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Usage and Impact of Information and Communication Technologies in Healthcare Delivery

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Abstract. This paper discusses two aspects of the use of information and communication technologies (ICTs) in healthcare: first, the prevalence of using tables and laptop computers by physicians during clinical visits and, second, the growing trend of using such technologies for delivering healthcare remotely. Phone interview data from a random sample of 1,600 individuals with diverse sociodemographic characteristics were collected. Open-ended and structured questionnaires were used to elicit relevant information, which was analyzed using qualitative content analysis and logistic regression models. Results suggest that, as computer literacy is increasing within the general population and caregivers' skills in using the computer technology is improving, patients are welcoming the use of ICTs in healthcare. The analysis also showed that age together with enabling factors, such as income and education, are substantial barriers to the use of remote care services, even more important than gender, place of residence, race or ethnicity, and care need. Income and education do not influence the acceptance of ICT use by doctors during visits. Females, older participants, and those with more children in the household showed more resistance to the use of ICT in healthcare. At the same time, the depersonalization of interactions with caregivers was a critical concern identified related to the use of ICT in healthcare.

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Keywords: health services and networks • service practice • service operations

Introduction

Healthcare expenditure accounts for a significant share of gross domestic product in many countries (for example, Germany [11.3%], Canada [10.4%], Japan [10.7%], and the United States [17.9%; Peterson–Kaiser[1]]). Meanwhile, during the last few years, there have been significant changes in how health services are delivered to patients. These changes include shift toward a more patient-centered delivery model (Danaher and Gallan 2016), the rise of consumerism in the healthcare market (Berry 2007, Krishnan et al. 2015, Shrank 2017), and the growing role of information and communication technologies (ICTs) in care delivery (Rouleau and Gagnon 2017). Patients now have access to information from many online sources regarding their symptoms and potential therapies and expect to be actively involved in their care decisions (Paluch and Blut 2013, Amante et al. 2015). Patients also expect more convenient and responsive care (Shrank 2017). Therefore, patient experience and satisfaction have become essential measures for healthcare in addition to clinical outcomes, such as infection rates and mortality (Jha et al. 2008, MacAllister et al. 2016).

Although the demand for responsive and convenient care is increasing, cost control of healthcare services continues to be a significant concern for both providers and patients. Furthermore, rising healthcare expenditures have been and are expected to be at the forefront of social and political debates in the United States, because new federal policies are expected to result in profound changes in healthcare expenditure priorities and coverage (Manchikanti and Hirsch 2016, Hirsch et al. 2017). The increasing demand for timely and convenient care accessible to all citizens on the one hand and the need for controlling the cost of services on the other hand have given rise to the use of ICT in health services to support care delivery strategies that meet both patients' needs and providers' financial goals (Barrett 2018). In particular, electronic health record technologies have emerged as an integral part of providers' efforts for improving coordination of care, reducing medical errors, enhancing patient-provider communications, and increasing efficiency (Chaudhry et al. 2006, Jarvis et al. 2013). The use of computers (either laptop and tablets) by

physicians during clinical visits (Frankel et al. 2005) to access electronic medical records and for entering follow-up orders (for example, prescriptions and laboratory work) has also increased (Hsu et al. 2005a). Moreover, electronic health record technologies coupled with the widespread use of tablets and smartphones by patients have resulted in a growing interest in using telemedicine services for diagnosis and delivery of care that do not require face-to-face contact (Mehrotra et al. 2013, Wünderlich et al. 2013) or when access to care is difficult for patients (Deslich et al. 2013).

Although ICT's use in healthcare delivery is growing, patient preferences for such technologies are becoming a critical factor for successful adoption (Deslich et al. 2013, Standing and Cripps 2015). Past studies have documented both negative and positive impacts of ICT on patient satisfaction (Johnson et al. 2004, Rolland et al. 2013, Duplaga 2015, Lee et al. 2015). Previous studies have explored the relationship between the adaption of and likeliness to use ICT and user's sociodemographic characteristics (Houston et al. 2004, Jung et al. 2011). The link between the use of healthcare services and individuals' predisposing characteristics, such as age and gender, and enabling resources has also been established (Andersen and Newman 1973). Our study further investigates the impact of demographic and socioeconomic status on preferences and perceptions of consumers regarding ICT application, specifically in the delivery of healthcare services.

