with options including: no future follow-up needed; future follow-up needed; referred (escalated) to urgent care; referred (escalated to primary care); referred (escalated) to ED; visit cancelled; patient terminated encounter; or unable to connect. Typically, a visit summary is sent to a patient following the encounter. Regarding additional patient contact, organizations reported varied follow-up care processes.

Figure 1. VUC visit encounter process



Study population and data sources

Our study population includes continually enrolled members (adults and children) of two self-insured health systems that offer VUC as a fully-covered plan benefit. We collected data on this population from two large 501-c3 nonprofit health systems operating in the Midwest and a leading third-party telemedicine vendor that contracts with each health system to support their VUC programs. Combined, participating health systems provide VUC as a covered benefit to approximately 50,000 employees and dependents. During the study period, both health systems contracted with the vendor to clinically staff and operate VUC services and provide organization-specific branding (i.e., white labeling) of user interfaces and marketing materials. These specific organizations were targeted for study participation due to a research collaboration between the telemedicine vendor and the University of Washington (UW) through the Center for Health Organization Transformation (CHOT). CHOT is an industry-university cooperative research center funded by the National Science Foundation and health organizations to conduct research supporting major management, clinical, and information technology innovations in healthcare.[24]

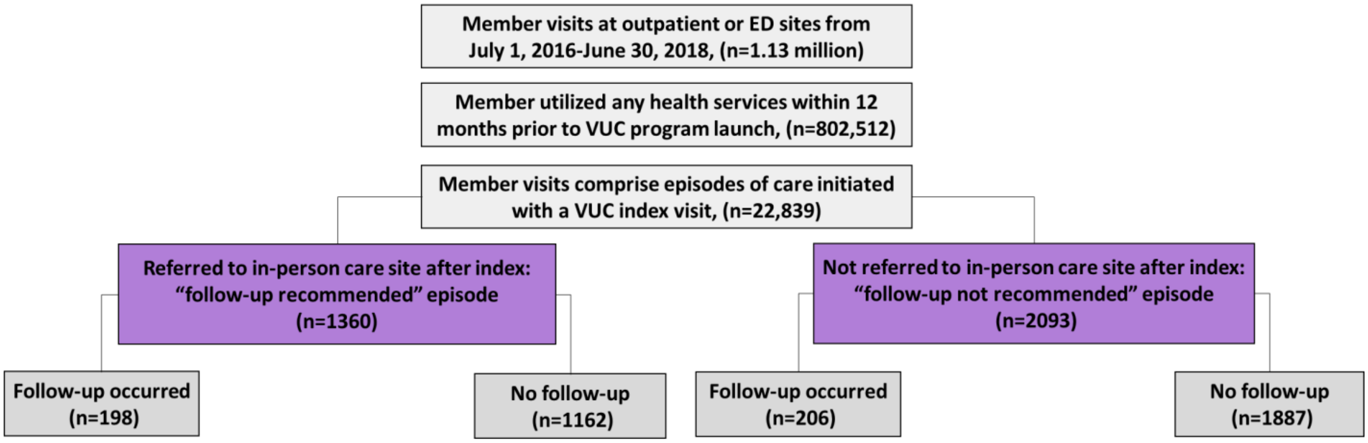
Data sources collected from participating organizations included retrospective patient-level information from medical and pharmacy claims, beneficiary enrollment, and virtual encounter files from June 2015 to July 2018. With these data sources, we are able to describe self-insured enrollees' healthcare utilization and associated costs for first 12-18 months of VUC program implementation as well as 12-months prior to launch. This data also includes robust VUC encounter visit information detailing when and how a patient engaged with the VUC service and whether their clinical symptoms were managed via the virtual encounter or referred to in-person services for follow-up care. Additionally, we linked county-level population data from the Area Health Resource File (AHRF), a publicly available database from the Health Resources and Services Administration (HRSA) that includes data on population demographics and socioeconomic characteristics, among other categories, at the county, state, and national level from over fifty sources.[25]

Defining study sample and cohorts

Our study sample, reviewed in Figure 2, was restricted to visit dates for outpatient (including physician office visits) or ED services in the post-VUC program launch period among self-insured plan members for all diagnoses, per the International Classification of Diseases Version 10 (ICD-CM-10). We included only visit dates for those patients who utilized any health services within the 12 months prior to VUC program launch (in order to account for trends in service utilization at baseline) and 28 days after an initial visit (in order to account for a complete episode of care). Episodes of care consisted of a VUC index visit (initial visit) and any outpatient (in-person or VUC) and ED follow-up visits within 28 days with the same primary diagnosis as the index (including laboratory testing, imaging, and pharmacy). We further restricted the study sample to visit dates that comprise episodes of care initiated with a VUC index visit. We excluded all inpatient hospitalizations and care received at ambulatory surgical centers, as this care was unlikely to be related to low-acuity conditions within the VUC scope of clinical service. A 28 day follow-up period was selected to account for appointment scheduling wait times and average treatment periods for common low-acuity conditions (if a medication is prescribed). If a patient had more than one potential index visit on the same day at different care sites, the following hierarchy was used to identify the index visit: VUC, office, urgent care, ED (VUC visits were always given first priority because we assumed patients were more likely to begin an episode of care with a virtual visit versus in-person).

We divided this sample into two VUC episode types: (1) follow-up recommended – patients were referred to an in-person care site to manage presenting condition after a VUC index visit; and (2) follow-up not recommended – patients did not receive any kind of recommendation for follow-up care after index visit. For each episode type, we further divided episodes into cohort groups: (1) episodes that had one or more follow-up visits related to the same diagnosis as the index; and (2) episodes that did not have any follow-up visits. The final analytic sample included 3453 total VUC episodes: 1360 follow-up recommended episodes (198 where follow-up occurred; 1162 where follow-up did not occur) and 2093 follow-up not recommended episodes (206 where follow-up occurred; 1887 where follow-up did not occur).

Figure 2. Sample selection and cohort construction



Variables

We considered two outcome variables: (1) a binary measure of any clinical follow-up within an episode of care after the index visit and (2) cost per VUC patient user. For cost, we used the total paid amount included in the claims data (including pharmacy spending). Paid amount (heretofore referred to as cost) included the sum of plan payments plus any member cost-sharing. Costs per user were defined as total episode costs during the study period.

To predict the probability of any follow-up, we considered a range of VUC user and index visit covariates (per prior literature).[19-23] VUC user covariates included age, gender, rural status, health care utilization and cost in the prior year, and comorbidity score. VUC index visit covariates included visit length, visit day of week, visit time of day, primary care status, request for primary care referral, medication prescribed, antibiotic prescribed, visit delivery type, and primary diagnosis category. Patient age was treated as a continuous variable. Patient gender and rural status were treated as binary measures. Rural status was based on dichotomized Rural-Urban Commuting Area (RUCA) codes that classify US census tracts using measures of population density, urbanization, and daily commuting.[26] Comorbidity scores were calculated using coding algorithms for Charlson Comorbidities[27]; we selected the Charlson index because it can be derived using diagnosis information in claims data (unlike some other indices) and is commonly used by investigators focusing on healthcare utilization outcomes.[28] Quartile categories, ranging from lowest to highest value, were generated to capture health care utilization and cost in the prior year. Visit length was treated as a continuous variable (in minutes). Visit day of week, visit time of day, primary care status, request for primary care referral, medication prescribed, and antibiotic prescribed were treated as binary variables. Visit delivery type was treated as a categorical variable, including phone, FaceTime, and other video. Primary diagnoses was treated as indicator variables, including acute upper respiratory infections (URI), disorders of the skin (skin), symptoms involving the circulatory and respiratory system (circulatory/respiratory), disorders of the ear (ear), digestive symptoms (digestive), disorders of the urinary system (urinary), and all other diagnoses. We considered only the first diagnosis listed. For the cost analysis, our key explanatory variable was a binary measure of whether or not follow-up occurred after an initial VUC visit (treated as an outcome variable above). Cost analysis covariates included the VUC user and index visit variables that were found to predict any follow-up.

Analytic Approach

All analyses are presented separately for each episode type (i.e., follow-up recommended; follow-up not recommended). To describe VUC user and index visit characteristics, we calculated means and proportions, comparing follow-up cohort groups (as appropriate). We used multivariate logistic regression to identify variables that significantly predict the likelihood of follow-up. We employed two approaches to model cost per person. We first estimated treatment effects using ordinary least squares regression. In order to control for selection bias, we also estimated cost per person using a two-stage residual inclusion (2SRI) estimation approach.[29] In stage-one, we modeled the likelihood of any follow-up using a logit model (including variables found to predict follow-up as covariates). In stage-two, we estimated treatment effects for cost using a generalized linear model (gamma distribution and log link) that included variables found to predict follow-up as well as first-stage residuals as covariates. Model specification and precision were assessed using standard goodness-of-fit tests.[19] We compared the sum of total costs per person for VUC episodes in which follow-up occurred versus episodes in which follow-up did not occur. In order to control for correlation in standard errors, the error term was clustered by repeated observations among the same plan member. We report average treatment effects using recycled predictions (standard errors estimated using the delta method).

Due to the range of primary diagnoses included in our main analysis, sensitivity analyses were performed to identify variables that predict the likelihood of follow-up and to estimate adjusted treatment effects for cost per person for individual leading diagnoses, including URI, skin, circulatory/respiratory, ear, urinary, digestive, and all other diagnoses. (See Appendix A for ICD-CM-10 codes.) Our main analysis does not include 21 VUC episodes that resulted in follow-up care at VUC (versus in-person) sites; as an additional sensitivity analysis, we modeled study outcomes including these additional episodes in our sample.