Technology acceptance by consumers in the service industry has been extensively studied. Past research includes identification of drivers of technology acceptance (Wang et al. 2003, Perea y Monsuwé et al. 2004, Ranaweera et al. 2008, Ruiz Mafe et al. 2010, Blut et al. 2016, Tandon et al. 2016), empirical testing of technology acceptance model (Davis 1989) and technology readiness index (Parasuraman 2000, van Dolen and de Ruyter 2002, Tsikriktsis 2004, Lin and Chang 2011, Lin and Hsieh 2012, Parasuraman and Colby 2015, Ramkumar and Jenamani 2015), consumer reactions (Lanseng and Andreassen 2007, Wünderlich et al. 2013, Lee et al. 2015, Susskind and Curry 2016, Van Doorn et al. 2017, Wirtz et al. 2018), and impact on employees and consumer behaviors (Lee et al. 2009, Smith et al. 2014, Bridges and Hofacker 2016, Tandon et al. 2017, Viswanathan et al. 2017). Our paper attempts to make a further contribution to one specific topic area related to the above research theme. We explore the willingness to use technology in healthcare delivery settings from a patient's perspective. We further explore the relationship between ICT use and patients' sociodemographic characteristics.

Background

According to Mair et al. (2007), the four critical domains of healthcare affected by ICTs include management systems, communication systems, computerized decision support systems, and information systems. ICT applications in management systems, best exemplified by the use of electronic health records, allow for the acquisition, storage, and transmission of administrative or clinical activities performed in delivering care. Communication systems, such as email, mobile phones, and telemedicine services, allow more effective diagnostic, counseling, educational, and support services by facilitating communications among providers or between providers and patients. ICT applications, such as decision support systems, help health professionals practice within clinical guidelines by providing access to decision aid tools from computers, tablets, and mobile phones. Finally, information systems refer to the use of internet technology to access health-related information sources by providers and patients (Rouleau and Gagnon 2017).

For patients, perceived ICT benefits are reported to be faster access to less expensive care (as a result of faster appointment scheduling, shorter waiting time in the doctor's office, and eliminating travel to the doctor's office) (Padman et al. 2010, Albert et al. 2011, Roettl and Bidmon 2016), being able to talk more openly about health issues that might be embarrassing in face-to-face meetings (Albert et al. 2011), better coordination of care among caregivers (for example, between primary care general physician and specialists) (Mehrotra et al. 2013), and faster communication of caregivers and patients with pharmacies and laboratories (Hickson et al. 2015). However, patients' concerns include the risk of misdiagnosis, because physical examination is not possible (Mehrotra et al. 2013, Hickson et al. 2015); information security and breach of privacy (Albert et al. 2011, Jung et al. 2011); lack of insurance reimbursement (Tang et al. 2006, Padman et al. 2010); and the absence of in-person interactions with caregivers (Katz et al. 2003, Roettl and Bidmon 2016).

As mentioned in the last section, we seek to understand how demographic and socioeconomic characteristics of users impact their preferences regarding the application of ICTs in healthcare delivery. Two main theoretical frameworks can help understand the ICT utilization by patients, namely the behavioral model of access to medical care proposed by Andersen and Newman (1973) and the technology acceptance model introduced by Davis (1989).

According to Andersen and Newman (1973), use of health services by individuals depends on their predisposing characteristics, the enabling resources that are available to them, and their need. Predisposing characteristics refer to attributes that exist before an illness occurs, including demographic characteristics (such as age, gender, and ethnicity). Enabling resources refer to personal, family, or community

resources required to access health services. Finally, need refers to the illness level. Regarding the role of predisposing characteristics, studies have documented that female patients are more likely to use healthcare services involving ICT (Houston et al. 2004, Carrell and Ralston 2006, Nijland et al. 2009, Cohen and Stussman 2010, Jung et al. 2011, Mehrotra et al. 2013, North et al. 2014), whereas older patients were less likely to use such services (Jung et al. 2011, Mehrotra et al. 2013, Jung and Padman 2014). Race and ethnicity are also reported to impact the likelihood of using a service involving ICT, with whites being more likely to use such services than other ethnic groups (Weingart et al. 2006, Goel et al. 2011, Yamin et al. 2011, North et al. 2014). Regarding the role of enabling resources, being employed and having health insurance (Weingart et al. 2006, Adamson and Bachman 2010) as well as having higher education levels (Liederman et al. 2005, Mehrotra et al. 2013, Roettl and Bidmon 2016) enhance the use of health services involving ICT applications, whereas lower income reduces the use of such services (Brodie et al. 2000, Roettl and Bidmon 2016). Care need is also found to impact the likelihood of using services involving ICT (Hsu et al. 2005b), and studies have reported that patients with more doctor visits in the prior year (Mehrotra et al. 2013) or those with more complex a conditions (indicated by the number of diagnoses and medications) (Houston et al. 2004, Jung et al. 2011) are more likely to use care services involving ICT applications.

The technology acceptance model has also been developed to understand the factors that impact the acceptance of information technology in general. According to Holden and Karsh (2010), technology acceptance in healthcare depends on the following four factors: perceived usefulness, perceived ease of use, social influence or subjective norms (perception of essential or relevant other beliefs regarding the technology use), and perceived facilitation conditions (organizational and technological infrastructure and support). For patients, Holden and Karsh (2010) noted that all four acceptance factors are affected by individual and environmental variables. According to Or and Karsh (2009), about one-third of factors affecting ICT acceptance identified in literature have to do with sociodemographic characteristics of patients and their prior experience and exposure to computer or health technology. Regarding the role of sociodemographic characteristics, Or and Karsh (2009) reported that age is found to be negatively associated with technology acceptance in the majority of studies, whereas education is shown to have a positive relationship. Unlike age and education, gender was found to have no meaningful direct relationship with healthcare technology acceptance. However, previous research did not achieve consensus on how sociodemographic characteristics impact individual acceptance and reactions on ICT. For example, although Or and Karsh (2009) found gender irrelevant to individuals' technology acceptance, Adamson and Bachman (2010) reported higher acceptance by females, which is explained by their role as the primary family caretaker. Studies have also reported that an increase in care need is associated with increased acceptance and use of services involving ICT applications (Millard and Fintak 2002, Jeannot et al. 2004).

Although studies have documented the impact of age, gender, race, income, education level, and healthcare needs, the main shortcoming in existing research is that the collective and concurrent effect of sociodemographic variables on ICT preferences and choices is not confirmed. In other words, the adjusted impact of each sociodemographic variable controlling for other variables is not fully understood. For example, although an increase in age might increase the likelihood of having a negative reaction to ICT application in healthcare, increase in care need or complexity of conditions (Houston et al. 2004, Jung et al. 2011) with age might enhance the acceptance of ICT in healthcare.

Hypotheses

In this study, we use data from a diverse sociodemographic group to understand the concurrent effects of predisposing characteristics, enabling resources, and care need on respondents' reactions to ICT applications in healthcare. We focus on two main dimensions of ICT application in care delivery from patients' perspective: respondents' reactions to the physicians' use of tablets or computers during visits and respondents' willingness to use remote care services involving ICT applications.

Earlier studies of computer use by doctors have reported that patients might not have a favorable view regarding computer use by physicians for reasons such as depersonalization of the medical encounter and concerns regarding the privacy of patients' medical information (Rethans et al. 1988). However, it is not unexpected to see that, as computer familiarity and literacy are increasing in the general population (Als 1997, Frankel et al. 2005) and caregivers' skills in using such technology are improving (Duke et al. 2013), patients welcome and trust the use of computers (Lelievre and Schultz 2010, Strayer et al. 2010) or tablets (Houston et al. 2003) by caregivers during the visit. Regarding remote care service, studies conducted in the last few years suggest a growing trend toward using what is referred to as electronic office visits or eVisits (Hickson et al. 2015). In addition to innovations in smartphone technology and phone applications (Mehrotra et al. 2013, Viswanathan et al. 2017), a rise in patients' desire for electronic access to healthcare providers (Albert et al. 2011), growing popularity of home-based primary care (to avoid long waits in the physician's office

or limited clinic hours) (Rust et al. 2008), and increasing access to home-based diagnostics (for example, allergy symptoms, pregnancy tests, and tests for conditions like high blood pressure and blood glucose) (Shrank 2017) are affecting the use of electronic office visits. Many health insurance plans now cover visits that are entirely virtual (Mehrotra et al. 2013).

As for the relationships between age and the acceptance of healthcare ICT applications, although older adults might particularly benefit from the ICT applications (for example, communicating with their caregivers or using remote care services), they might be more concerned than other age groups with the depersonalization of their encounters (Strayer et al. 2010) or breach of privacy as a result of data security issues (Charness and Boot 2009, Dimitropoulos et al. 2011). However, younger individuals might perceive less difficulty (Wallin et al. 2015) and higher social motive (as a result of social influence or perceived social norm) for using the technology (Roettl and Bidmon 2016). In summary, we hypothesize the relationship between age and healthcare ICT use and acceptance to be negative.