Results

VUC user characteristics

Table 1 reviews key user characteristics for our two VUC episode types of interest, including: 1360 follow-up recommended episodes, and 2093 follow-up not recommended episodes. Among follow-up recommended episodes, 198 (14.6%) resulted in follow-up. For this episode type, the highest proportion of episodes that resulted in follow-up occurred among children (35.9%). By comparison, episodes that did not result in follow-up tended to occur among older patients and the highest proportion of follow-up tended to occur among patients 18-34 years (29.9%). The majority of patients in both follow-up cohorts were female, resided in urban areas, and had a low disease burden (as indicated by a comorbidity score of zero).

Among follow-up not recommended episodes, 206 (9.8%) resulted in follow-up. For this episode type, episodes that resulted in follow-up again tended to occur among younger patients, with the highest proportion occurring among children (38.3%). For episodes not resulting in follow-up, the mean age was 32.3 years and the highest proportion occurred among patients 18-34 years (32.5%). A higher proportion of females had follow-up visits (52.9%) versus no follow-up (32.2%). The majority of patients in both cohort groups resided in urban areas and had a low disease burden.

One of the participating health systems contributed the majority of VUC episodes to the sample (likely due to an earlier program launch date), including 57.2% of follow-up recommended episodes and 53.2% of follow-up not recommended episodes. The distribution of follow-up visits between the two participating health systems was proportional to the full sample.

Table 1. Baseline VUC user characteristics

	Follow-up recommended (n=1360)		**Follow-up not recommended (n=2093)**	
	Follow-up occurred (n=198)	No follow-up (n=1162)	Follow-up occurred (n=206)	No follow-up (n=1887)
User characteristics				
Age, mean (SD)	**26.8 (17.3)**	**31.7 (17.0)**	**27.2 (18.2)**	**32.3 (17.1)**
Age categories, n (%):				
<18 year	**71 (35.9)**	**288 (24.8)**	**79 (38.3)**	**438 (23.1)**
18-34 years	**54 (27.3)**	**347 (29.9)**	**53 (25.7)**	**614 (32.5)**
35-49 years	**52 (26.3)**	**330 (28.4)**	**49 (23.4)**	**485 (25.7)**
50-64 years	**19 (9.6)**	**187 (16.1)**	**25 (12.1)**	**327 (17.3)**
65+ years	**2 (1.0)**	**10 (0.9)**	**0 (0.0)**	**23 (1.2)**
Female, n (%)	120 (60.6)	777 (66.9)	**109 (52.9)**	**608 (32.2)**
Rural, n (%)	**12 (6.3)**	**31 (2.7)**	**18 (8.7)**	**74 (3.9)**
Top quartile utilization in prior year*, n (%)	21 (10.7)	103 (8.8)	53 (7.4)	123 (6.5)
Top quartile spending in prior year*, n (%)	49 (24.8)	303 (26.1)	55 (26.5)	504 (26.7)
Comorbidity score, n (%)				
0	194 (98.1)	1150 (99.0)	204 (99.2)	1180 (99.4)
1	4 (0.09)	12 (1.0)	2 (0.08)	7 (0.06)
2+	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Bold indicates differences (p<0.01) between groups. Top quartile utilization and spending in prior year generated based on entire sample.

VUC episode characteristics

Table 2 reviews key VUC episode characteristics, including VUC index visit and resulting follow-up visit characteristics by episode type and follow-up cohort. Among follow-up recommended episodes, the majority of index visits occurred during weekdays for both cohorts, with an average visit length of 15.3 minutes. Rates of any prescribed medications (12.4-13.1%) or antibiotics (5.8-5.9%) were similar between cohorts. Trends in follow-up care assessment were also similar, with approximately 75% of episodes in both cohort groups receiving a referral to an in-person care site. Episodes that resulted in follow-up versus not had a higher proportion of index visits that occurred outside of business hours (66.1% versus 59.0%) and took place via some form of video (62.5% versus 41.6%); and a lower proportion of index visits among patients that identified having an established primary care provider (24.8% versus 29.3%) or requested a referral to primary care (4.6% versus 8.4%). Regarding follow-up visits, the majority occurred in a physician office setting (60.1%), with an average of 1.9 follow-up visits per VUC episode.

Among the follow-up not recommended group, episodes that resulted in follow-up versus not had a higher proportion of index visits that occurred outside of business hours (62.2% versus 55.5%) and took place via some form of video (97.4% versus 46.8%); very few episodes that resulted in follow-up occurred by phone (2.6%). Episodes with follow-up also comparatively had a lower mean visit length

(13.9 versus 19.8 minutes) and a lower proportion received a prescription for any medication (46.8% versus 62.5%) or antibiotic (25.6% versus 30.5%). The majority of follow-up visits in the follow-up not recommended group occurred in a physician office setting (58.3%), with an average of 2.5 follow-up visits per episode.

Across our entire sample, ten primary diagnosis categories comprised more than 85% of all VUC episode types, including acute upper respiratory infections, disorders of the skin, symptoms involving the circulatory and respiratory systems, disorders of the ear, disorders of the urinary system, digestive symptoms, general symptoms and signs, influenza and pneumonia, and dorsopathies. Table 2 reviews the top six leading diagnoses by episode type and follow-up cohort. Cohort trends by primary diagnosis were quite similar among the follow-up recommended group. In the follow-up not recommended group, a higher proportion of skin disorder episodes resulted in follow-up.

Table 2. VUC episode characteristics

	Follow-up recommended (n=1360)		Follow-up not recommended (n=2093)	
	Follow-up occurred (n=198)	No follow-up (n=1162)	Follow-up occurred (n=206)	No follow-up (n=1887)
VUC index visit characteristics				
Visit on weekend, n (%)	**57 (28.8)**	**345 (29.7)**	**53 (25.6)**	**509 (27.0)**
Visit outside of normal business hours, n (%)	**131 (66.1)**	**686 (59.0)**	**128 (62.2)**	**1047 55.5)**
Visit length (minutes), mean (SD)	15.3 (16.0)	15.3 (22.6)	13.9 (10.6)	19.8 (41.7)
Visit modality, n (%):				
Phone	**74 (37.5)**	**657 (56.5)**	**5 (2.6)**	**964 (51.1)**
FaceTime	21 (10.7)	105 (17.6)	52 (25.0)	385 (20.4)
Other video	**103 (51.8)**	**179 (24.0)**	149 (72.4)	498 (26.4)
Skype	0 (0.0)	22 (1.9)	0 (0.0)	42 (2.2)
Primary diagnosis, n (%):				
URI diagnoses	47 (23.9)	300 (25.8)	92 (44.7)	787 (41.7)
Skin diagnoses	33 (16.9)	248 (14.9)	**36 (17.3)**	**219 (11.6)**
Circulatory/respiratory diagnoses	28 (14.1)	188 (16.2)	18 (8.6)	108 (5.7)
Ear diagnoses	23 (11.4)	87 (7.5)	**3 (1.5)**	**62 (3.3)**
Urinary diagnoses	16 (8.2)	143 (12.3)	**17 (8.1)**	**289 (15.3)**
Digestive diagnoses	16 (8.2)	69 (5.9)	7 (3.6)	85 (4.5)
All other diagnoses	34 (17.3)	202 (17.4)	33 (16.2)	338 (17.9)
Any medication prescribed, n (%)	25 (12.4)	152 (13.1)	**96 (46.8)**	**1179 (62.5)**
Any antibiotics prescribed, n (%)	12 (5.9)	67 (5.8)	**46 (22.4)**	**625 (33.1)**
Established primary care provider identified by user, n (%)	49 (24.8)	340 (29.3)	53 (25.6)	576 (30.5)
Primary care referral requested, n (%)	9.1 (4.6)	98 (8.4)	7 (3.2)	113 (6.0)
Follow-up care assessment, n (%):				
No future follow-up needed	--	--	206 (100.0)	1887 (100.0)
Future follow-up needed (no referral site specified)	55 (27.8)	206 (26.3)	--	--
Referred to urgent care center	89 (45.0)	527 (45.4)	--	--
Referred to primary care office	39 (19.7)	243 (20.9)	--	--
Referred to ED	15 (7.6)	87 (7.5)	--	--
Follow-up care characteristics:				
Site of follow-up care*, n (%):				
Office visit	119 (60.1)	--	120 (58.3)	--
Urgent care center	11 (5.7)	--	10 (4.7)	--
ED	10 (5.0)	--	7 (3.6)	--
Laboratory	27 (13.7)	--	50 (19.9)	--
Other outpatient site	19 (14.7)	--	27 (13.2)	--
Follow-up visits per episode, mean (SD)	1.9 (0.8)	--	2.5 (2.1)	--

Bold indicates differences ($p<0.01$) between groups. *If an episode included more than one follow-up care visit, we reported the site with the visit date closest to the index visit.

Predictors of follow-up among VUC episodes

Both VUC user and index visit characteristics emerged as significant predictors of any clinical follow-up care. (See Table 3). Among follow-up recommended episodes, the odds of follow-up were significantly lower with increasing patient age (OR=0.98) and higher among episodes with patients residing in rural areas (OR=1.67). Compared to index visits that were delivered by phone, the odds of follow-up were more than three times higher for index visits delivered by video (OR=3.43). Among follow-up not recommended episodes, the odds of follow-up were lower with increasing age (OR=0.98); lower among episodes with female patients (OR=0.61); and higher among episodes with patients residing in rural areas (OR=1.42). In addition, odds of follow-up were lower among index visits that lasted longer (OR=0.94) and resulted in prescriptions for any medication (OR=0.53) and for antibiotics (OR=0.59). Primary diagnosis did not appear to impact the likelihood of follow-up for either episode types.