Hypothesis 1. *Age has a negative relationship with the use and acceptance of healthcare ICT.*

Regarding gender differences, although studies suggest that women might be more likely to use services involving ICT applications as a result of their role as the primary family caretaker (Adamson and Bachman 2010), concerns regarding the security of information exchanged via ICT are reported to be higher among women than men, resulting in more resistance (Gadd and Penrod 2000). Women are also reported to experience more computer anxiety than men as a result of higher perceived internal (for example, ability to use the technology or perceiving that using the technology is within the individual's control) or external (for example, the availability of resources needed to use the technology) constraints in using it (Or and Karsh 2009). In other words, from the perspective of the technology acceptance model, perceived ease of use and perceived facilitation conditions might be lower in women than in men. As a result, we hypothesize the following.

Hypothesis 2. *Females are less likely than males to use and accept healthcare ICT.*

Consistent with the overall disparities in healthcare by race and ethnicity, studies have reported evidence of disparities in the adoption of healthcare ICTs (Weingart et al. 2006, Goel et al. 2011, Yamin et al. 2011, North et al. 2014). This disparity is attributed to the digital divide and inequality across racial and ethnic groups that still exist in the United States despite the increased availability of computers and internet access (Yamin et al. 2011, Robinson et al. 2015). Differences in computer literacy and perceived benefits of healthcare ICT are also reported to be the reason behind racial and ethnic disparities in the adoption of healthcare ICTs (Yamin et al. 2011). Thus, we hypothesize the following.

Hypothesis 3. *Whites are more likely than other race and ethnicity groups to use and accept healthcare ICT.*

Healthcare disparities and the digital divide between demographic groups in using healthcare ICTs are also reported on economic and educational lines (Brodie et al. 2000, Yamin et al. 2011). Groups with higher education and income levels usually have more prior experience and more literacy in using the technology than other groups, which enhance the perceived usefulness and perceived ease of technology use (Or and Karsh 2009). The following hypotheses are suggested regarding the relationship between education, income, and healthcare ICT acceptance and use controlling for other sociodemographic characteristics.

Hypothesis 4. *Income has a positive relationship with the use and acceptance of healthcare ICT.*

Hypothesis 5. *Education has a positive relationship with the use and acceptance of healthcare ICT.*

Finally, household size is also expected to affect the acceptance and use of healthcare ICTs. First, an increase in the number of individuals in the household can increase healthcare needs, enhancing the acceptance of care services involving ICT applications to facilitate organizing health records and communicating with caregivers. Second, larger household size is reported to be associated with higher use of broadband in the home (Prieger 2013), facilitating the use of healthcare ICTs. Thus, the following hypotheses are suggested for the relationship between household size and the acceptance and use of healthcare ICTs controlling for other demographic characteristics.

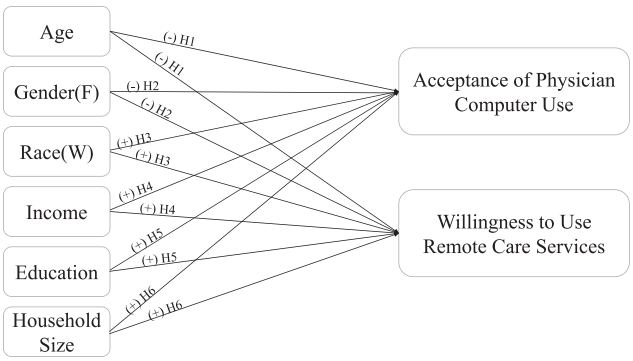
Hypothesis 6. *Household size has a positive relationship with the individual's use and acceptance of healthcare ICT.*

To better understand the effect of household size, we distinguished between the number of children (individuals under 18 years old), elderly individuals (individuals older than 65 years old), and adults between 18 and 64 years old.

Figure 1 presents our hypotheses in a more illustrative way.

Residence (residing in proximity to population centers), care need, social ideology (conservative, moderate, or liberal), and rating of most recent hospital visit are also included in the analysis as control variables to control for their potential impact on healthcare ICT preferences and choices.