Table 3. Odds ratios predicting differences in likelihood of any follow-up associated with VUC user and index visit characteristics by episode type

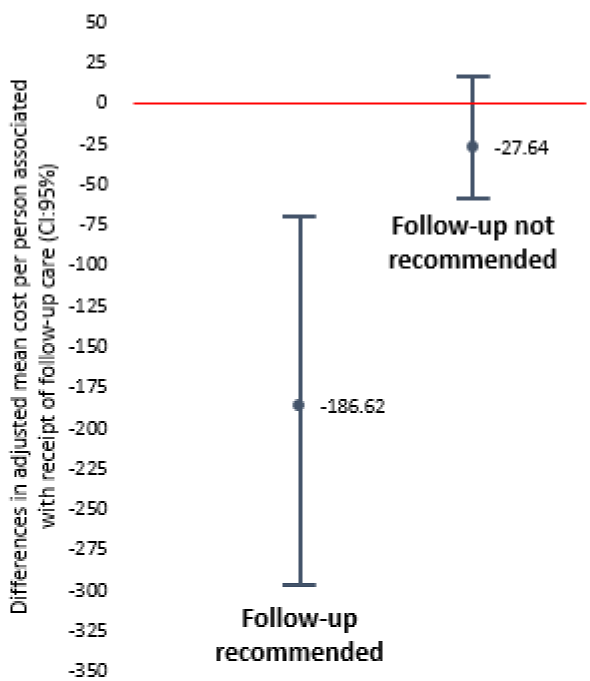
	Follow-up recommended (n=1360)			**Follow-up not recommended (n=2093)**		
Variables	Odds Ratio*	Std. Err.	95% CI	Odds Ratio*	Std. Err.	95% CI
Age	**0.98**	0.004	(0.97, 0.99)	**0.98**	0.004	(0.97, 0.99)
Female	1.62	0.56	(0.82, 3.20)	**0.61**	0.11	(0.43, 0.86)
Rural	**1.76**	0.55	(0.95, 3.26)	**1.42**	0.10	(1.24, 1.62)
Top quartile utilization in prior year	1.67	0.62	(0.81, 3.44)	1.32	0.46	(0.66, 2.62)
Top quartile spending in prior year	0.64	0.35	(0.22, 1.88)	1.82	1.41	(0.40, 8.33)
Visit on weekend	1.32	0.40	(0.73, 2.38)	0.96	0.18	(0.66, 1.40)
Visit after hours	0.83	0.24	(0.47, 1.47)	1.39	0.24	(0.98, 1.96)
Visit length	1.00	0.008	(0.99, 1.02)	**0.94**	0.01	(0.92, 0.96)
Primary care provider	0.80	0.16	(0.43, 1.17)	0.79	0.15	(0.54, 1.14)
Primary care request	0.53	0.11	(0.24, 1.15)	0.52	0.24	(0.21, 1.29)
Medication prescribed	1.15	0.75	(0.32, 4.12)	**0.53**	0.09	(0.38, 0.73)
Antibiotic prescribed	0.99	0.87	(0.18, 5.52)	**0.59**	0.12	(0.40, 0.86)
Visit type delivered:						
Phone	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
FaceTime	0.94	0.46	(0.37, 2.43)	0.43	0.50	(0.45, 4.18)
Other video	**3.43**	1.07	(1.86, 6.32)	8.37	9.68	(0.87, 80.78)
URI diagnoses	1.32	0.55	(0.58, 3.00)	1.06	0.25	(0.67, 1.67)
Skin diagnoses	1.10	0.55	(0.41, 2.96)	1.48	0.43	(0.67, 1.67)
Circulatory/respiratory diagnoses	0.96	0.49	(0.35, 2.61)	1.13	0.44	(0.53, 2.42)
Ear diagnoses	1.65	0.92	(0.55, 4.92)	0.51	0.32	(0.15, 1.77)
Urinary diagnoses	0.79	0.49	(0.23, 2.67)	0.62	0.24	(0.29, 1.30)
Digestive diagnoses	1.68	0.98	(0.53, 5.26)	1.03	0.46	(0.15, 1.77)
All other diagnoses	0.84	0.30	(0.42, 1.67)	0.97	0.18	(0.15, 0.98)

***Bold** indicates differences between groups (p<0.01)

Healthcare spending per VUC user

In our ordinary least squares analysis of cost per person, follow-up was associated with $138 lower spending among follow-up recommended episodes (p=0.03; 95% CI: -262.64, -13.42). We observed no cost differences between cohort groups among follow-up not recommended episodes. Using at 2SRI estimation approach, follow-up was again associated with lower per user spending among follow-up recommended episodes (Figure 4). Compared to users that did not have follow-up when recommended, follow-up was associated with $186.62 lower average per user spending during the study period (p-value=0.002; 95% CI: -$305.15, -68.10). We observed no differences between follow-up cohorts among follow-up not recommended episodes. (See Appendix B for model coefficients).

Figure 4. Adjusted average cost per VUC user by episode type



Sensitivity analyses

Our sensitivity analysis of cost per person for individual leading diagnoses revealed few significant differences between follow-up cohort groups. No diagnosis-specific cost differences were observed for URI, skin, circulatory/respiratory, ear, urinary, or digestive diagnoses for either episode type. For our "all other diagnoses" category, follow-up was associated with $170.30 lower average per user spending during the study period for follow-up recommended episodes (p-value=0.004; 95% CI: -$286.62, -53.38); no differences were observed in this diagnosis category for follow-up not recommended episodes. Lastly, our sensitivity analysis including episodes resulting in follow-up visits at VUC (versus in-person) sites showed consistent relative odds ratios and cost differences as our main analysis that did not include these additional episodes. (See Appendix C for additional sensitivity analysis details).

Discussion

While our analysis does not provide direct comparisons between VUC and other services, our findings suggest that some VUC users are not receiving appropriate follow-up services to resolve clinical symptoms, potentially signaling unmet medical need. We found that approximately 85% of VUC episodes did not resulted in follow-up when it was recommended. Prior research generally indicates lower or similar rates of follow-up comparing episodes of care initiated in VUC versus physician office or ED settings, and have taken this to indicate adequate rates of clinical resolution for VUC episodes.[8-9,14]; our results may put that interpretation into question, in some cases. Meanwhile, rates of follow-up were comparatively low (10%) among VUC episodes that did not receive a recommendation for follow-up. This finding aligns with the limited body of existing literature that suggests most VUC patients are not using virtual visits as a first step before seeking in-person care when there is no evidence of clinical need.[9]

In addition, we found that when recommended follow-up did occur among VUC users, the distribution of where follow-up visits took place generally did not align with where patients were referred at the VUC index visit. Although the descriptive nature of this analysis limits our ability to comment on trends among individual patients over time, we found this misalignment to be particularly striking for patients referred to for follow-up at urgent and primary care sites. As presented in Table 2, while 45% of patients were referred to urgent care for follow-up, urgent care sites comprised only 6% of follow-up visits. On the other hand, approximately 60% of follow-up visits occurred in physician offices, while only 20% were referred there. This may in part be explained by lack of available and convenient urgent care services were some VUC users live or work.[13]

We also found that recommended VUC episodes were three times as likely to result in follow-up if the VUC index visit was delivered by video (versus phone). Prior research has demonstrated the importance of strong patient-provider bonds for successful technology-mediated service interactions.[30] While there is little indication of differences in patient satisfaction between video- versus phone-based virtual visits[22], it is possible that visual, video-based interactions with a provider promotes stronger patient-provider bonds and encourages higher rates of follow-up adherence among VUC patients. Health organizations offering VUC services may wish to expand patient access to video visits (if not yet available) and raise awareness of video-based options.

Overall, the follow-up trends observed in our study may indicate potential weaknesses and inefficiencies in the VUC processes currently in place to connect patients to follow-up services at other existing health system structures. Our prior research describing VUC service operations among early adopter organizations suggests that lack of a strong and standard post VUC visit encounter process may weaken patient care coordination to other healthcare services.[18] Our study may offer additional empirical evidence of these weak linkages. Suggested by prior research, potential strategies to improve continuity and integration with other services may include contacting patients after an initial visit (via phone, email, or text) to check on resolution of clinical symptoms and/or provide patient education about the medical situations in which VUC is appropriate.[18] Other strategies may include greater clinical integration between VUC services and electronic medical records and scheduling software at other to more easily facilitate follow-up appointment.[18] Additional research will be needed to understand to what extent these and other strategies are being used to improve post visit encounter processes, and how they may directly impact care fragmentation associated with VUC use.

Regarding differences in healthcare spending associated with use of follow-up services, our spending analysis revealed that, if used when recommended, follow-up after an initial VUC visit can reduce per person healthcare spending. A key attraction of VUC and other convenient care options for health organizations is their potential to reduce healthcare spending.[22-23] While prior research demonstrates convenient care options are generally less expensive than traditional services (e.g., physician office visits, ED) at the visit and episode-level, VUC in particular,[17] other analyses that focuses on changes in per person spending indicate that use of convenient care options may lead to higher overall healthcare spending due to increased total service utilization.[22-23] This dichotomy has raised questions about the cost savings potential for VUC and other convenient care options, as well as judgement questions regarding whether or not increased total service utilization should be perceived as good or bad if new utilization is occurring among patients that would not have otherwise sought needed care for health conditions. Specific to the VUC context, our findings add to this current debate by demonstrating the potential importance of follow-up care processes in improving cost-savings potential. Among a population of VUC users, per person costs are lower when recommended follow-up services occur. Additional research will be needed see how if similar trends are seen among other convenient care options, and how this may impact other cost analyses when directly comparing VUC services to more traditional in-person care options.

Limitations

First, our study focuses on data collected from only two health systems using one VUC product, however, we constructed a relatively robust analytic sample in terms of size and low-acuity conditions and have no particular reason to believe VUC services would have been performed differently by other health systems. Second, we are unable to conclusively determine whether follow-up visits and associate costs are related to an index visit and part of the same episode of care. Much of this challenge relates to inherent limitations of claims information that may not provide a full record of care. Third, we assessed VUC index visits, follow-up visits, and associated spending among a study population of self-insured patients with access to VUC as a covered insurance plan benefit. It is possible that patterns of service use and associated spending may be different among patients with high deductible plans, high co-payments, or no insurance. Yet, adoption of VUC is growing rapidly among self-insured health systems, making this a patient population well-deserving of study in its own right.

Lastly, we pooled data across all primary diagnoses to perform study analyses. It is possible that patterns in follow-up utilization and associated spending may vary by clinical diagnosis; however, while our diagnoses-specific sensitivity analyses revealed few significant differences, they did indicate generally consistent odds ratios and cost differences with our main pooled analysis in terms of direction and size of effect. Given that our descriptive analysis of primary diagnoses revealed some differences in follow-up patterns by episode type (see Figure 3), future research should consider focusing additional attention on diagnosis-specific analyses to better understand potential variation by diagnosis. Disorders related to the urinary system and eye may be of particular interest, as we found a lower proportion of episodes with these conditions resulted in follow-up when recommended.

Conclusion

Here we have demonstrated that a high proportion of VUC patients are not receiving recommended follow-up visits to treat presenting symptoms after an initial virtual visit. Follow-up non-adherence may indicate care fragmentation with other existing healthcare structure and unmet medical need among virtual users, echoing findings from other forms of convenient care options. However, we also find that adherence to recommended follow-up care can reduce overall healthcare spending among VUC users, indicating greater cost saving potential for VUC in the presence of continuity with in-person services. For the research community, our study imparts novel insights regarding patterns of follow-up care utilization and associated costs. For health systems offering VUC, our study points to potential opportunities to strengthen VUC care processes that promote appropriate follow-up care utilization. To build on our work, we encourage future VUC studies to focus on a wider range of clinical diagnoses, insurance types, and health organizations to better understand spending and utilization patterns associated with follow-up services for VUC and other emerging forms of telemedicine.

Chapter 5: Conclusions

Using the instantiation of VUC, the original dissertation research reviewed above highlights a number of key learnings in the investigation of on-demand telemedicine as a disruptive health technology. In this conclusion chapter, I provide:

- A high-level summary of my dissertation research findings
- Practice and policy implications regarding the future trajectory of on-demand telemedicine
- General study limitations
- Future research directions

Summary of dissertation research findings

Journal Article 1

In our study of VUC business models, our qualitative data revealed that early adopter organizations are deploying value-adding process models that appear to appropriately match resources, processes, and profit formula to support value propositions for VUC. This general business model archetype focuses on delivering a consistent, high quality patient care experience that is quick, convenient, and highly accessibility, facilitated by standardized inputs and uniform processes.

A core set of disruptive strategies were found to particularly help transform the VUC business model into action. These strategies included:

- *Innovations in models of care delivery*: While the home-based care innovations associated with VUC present clear gains in convenience and accessibility for patients, the presence of workflow bottlenecks and care coordination limitations observed within the post visit encounter process may indicate a struggle to integrate home-based services into the larger continuum of care when patient contact and coordination services are needed beyond the initial virtual visit.
- *Outsourcing support*: Outsourcing support emerged as a key resource for many early adopters. While a variety of outsourcing contract arrangements were described in our research, those that balanced internal resources with important scaffolding support from vendors appeared best suited to meet proposed VUC value propositions.

  Marketing strategies: Direct-to-consumer marketing emerged as an important but challenging strategy to raise awareness of VUC services among potential patients. Many early adopters commented that these VUC marketing strategies was largely new and uncharted terrain for their organizations, which was identified as a main contributed to lower than expected VUC service volumes.
- *Unique organizational partnerships*: To increase opportunity for return on investment and profit generation for VUC services, many early adopters were particularly motivated to explore innovative relationships with external entities. A prominent example that emerged from our data was contracting between health systems and self-insured organizations to offer VUC services directly (cutting out vendor "middleman"). However, the success of these relationships and their impact on business model innovation remains unclear.

While the value-adding process model archetype is currently dominant among early adopters, our research indicates that organizations are continuing to evolve their business models and recalibrate their core model components and strategies to chase market share as new challenges and opportunities arise. Despite the ongoing struggles we identified, VUC business model trends among early adopters generally bode well for its future as a disruptive health technology: prior research has demonstrated a strong link between business model innovation and success of disruptive technologies in healthcare delivery [24-26].

Journal Article 2

In our study of VUC service utilization and cost impacts for UTI and RSD diagnoses among self-insured patients, our quantitative data suggest VUC initiated episodes are less expensive and less likely to result in follow-up, compared to traditional in-person care settings (e.g., physician office, urgent care, ED). This finding general suggests VUC can serve as a low cost alternative to other in-person services for some common low-acuity conditions.

Our cost related findings in this study align with the limited body of existing literature that similarly indicates lower costs for VUC initiated episodes compared to in-person. However, our findings related to the likelihood of follow-up present contrasts to prior research that utilized similar definitions for an episode of care: other research has generally found little difference in rate of follow-up comparing VUC and in-person services [11]. This contrast is of note, as low rate of follow-up in the context of VUC has often been used as a proxy measure of adequate clinical resolution following in initial virtual visit [9,11].

We explored a number of potential drivers that may help to reconcile our findings regarding rates of follow-up to the prior literature. It is possible these differences relate to the diagnosis-specific nature of our research; more complicated medical diagnoses with less clear clinical guidelines (compared to RSD and UTI), such as management of chronic conditions, may experience different rates of clinical follow-up after an initial VUC visit. We also discussed the possibility that differences may be attributable to the organizational context of our study. We examined utilization and cost trends in the context of self-insured health systems that offer VUC services as a covered benefit to their plan members. In contrast, other VUC studies have targeted study populations with access to virtual visits only via independent online telemedicine companies with little if any connection to a patient's primary source of care, which is often a health system. This consideration may harken back to the importance of strong links between a patient and a sponsoring health organization for the success of technology-mediated service interactions, as has been suggested in other telemedicine research [49].

However, whether the low rates of follow-up we observed in our study truly indicate clinical resolution, as has been suggested in prior studies, remains unclear. It is also possible these results indicate unmet patient need following an initial virtual visit. Our third journal article analysis of patterns of follow-up utilization among VUC users begins to unpack this question.

Journal Article 3

Lastly, in our quantitative study of patterns of follow-up utilization among VUC users, our data revealed that many VUC episodes (approximately 85%) are not resulting in follow-up services when recommended. This finding potentially indicates care fragmentation via lack of continuity with other existing health system structures. Although we did directly compare patterns between VUC to in-person services, our study findings may also indicate that low rates of patient follow-up after an initial VUC visit – as observed in my own research (see Chapter 3) as well as other published studies - may not always represent clinical resolution, but instead unmet patient need.

Echoing our earlier findings regarding key business model processes (see Chapter 2), these follow-up patterns may indicate potential weaknesses and inefficiencies in the VUC care processes currently in place to connect patients to in-person follow-up services when they are needed. The predictors of follow-up identified in our study may point to some targeted opportunities to strengthen care processes, such as EMR and scheduling software integration to schedule for example older patients as part of the standard VUC care encounter, as that population demonstrated a likely likelihood of skipping follow-up visits when recommended.

Our study findings also indicate that adherence to recommended follow-up may lower per person healthcare costs. In other words, there may be greater cost savings potential for VUC in the presence of continuity with in-person services.

Conceptual connections between journal articles

Introduced in Chapter 1, the conceptual framework guiding my dissertation research proposes pathways between the on-demand telemedicine business model and resulting strategies (studied in Article 1) and health service utilization by individuals and associated cost (studied in Articles 2 and 3). While not directly empirically explored in my studies, my research offers some early insights regarding the primary drivers of these proposed pathways. In Article 1, my research found evidence to suggest that efforts to raise awareness of on-demand services, via deployed marketing strategies, is likely to impact patient use of virtual visits. Depending on the purpose of the marketing strategy (including: providing understanding of availability of VUC services; providing understanding of the medical situations where VUC is an appropriate option; and building patient-organization bonds) and the effectiveness of the specific method (i.e., search engine optimization; and endorsements by primary care providers), our study data suggest these strategies are also likely to impact a patient's behavior regarding the use of follow-up services and associated costs (studied in Articles 2 and 3). Further, encompassed by our research of VUC business model components, data also suggest that degree of standardization of VUC care processes to connect patients to follow-up services is also likely to impact patient behavior and associated following an initial virtual visit. Particularly, as reviewed in our Article 3 findings, lack of standardization of post-VUC visit processes among early adopter organizations may promote lack of continuity with in-person health services, as evidenced by low adherence to recommended follow-up after an initial virtual visit. Whether the source of VUC program resources, particularly clinical staffing and technology infrastructure to integrate clinical and administrative systems, is primarily outsourced versus supported by internal resources may influence the level of standardization of these care processes. However, future research will be needed to better specify hypothesized pathways between business models and strategies and health service utilization spending in the context of on-demand telemedicine.

Future trajectory of on-demand telemedicine as a disruptive health technology

To truly be a positive disruption that will increase convenience, accessibility, and affordability, disruptive technology research suggests on-demand telemedicine must cross into the early majority stage of widespread assimilation [13-14]. Viewed as a whole, my dissertation research identifies four key practice and policy implications that may help to smooth the trajectory across the "innovation chasm" for on-demand telemedicine. For current early adopter organizations, these practice implications may serve to help leverage their position of early entry. For potential early majority organizations that are considering launch, these insights provide an opportunity to learn from the experiences of early adopters.

1. *Raise service awareness to drive uptake*: Our research connects the dots between raising VUC awareness and knowledge and driving uptake to increase VUC service volumes, which is central to

the profit formula for the on-demand services. Direct-to-consumer marketing was identified as a crucial mediating factor that many early adopter organizations struggle to execute effectively. Based on our research, marketing efforts appear to have varied purposes, including: (a) providing potential users with understanding about the availability of VUC, (b) providing potential users with understanding about the availability of VUC, educating patients about the medical situations when VUC is a good option, and (c) "selling" the health organization, as this is where a strong link needs to be created for the potential user to turn to the health organization for VUC services instead of other competitors.

2. *Use outsourcing support strategically*: The second implication is the importance of continuing to evolve business models and strategies as new challenges and opportunities arise in the market. To facilitate this, early adopters are thinking strategically about how to use outsourcing support, which increasingly includes balancing internal resources with important scaffolding support from vendors. As another tool to drive evolution, early adopters are adding conveniences and capabilities to what the on-demand services delivery model is able to offer – such as integrating at home diagnostic testing. Finally, early adopters are leveraging new relationships with other organizations that integrate different business model archetypes to expand patient base and generate profit.

3. *Improve continuity/integration with other health system structures and services:* A theme throughout my research is signs of potential inefficiencies in VUC care processes to connect patients with in-person follow-up after an initial virtual visit, potentially contributing to care fragmentation. Our study data suggest that integrating greater levels of standardization into VUC care process may help to promote these connections. With improved care processes, there may be greater opportunities for cost savings when follow-up services are needed by VUC users.

4. *Define different use cases for on-demand services*: The final implication that emerged is the need to define different use cases for on-demand telemedicine. While our research suggests VUC can serve as a low-cost alternative for some low-acuity medical conditions, in other cases, in-person follow-up is needed to resolve symptoms. VUC can serve as a triaging tool, or a complimentary service, to get those patients to the most appropriate in-person care site. This idea of VUC as a complimentary service aligns with some recent scholarly work in disruptive technology research, contending that many cases disruptors may function as a complementary service that can be delivered or consumed together with market leaders, as opposed to a replacement. To promote continuity across the full spectrum of healthcare services and set expectations for potential costs savings associated with on-demand telemedicine, adopting organizations will need to better understand and define separate use cases for when VUC can serve as a 1:1 replacement for in-person care, or as a complimentary service.

Study limitations

Our focus on a narrow study population of VUC early adopter organizations may limit the generalizability of our study findings. As a result, some findings may not be applicable to other forms of on-demand telemedicine or later stage adopters. In addition, we did not study non-adopters or organizations with failed VUC adoption experiences; learning about the experiences and challenges faced by these organizations may have provided additionally meaningful insights to address our research objectives. In addition, for journal articles two and three, we collected data from only two health systems using one VUC product and assessed clinical service utilization and spending among a study population of self-insured patients with access to VUC as a covered insurance plan benefit. However, we constructed a relatively robust analytic sample in terms of size and low-acuity conditions and have no particular reason to believe VUC services would have been performed differently by other health systems. While it is possible patterns of service use and associated spending may be different among patients with high deductible plans, high co-payments, or no insurance, adoption of VUC is growing rapidly among self-insured health systems, making this a patient population well-deserving of study in its own right. For our quantitative work, we are also unable to conclusively determine whether follow-up visits and associate costs are related to an index visit and part of the same episode of care. However, much of this challenge relates to inherent limitations of claims information that may not provide a full record of care. Lastly, we did not have access to certain data fields that may have been relevant to include in study analyses. For example, instruments that may help to explain propensity to use VUC services, such as marketing exposure or geographic information to calculate distance to provider.

Directions for future research

While my dissertation research addresses many current research gaps related to our knowledge of on-demand telemedicine as a disruptive health technology, it also highlights several directions for future research.

Because it is possible that patterns of service use and associated spending may be different among patients with different insurance coverage, future research should expand our current work to other types of insurance coverage (e.g., government-sponsored) and reimbursement structures (e.g., non-fee-for-service environments, such as accountable care organizations). Similarly, future research should explore outcomes among a wider set of diagnoses with different disease severity (e.g., chronic disease management) to better understand patterns of service utilization and cost for different on-demand use cases. Researchers should also consider supplementing service utilization and cost outcomes with additional studies to elicit information from perspective of patients regarding their motivations and subsequent service use behavior after an initial virtual visit. Such a patient perspective will also allow for a more detailed analysis of the proposed conceptual links between the deployed business model/strategy and patient use and spending on health services.

Future research should also be directed towards studying other potential drivers of on-demand utilization and cost effects. For example, race/ethnicity, virtual provider type and training, and types of marketing endeavor deployed by adopting organizations. As patient uptake of these services increase, prior patient exposure to virtual visits, to evaluate something to the effect of dose-response, may also be quite interesting to explore.

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Appendix B: References and appendices for Journal Article 1

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Appendix 1: Overview of VUC patient encounter process

In the typical VUC encounter, a patient in need initiates a request for a virtual visit using a web browser, phone, or tablet. The patient will complete an online intake form, detailing medical history, presenting symptoms, and primary care provider (PCP) status; if no established PCP is indicated, the patient is prompted to indicate if they would like a referral request. After completing intake, a patient will typically connect with a virtual provider within 10-15 minutes. Based on chief medical complaint and history, the provider will treat the patient through the virtual visit (may include prescribing medications) or, if clinically indicated, triage the patient to a form of in-person care for immediate consultation or recommended follow-up.

Appendix 2: Interview protocol

Virtual Care Clinic Interview Prototype (General Interviews)

Length of Interview: 45-60 minutes **Milieu**: Telephone

Methodology: An email interview request with an overview will be sent to participants in advance of the interview to allow for proper preparation and effective use of interview time. Interviews will be recorded and notes will be taken. The interview is discreet. Results will be de-identified and only the interviewers will have access to the transcripts.

Dial-in Number: 712-770-4700
Access Code: 259459
Host PIN code: 6856

Note that the questions listed are a bank of questions desired for each participating organization.

Key questions to be asked of all interviewees.

Prompts -- Prompts are supporting questions and are listed under the main questions (indented). Prompts are asked if the respondent does not seem to understand the main question address the main question as expected.

INTRODUCTIONS TO INTERVIEWERS

- Thank you for setting aside time for this interview.
- ________ (interviewee name), it is a pleasure to speak with you.
- We can start with introductions
- My name is _______ (Cynthia or study research assistants). I am a _____ (Cynthia or study research assistants) with the University of Washington and am currently working with the National Science Foundation's Center for Health Care Transformation to identify best practices and lessons learned from early adopter organizations of virtual care clinics. My role is to serve as an independent expert to conduct interviews and analyze the resulting information.
- I would like to also introduce ________ (Cynthia or study research assistants), from my team, who is present to listen, take notes, and interject follow-up questions at appointed times, in the event clarification is needed.
- Would you like to introduce yourself?

INTRODUCTION TO THE INTERVIEW (ADAPT TO WHO SPEAKING WITH AND PRIOR COMMUNICATION AND MATERIALS SENT):

- The focus of this interview is to understand your experiences and lessons learned. We are speaking with representatives of health organizations across the country that offer virtual care services so that we can identify important insights to share around implementation, operations, and patient engagement.

THE PROCESS

- The interviews will be completely confidential. Your identity will only be known to interviewers on the research team. You or anyone you refer to during this interview will not be mentioned by name nor will your site be identified by name. Interview results will be de-identified before they are analyzed or reported in order to protect confidentiality. Your participation in this research is completely voluntary. You may decide to stop participating in the research at any time. Do you have any questions regarding the interview process or the treatment the information that will be collected at this time?
- ______ (Cynthia or study research assistants) will serve as the lead interviewer.
- We have grouped these questions into categories to facilitate the flow of the conversation.
- _________ (Cynthia or study research assistants) will break for a moment at the end of each category to see if _____ (Cynthia or study research assistants) has any follow-up questions or would like to clarify any comments made.
- We would like to audio record the interview with your permission to ensure that we capture your thoughts accurately and allow us to fully focus on the conversation with you, rather than on note taking. If there are any comments that you do not want to have recorded, just let us know and we can postpone discussion until the recorder is turned off. Do you have any problems with recording? We will now turn on a recorder to capture the interview.

TURN ON THE RECORDER

- I am now recording with your permission.

OVERVIEW OF ORGANIZATONAL ROLE (announce this and forthcoming categories to interviewee): I'd like to start by learning a bit more about you and your organization.

1. What is your role within ___________ (organization)? How does telemedicine in general fit with your role?
   a. What about virtual care services?

STRATEGY AND VISION: These next questions are related to the scope and background of VUC services at your organization.

2. What motivated VUC launch within your organization?
   a. Was the decision influenced by your organization's strategic plan?
      i. Related to cost containment efforts?
      ii. Related to patient care?
      iii. Related to patient acquisition?
   b. Was the decision influenced by the nature of your organizational culture?
      i. Embrace new ideas?
      ii. Be a leader in innovation?
   c. Was the decision related to the desire to expand existing services?
      i. Size/maturity?
      ii. Preexisting experience/knowledge?
   d. Was the decision related to the desire to compete with peer organizations or other service options?
   e. Did any state or organizational policy change influence the decision?
      i. Reimbursement changes?

3. Tell me about VUC services at your organization?
    a. How long has your organization offered VUC services?
    b. What is the extent of current VUC service provisions?
    c. Has this changed since initial VUC launch?

4. How are VUCs services funded within your organization?
    a. Are VUC services funded through a core budget?
    b. Funded through a grant initiative?
    c. Funded as a pilot program?

5. How can patients access VUC services?
    a. Is this something you contract out to a vendor company?
    b. What telecommunication modalities can patients use?
    c. Are patients referred to follow-up care services if needed??
    d. Is a care summary sent back to a patient's primary care provider (if the information is available)?

PATIENT ENGAGEMENT: Now we're going to transition to a set of questions that focus on the patient side of VUC services at your organization.

1. How are patients made aware of VUC services?

2. How are you currently engaging with patients to encourage VUC service use?
    a. Do you (or have you) made any formal marketing efforts?
        i. Do you target specific patient groups through those efforts? Let's talk about that.
        ii. Is there any document or marketing materials you would be willing to share with us?
    b. Or are engagement efforts more passive?
    c. Have efforts proven successful?
    d. How do you track patient engagement?
    e. What would you say are important barriers to engaging patients related to their use of VUCs services?
    f. What about important facilitators?

3. What has patient uptake been like for VUC services?
    a. What has patient uptake looked like over time? Are you satisfied with where uptake is at this point?
    b. How would you describe a typical user of VUC services?
    c. What are some of the most frequent reasons patient's use these services?
    d. What are some of the barriers you've had to overcome to get patient uptake to where it is today? What remaining barriers do you have to overcome to get uptake to where you ultimately want it?
        i. How have you overcome these barriers (or how do you think you can overcome these barriers)?

    e. What are some of the reporting mechanisms you use to collect and track patient uptake?

4. How do patients that use VUC services respond to the service?
    a. Would you say current services are meeting patient needs?
    b. Have patients reported any difficulty accessing and/or using services?
        i. Related to technology?
        ii. Related to interactions with medical providers?
        iii. Related to the operational process?
    c. How would you say the VUC experience at your organization compares to similar services offered through other access points? For example, similar services might include face-to-face primary care, or services received at urgent care centers or convenient care clinics.
    d. What are some of the reporting mechanisms you use to collect and track patient experience information?

IMPLEMENTATION PROCESS: Now we're going to focus specifically on how VUC was implemented at your organization.

5. Who supports VUC implementation and operations?
    a. Is everything outsourced? (if vendor company is used)
    b. Is there a department or service line that supports these activities?
        i. What does the staffing look like associated with the department or service line?
    c. How are decisions made related to VUC implementation and operations? How is information exchanged between stakeholders?
        i. Vertically?
        ii. Workgroup structure?
    d. What are some of the reporting mechanisms you use to collect and track information related to the impact of VUC implementation and operations?

6. In looking back on the implementation process, what were some things that were instrumental?
    a. Leadership?
    b. Champions?
    c. Technical support?
    d. Funding?
    e. What would you say got in the way of successful implementation?

7. If you were going to advise someone just starting this program, what would you tell them based on what you've learned to date?

CLOSING REFLECTIONS: We're just about done. Now we're going to wrap up with a few big picture questions related to lessons learned and the future of VUC services at your organization.

8. What suggestions do you have for current and future VUCs within other health organizations based on what you have learned to date?

9. So what does the future look like for VUC within your organization? What are the critical success factors moving forward?

10. Are you using VUC services to leverage any other opportunities?
    a. Expanded telemedicine services?
    b. Community benefit?
    c. Grants?
    d. Patient acquisition?

11. Are there topics or issues regarding VUC implementation, operations, and patient engagement that we have not covered would be important to understand?

12. Is there anyone else that you would suggest that it would be important to speak with to learn more about VUC services at your organization?

CONCLUSION

- That concludes this interview.
- Thank you for taking the time out of your busy schedule to meet with us. Speaking with you was both enjoyable and informative.
- In the remote chance that I have a follow-up question to gain clarity after reviewing the notes or transcripts, would it be ok to reach out to you via email?
- Also, as the project continues, would it be ok to check back with you regarding updates and additional insights?

TURN OFF THE RECORDER.

- IMMEDIATELY download the recorded file.
- Once the file has been checked, remove the recorded file from the pass key web site.
- Send recording to transcription service.

Appendix 3. Summary of core strategic components of emerging business model archetype

Core strategic component	Supporting quotes
Value proposition	**Efficiently meet patient need:** "The value proposition for us, really comes down to better service, easier access, faster access, being mobile, you know, being able to go right where those patients are, rather than having them come to us, and really the big keyword for all of [our goals] came down to access…" "…so [telemedicine] has more so become an additional door or an access point rather than this you know shinny object that lets you do video chat and so in terms of the value I think they are trying to figure out how to be more efficient and they are using virtual care in many ways to support that goal." **Patient acquisition:** "It's very expensive to acquire a new patient for health systems and so offering a convenient [virtual] urgent care and other consumer acquired services, it can be a very good way to acquire new patients and develop a new relationship with patients." **Retain patient base:** "A lot of times when they have a risk contract and they're responsible for the life of the patient, they're also interested in retaining patients, so they'd rather not see that patient go off to another organization and get even urgent care from the other organization because that very encounter can lead to, "Okay, actually you need to be seen. Why don't you come in to our other facility…" and then care becomes discontinuous for the health system. So that, I think is a really important value driver." **Extend brand recognition:** "They are looking to be a brand in the market, they are looking to expand beyond their four walls. They are trying to cast a larger net so to speak." **Contain costs:** "…there is an incentive for the health care system to be seeing patients in this way... I think it saves them money, it saves on unnecessary costs incurred by patients being seen when they didn't have to be seen or … coming to an emergency room and utilizing resources that could better be utilized for patients who need that sort of in person service." **Improve provider capacity:** "For us we are having a real access issue in our small rural county. And so we were using [VUC] as a way to provide services to our community whenever we don't have capacity into our primary care clinic." **Tool to align with value-based care initiatives:** "…it's really more about the move from a pay for service model of care to a value model. And in that value model when doctors aren't paid anymore on RVU's and aren't paid for the procedures that they do and it's not about volume they are not going to care to necessarily see the three year old with pink eye because it ends up being a waste of their time. And we need to free them up so that they are dealing

Core strategic component	Supporting quotes
	with the more complex cases. And that's a much longer road to get there and has a lot more… everybody has to move to value because the model of fee for services is broken" "Now long-term as healthcare is trying to move to value where it becomes more and more important to really offer a cost efficient and high quality product to existing patients and especially to the rich population. Our strategy will be augmented and extended in that sense to offering to the existing and risk population. But right now at this point it's really a new patient acquisition tool." **Innovator perception:** "…health systems see the value in extending their brand, and being seen as the leader in the market of telemedicine or virtual care, it allows them to differentiate in that manner… they see this as another arm in the overall machine of trying to generate new business for the organization."
Key resources	**Virtual platform:** "They can come through phone or if they want to self-select on the website they can do so in that way. It's a brief in-take of 4 or 5 pages, that they list out how they are feeling, how they would like to receive care, they select their primary care provider if they have one in the health system, then consent and okay, and depending on what modality they choose they would enter an exam room for an outbound call from a provider or a video call." **Technology infrastructure for integration:** "…so I think most important thing is the integration of the EMR…that to me in terms of being a clinician, having the continuity of care, having the record in place, being able to access medical history and medication and things like that in any EMR integration of data… it makes a difference in what we do and how we provide that care." **Virtual providers:** "I'm thinking of the providers that I'm bringing on, what truly makes them really good, it's that passion for care, I don't think there is anything different than any other providers out there in any clinic settings if you will…Using the technology is another avenue to bring care to the patient." **Vendor experience/expertise:** "I mean if it was just putting up a video chat component that's not that difficult and anyone can do it but there is you know a lot of aspects to it, there's billing, there's claims processing, there is integration to their systems, there is doctor availability, there is managing, training…so when you come to us you kind of get that complete package plus the expertise of you know what we have been able to accomplish over the past 10 years." "The reason that we went with a vendor was speed to market. In order to build [the platform] ourselves it would have taken longer and we wanted to get out in the market place as quickly as possible. **Challenge to meet around-the-clock demand using internal providers:**

Core strategic component	Supporting quotes
	"Our intent is to staff it as much as possible with our employed providers. But it just doesn't make economic sense for us and we wouldn't be able to maintain a low cost point if we're having to staff [the virtual clinic] at every low utilization time, for example in the early morning. And then also we wanted to be highly accessible not just in the states where … our patients are, but have it available to those patients as they travel out of state … so we have [a] partner network [with a vendor]." **Vendor support as scaffolding to build internal capacity over time:** "While we could build it in house, our IT currently doesn't have a skill set to be able to sport something of this magnitude, plus sometimes you know, in the time it takes us to learn, and hire, and train, and figure out all the best practices and all that and the other thing, and get this all up and running and smooth, you know, that's a big piece. Sometimes you got to just rely on a company that's just done it many times before, and have other clients and have the technical support at your fingertips… Now that being said, I know we are currently in discussions and are working on a plan, that hopefully within the next six to 12 months, that will start to combine [vendor] providers with our own"
Key processes	**Telemedicine specific protocols:** "There is a pretty standard protocol in terms of caring for the patient during the actual examination itself." **Referral system to establish with primary care provider:** "…if [the patient] had told us during the registration process that they wanted a PCP they would be immediately warm transferred to our centralized scheduling [team].If they told during the registration process that they didn't have a PCP but they didn't want one then we get a report within four hours that says who those patients are that don't have a PCP and we and we reach out to them and we talk to them about the benefits of a primary care provider.". **Referral system when telemedicine not suitable:** "Obviously we see some conditions that are not virtually appropriate or cannot be managed virtually so that would warrant a referral back into the health system." **Post-encounter "hand-off" source of workflow bottlenecks and care coordination limitations:** "Well ideally we would be able to get them in for a [visit] if they were hoping to have a primary care provider in our system. And so usually what ends up happening is we call them and get them on a wait list. It would be ideal if we could have more access and were able to actually pull them into our system." **"Hand-off" aided by more direct access to internal systems (e.g., EMR):** "I think some health care systems are adopting this model and finding it better than hiring a [vendor] simply because having it done internally, people understand the internal process, they are already utilizing the same [electronic medical record] which ends up being a huge problem with hiring a [vendor] sometimes. And so the workflow and the integration and the follow up on patient care can be a lot easier when it's done in-house rather than hiring one of these [vendors]." **Varied standardization re: new patient referral and follow-up processes:**

Core strategic component	Supporting quotes
	"Clearly where we have an integration with the EHR then we're able to instantiate a new patient into the health record for the health system. But the health system may have a process where they want us to refer the patient to a referral number by phone. They may have a process where they're going call back the patient, then they have a process whereby we do a warm transfer. It's... there are a variety of processes that happen" "We do follow phone calls; oh that's a lot of differentiation. We actually call the patient. We call every patient to follow up with them and make sure that what we… what we prescribed is actually making a difference for them."
Profit formula	**Volume-driven, but not meeting initial volume expectations:** "I mean we're satisfied with the quality and the customer satisfaction. We are not terribly satisfied with the volume for the growth trajectory …. We thought it would grow faster than it did last year." "[Patient] conversion is lower than what was targeted… I think we may have over projected potentially, initially on conversion. " **Volume peaks associated with marketing campaigns/seasons of high need:** "And in one of my favorite campaigns we did, we did at Christmas…and we set up a booth and we had our door price and our big sign that had Santa on it and was pretty much who does Santa call when he gets sick? Well, we all know who Santa is? So it was a big draw…" **Difficulty measuring ROI:** "So a lot of hospitals systems that we meet with us say, 'Well we did the math and it cost X to use your technology and what we found is we don't believe we'll be able to do more than X number of visits.' So they tie a lot of it into how many visits they're going to do and what that exact revenue is. That's not the way we've been looking at it because as I mentioned it's still a nascent space and a lot of this is arbitrary. So I think that when we get a health system that's being realistic and thinking about this in a big picture way, I think our measure of success is having a solution that's you know branded to them and works really well."

Appendix C: References and appendices for Journal Article 2

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Appendix A: ICD-CM-10 codes for UTI and RSD diagnoses

Table A1. UTI ICD-CM-10 codes

ICD Section Description	ICD Section	ICD Code	ICD Code Description
Urinary Tract Infection			
Other diseases of the urinary system	N30-N39	N30.00	Acute cystitis without hematuria
Other diseases of the urinary system	N30-N39	N30.01	Acute cystitis with hematuria
Symptoms and signs involving the genitourinary system	R30-R39	R30.0	Dysuria
Symptoms and signs involving the genitourinary system	R30-R39	R39.19	Other difficulties with micturition
Symptoms and signs involving the genitourinary system	R30-R39	R35.0	Frequency of micturition
Symptoms and signs involving the genitourinary system	R30-R39	R30.9	Painful micturition, unspecified
Symptoms and signs involving the genitourinary system	R30-R39	R34	Anuria and oliguria

Table A2. RSD ICD-CM-10 codes

ICD Section Description	ICD Section	ICD Code	ICD Code Description
Respiratory System Disease			
Acute upper respiratory infections	J00-J06	J01.90	Acute sinusitis, unspecified
Acute upper respiratory infections	J00-J06	J01.00	Acute maxillary sinusitis, unspecified
Acute upper respiratory infections	J00-J06	J00	Acute nasopharyngitis [common cold]
Acute upper respiratory infections	J00-J06	J06.9	Acute upper respiratory infection, unspecified
Acute upper respiratory infections	J00-J06	J02.9	Acute pharyngitis, unspecified
Acute upper respiratory infections	J00-J06	J03.90	Acute tonsillitis, unspecified
Acute upper respiratory infections	J00-J06	J02.0	Streptococcal pharyngitis
Acute upper respiratory infections	J00-J06	J01.10	Acute frontal sinusitis, unspecified
Acute upper respiratory infections	J00-J06	J06.0	Acute laryngopharyngitis
Acute upper respiratory infections	J00-J06	J05.0	Acute obstructive laryngitis [croup]
Acute upper respiratory infections	J00-J06	J01.91	Acute recurrent sinusitis, unspecified
Acute upper respiratory infections	J00-J06	J03.00	Acute streptococcal tonsillitis, unspecified
Acute upper respiratory infections	J00-J06	J02.8	Acute pharyngitis due to other specified organisms
Influenza and pneumonia	J09-J18	J11.1	Influenza due to unidentified influenza virus with other respiratory manifestations
Influenza and pneumonia	J09-J18	J11.2	Influenza due to unidentified influenza virus with gastrointestinal manifestations
Influenza and pneumonia	J09-J18	J11.89	Influenza due to unidentified influenza virus with other manifestations

ICD Section Description	ICD Section	ICD Code	ICD Code Description
Influenza and pneumonia	J09-J18	J15.7	Pneumonia due to Mycoplasma pneumoniae
Other acute lower respiratory infections	J20-J22	J20.9	Acute bronchitis, unspecified
Other diseases of upper respiratory tract	J30-J39	J34.9	Unspecified disorder of nose and nasal sinuses
Other diseases of upper respiratory tract	J30-J39	J30.9	Allergic rhinitis, unspecified
Other diseases of upper respiratory tract	J30-J39	J30.0	Vasomotor rhinitis
Other diseases of upper respiratory tract	J30-J39	J30.2	Other seasonal allergic rhinitis
Other diseases of upper respiratory tract	J30-J39	J34.89	Other specified disorders of nose and nasal sinuses
Other diseases of upper respiratory tract	J30-J39	J30.1	Allergic rhinitis due to pollen
Chronic lower respiratory diseases	J40-J47	J45.998	Other asthma
Chronic lower respiratory diseases	J40-J47	J45.909	Unspecified asthma, uncomplicated
Chronic lower respiratory diseases	J40-J47	J45.901	Unspecified asthma with (acute) exacerbation
Chronic lower respiratory diseases	J40-J47	J45.21	Mild intermittent asthma with (acute) exacerbation
Other respiratory diseases principally affecting the interstitium	J80-J84	J80	Acute respiratory distress syndrome
Symptoms and signs involving the circulatory and respiratory systems	R00-R09	R09.81	Nasal congestion
Symptoms and signs involving the circulatory and respiratory systems	R00-R09	R05	Cough
Symptoms and signs involving the circulatory and respiratory systems	R00-R09	R07.9	Chest pain, unspecified
Symptoms and signs involving the circulatory and respiratory systems	R00-R09	R06.82	Tachypnea, not elsewhere classified
Symptoms and signs involving the circulatory and respiratory systems	R00-R09	R04.0	Epistaxis
Symptoms and signs involving the circulatory and respiratory systems	R00-R09	R06.02	Shortness of breath
Symptoms and signs involving the circulatory and respiratory systems	R00-R09	R09.82	Postnasal drip
Symptoms and signs involving the circulatory and respiratory systems	R00-R09	R06.4	Hyperventilation

Appendix B: Tables with full regression results for main analysis

Table A1. Cost per episode for UTI diagnoses (differences in adjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-370.21	30.97	<0.001	-430.91, -309.52
Office	-341.53	39.75	<0.001	-419.48, -263.58
Urgent Care	-107.16	33.16	0.001	-172.43, -41.90
ED	-1207.48	167.28	<0.001	-1537.41, -877.54

Table A2. Probability of follow-up for UTI diagnoses (adjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.47	0.11	0.001	0.32, 0.72
Office	0.47	0.10	<0.001	0.31, 0.72
Urgent Care	0.26	0.06	<0.001	0.17, 0.41
ED	0.43	0.11	<0.001	0.27, 0.70

Table B1. Cost per episode for RSD diagnoses (differences in adjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-516.48	35.06	<0.001	-585.20, -447.76
Office	-342.31	35.42	<0.001	-411.73, -272.89
Urgent Care	-469.84	32.83	<0.001	-534.22, -405.46
ED	-1220.90	80.09	<0.001	-1377.94, -1063.85

Table B2. Probability of follow-up for RSD diagnoses (adjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.34	0.03	<0.001	0.29, 0.40
Office	0.37	0.03	<0.001	0.32, 0.44
Urgent Care	0.34	0.03	<0.001	0.29, 0.41
ED	0.24	0.02	<0.001	0.20, 0.49

Appendix C: Tables with results for sensitivity analyses

Table A1. Cost per episode for UTI diagnoses (differences in unadjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-369.27	181.67	0.042	-725.47, -13.07
Office	-340.82	188.45	0.071	-710.39, 28.75
Urgent Care	-106.13	27.38	0.036	-205.52, -6.74
ED	-1246.56	125.09	<0.001	-1579.25, -834.92

Table A2. Probability of follow-up for UTI diagnoses (unadjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.17	0.03	<0.001	0.12, 0.24
Office	0.18	0.03	<0.001	0.12, 0.26
Urgent Care	0.05	0.01	<0.001	0.03, 0.08
ED	0.16	0.14	<0.001	).09, 0.26

Table B1. Cost per episode for RSD diagnoses (differences in unadjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-520.86	62.57	<0.001	-643.51, -361.22
Office	-346.25	54.18	<0.001	-452.46, -240.05
Urgent Care	-475.84	24.04	<0.001	-522.97, -428.70
ED	-1231.99	70.08	<0.001	-1369.41, -1094.57

Table B2. Probability of follow-up for RSD diagnoses (unadjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.32	0.03	<0.001	0.27, 0.38
Office	0.36	0.03	<0.001	0.31, 0.43
Urgent Care	0.33	0.03	<0.001	0.27, 0.40
ED	0.18	0.02	<0.001	0.14, 0.21

Table C1. Cost per episode for acute upper respiratory system diagnoses (differences in adjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-631.28	47.38	<0.001	-724.17, -538.39
Office	-532.05	54.34	<0.001	-638.60, -425.50
Urgent Care	-385.70	150.82	0.011	-681.85, -89.55
ED	-800.20	140.53	<0.001	-1076.08, -524.31

Table C2. Probability of follow-up for acute upper respiratory system diagnoses (adjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.17	0.03	<0.001	0.11, 0.24
Office	0.19	0.04	<0.001	0.13, 0.27
Urgent Care	0.12	0.03	<0.001	0.07, 0.19
ED	0.12	0.02	<0.001	0.08, 0.18

Table D1. Cost per episode for Influenza and pneumonia diagnoses (differences in adjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-610.86	118.80	<0.001	-845.53, -376.17
Office	-402.17	122.60	0.001	-645.46, -158.88
Urgent Care	-366.54	0.0029	<0.001	-366.54, 367.54
ED	-351.63	124.43	0.006	-599.36, -103.90

Table D2. Probability of follow-up for Influenza and pneumonia diagnoses (adjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.16	0.08	<0.001	0.06, 0.45
Office	0.20	0.10	0.002	0.07, 0.56
Urgent Care	--	--	--	--
ED	0.14	0.07	<0.001	0.05, 0.39

Table E1. Cost per episode for other diseases of the upper respiratory diagnoses (differences in adjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-525.97	72.34	<0.001	-668.01, -383.92
Office	-398.14	47.15	<0.001	-490.76, -305.52
Urgent Care	-270.07	160.91	0.107	-603.78, 63.63
ED	-1033.50	440.94	0.027	-1938.23, -128.77

Table E2. Probability of follow-up for other diseases of the upper respiratory tract diagnoses (adjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.21	0.20	0.107	0.03, 1.40
Office	0.22	0.22	0.122	0.03, 1.50
Urgent Care	0.23	0.31	0.276	0.02, 3.18
ED	0.13	0.14	0.053	0.21, 1.03

Table F1. Cost per episode for chronic lower respiratory disease diagnoses (differences in adjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-988.84	182.23	<0.001	-1347.06, -630.63
Office	-866.02	244.91	<0.001	-1348.07, -383.98
Urgent Care	-95.14	0.0032	<0.001	-95.14, 93.14
ED	-796.12	203.69	<0.001	-1207.49, -384.75

Table F2. Probability of follow-up for chronic lower respiratory disease diagnoses (adjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.29	0.28	0.201	0.04, 1.92
Office	0.33	0.31	0.244	0.05, 2.15
Urgent Care	--	--	--	--
ED	0.22	0.21	0.120	0.03, 1.48

Table G1. Cost per episode for other symptoms and signs involving the circulatory and respiratory systems diagnoses (differences in adjusted mean cost per episode of care comparing episodes originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	-949.29	94.20	<0.001	-1134.03, -764.55
Office	-949.29	94.20	<0.001	-1134.03, -764.55
Urgent Care	-949.29	94.19	<0.001	-134.02, -764.55
ED	-949.29	91.20	<0.001	-1134.03, -764.55

Table G2. Probability of follow-up other symptoms and signs involving the circulatory and respiratory systems diagnoses (adjusted odds ratios predicting differences in any clinical follow-up comparing episodes of care originating at VUC versus in-person sites)

	Coefficient	Standard Error	P-value	95% Confidence Internal
All in-person sites	0.48	0.43	0.415	0.08, 2.83
Office	0.47	0.43	0.415	0.08, 2.83
Urgent Care	0.48	0.43	0.415	0.08.2.83
ED	0.48	0.43	0.415	0.08, 2.83

Appendix D: References and appendices for Journal Article 3

References

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Appendix A: ICD-CM-10 codes for diagnosis sub-categories considered in sensitivity analyses

Table A1. Acute upper respiratory infection ICD-CM-10 codes

ICD Section Description	ICD Section
Acute upper respiratory infections	J00-J06

Table A2. Skin disorder ICD-CM-10 codes

ICD Section Description	ICD Section
Viral infections characterized by skin and mucous membrane lesions	B00-B09
Infections of the skin and subcutaneous tissue	L00-J08
Dermatitis and eczema	L20-30
Disorders of skin appendages	L60-L75
Other disorders of the skin and subcutaneous tissue	L80-L99
Symptoms and signs involving the skin and subcutaneous tissue	R20-R23

Table A3. Circulatory and respiratory symptoms ICD-CM-10 codes

ICD Section Description	ICD Section
Symptoms and signs involving the circulatory and respiratory systems	R10-R19

Table A4. Ear disorder ICD-CM-10 codes

ICD Section Description	ICD Section
Diseases of external ear	H60-H62
Diseases of middle ear and mastoid	H65-H75
Disease of inner ear	H80-H83
Other disorders of ear	H90-H94

Table A5. Digestive symptoms ICD-CM-10 codes

ICD Section Description	ICD Section
Intestinal infectious diseases	A00-A09
Other diseases of the digestive system	K90-K95
Symptoms and signs involving the digestive system and abdomen	R10-R19

Table A6. Urinary disorder ICD-CM-10 codes

ICD Section Description	ICD Section
Urticaria and erythema	L49-L54
Urolithiasis	N20-N23
Other diseases of the urinary system	N30-N39
Inflammatory diseases of female pelvic organs	N70-N77
Noninflammatory disorders of female genital tract	N80-N98
Symptoms and signs involving the genitourinary system	R30-R39

Appendix B: Tables with full regression results for main cost per person analysis

Table B1. Average adjusted cost per person by episode type using 2SRI approach (differences in adjusted mean cost person comparing the sum of total costs per person for VUC episodes in which follow-up occurred versus episodes in which follow-up did not occur)

	Treatment effect	Standard Error	P-value	95% Confidence Internal
Follow-up recommended episodes	-168.37	45.84	0.005	-297.86, -38.89
Follow-up not recommended episodes	-27.64	26.81	0.125	-93.74, 11.42

Appendix C: Tables with results from sensitivity analyses

Table C1. Average unadjusted cost per person by episode type using ordinary least squares (differences in unadjusted mean cost person comparing the sum of total costs per person for VUC episodes in which follow-up occurred versus episodes in which follow-up did not occur)

	Treatment effect	Standard Error	P-value	95% Confidence Internal
Follow-up recommended episodes	-49.99	64.94	0.147	-221.57, 33.22
Follow-up not recommended episodes	-42.99	26.76	0.108	-95.49, 9.50

Table C2. Average adjusted cost per person by individual diagnosis among follow-up recommended episodes using 2SRI approach (differences in adjusted mean cost person comparing the sum of total costs per person for VUC episodes in which follow-up occurred versus episodes in which follow-up did not occur)

	Treatment effect	Standard Error	P-value	95% Confidence Internal
URI	73.92	29.97	0.014	15.18, 132.67
Skin	42.58	63.91	0.508	-85.39, 170.56
Circulatory/respiratory	-129.81	147.14	0.393	-422.50, 168.88
Ear	-135.92	358.78	0.708	-872.09, 600.24
Digestive	-130.23	526.34	0.805	-1161.83, 901.38
Urinary	45.95	150.02	0.759	-248.08, 339.98
All other diagnoses	-170.30	59.34	0.004	-286.62, -53.99

Table C3. Average adjusted cost per person by individual diagnosis among follow-up not recommended episodes using 2SRI approach (differences in adjusted mean cost person comparing the sum of total costs per person for VUC episodes in which follow-up occurred versus episodes in which follow-up did not occur)

	Treatment effect	Standard Error	P-value	95% Confidence Internal
URI	-8.43	5.09	0.099	-18.48, 1.61
Skin	-2.66	19.44	0.891	-41.19, 35.86
Circulatory/respiratory	85.63	139.47	0.541	-192.99, 364.26
Ear	31.00	33.54	0.368	-39.75, 101.77
Digestive	-80.98	236.65	0.732	-544.81, 382.84
Urinary	-3.65	27.30	0.894	-57.17, 49.86
All other diagnoses	-71.30	31.44	0.023	-132.92, -9.69

Table C4. Average adjusted cost per person (including episodes resulting in follow-up to VUC) by episode type (differences in unadjusted mean cost person comparing the sum of total costs per person for VUC episodes in which follow-up occurred versus episodes in which follow-up did not occur)

	Treatment effect	Standard Error	P-value	95% Confidence Internal
Follow-up recommended episodes	-126.43	25.75	0.01	-201.86, -17.37
Follow-up not recommended episodes	-7.96	26.81	0.51	-39.74, 16.62