Figure 1. Hypotheses Illustration



Research Methods

Multiple methods, such as field data collection (Devaraj et al. 2008), survey methods (Tandon et al. 2016), meta-analysis (Blut et al. 2016), and qualitative research methods (such as interviews) (Watanabe and Mochimaru 2017) have been used by previous research on technology usage and acceptance in service content. Among the articles that we sampled, survey is one of the most widely used methods. Tandon et al. (2016) used a survey to further extend the Unified Theory of Acceptance and Use of Technology 2 in the context of online shopping in India; Tsikriktsis (2004) sought to use survey data to extend an original theory on consumer technology readiness into a different (British) culture based on 117 customer sample. Weijters et al. (2007) conducted a survey to collect data on customers of a grocery retail chain to study their use of self-service technology; Ramkumar and Jenamani (2015) used a survey to further extend the technology acceptance model by investigating the impact of managerial interventions and user-level cognitive belief factors. In our study, we aimed to find empirical evidence of our hypothesis by studying consumers' perspective; thus, survey is an appropriate method in this context. Our data sample represents the actual population distribution in New York state, capturing people's perception of technology use in healthcare delivery.

Data

Data for this study were collected by the Survey Research Institute (SRI) at Cornell University as a part of its annual Empire State Poll (ESP), a general survey of adult New York state residents age 18 years old and over. The ESP is a combination of an annual core of the community, economic, and social science modules along with particular topical issue questions proposed by faculty members each year. In this study, data from 2016 and 2017, the 14th and 15th annual polls conducted by SRI, are used. The survey sample consisted of a dual-frame random digit dial telephone sample covering both cellular and landline exchanges for New York state. After a household was sampled, every adult had an equal chance to be included in the poll. Table 1 shows a list of questions used in this study.

In addition to the data on the questions listed in Table 1, the research team used a respondent's

Table 1. List of Interview Questions and Response Choices Used in This Study

Construct	Interview question	Response choices
Perceived impact of physician computer use on care[a]	Some doctors use computers in their appointments with patients. How do you think using this kind of technology during a visit impacts the care you receive? In this case, computers could include a laptop, smartphone, or tablet	Very negative impact Somewhat negative impact Has no impact on the healthcare I receive Somewhat positive impact Very positive impact My doctor doesn't use a computer
Preferred levels of medical care via technology	Care for many types of medical conditions could be delivered via mobile phone or tablet in the future. This can be care for minor health issues with little impact on your daily life, moderate health issues that interrupt your normal life, or major health issues that stops you from having a normal work life. Which levels of care, if any, would you prefer to receive through such technology?	Open ended[b]
Care need and utilization	How often during the last 12 months did you, as a patient, visit a care provider for a health problem or preventative care (like checkups)? This includes physical, mental, or dental health provided in any type of healthcare facilities	Never 1–2 times Once every few months Once a month Twice a month Once a week 2–3 times a week
Rating of last visit experience	How would you rate the overall level of customer service experience during your most recent visit to the healthcare facility?	Very poor Somewhat poor Average Somewhat positive Very positive

Table 1. (Continued)

Construct	Interview question	Response choices
Social ideology	When it comes to social issues, do you usually think of yourself as	Extremely liberal Liberal Slightly liberal Moderate or middle of the road Slightly conservative Conservative Extremely conservative
Age	What year were you born?	Age was calculated from the year of birth
Gender	Recorded by the interviewer	Male Female
Education level	What is the last grade or class that you completed in school?	None or grades 1–8 High school incomplete (grades 9–11) High school graduate (grade 12 or GED certificate) Technical, trade, or vocational school after high school Some college, no 4-year degree (including associates degree) College graduate (BS, BA, or other 4-year degree) Postgraduate training or professional schooling after college
Hispanic or Latino	Are you, yourself, of Hispanic origin or descent, such as Mexican, Puerto Rican, Cuban, or some other Spanish background?	Yes No
Race	What best describes your race? Please tell me yes or no for each of the following races: white or Caucasian; black or African American; American Indian, Aleut, Eskimo; Asian or Pacific Islander; other	Yes No To each race question (total of 5 questions)
Household size	How many total people in your household are adults (65 and older), adults (18–64), children (under 18)?	None. Respondents indicated the number of people in each age group separately
Household income before taxes	Two questions covered income. The first question asked interviewees what their total household income was in 2015 from all sources before taxes. Follow-up questions asked interviewees to, instead of a specific number, indicate if their total household income was under or over $50,000 and then, use a scale to indicate their income level. Best responses obtained from these questions were used to code income	

Note. Ratings of last visit experience and social ideology are included as control variables.
[a]In 2017, a follow-up open-ended question was included in the interview asking participants to explain their response.
[b]Only included in the 2017 survey.

self-reported county to designate the region (downstate, which includes Brooklyn, Manhattan, Staten Island, Bronx, Queens, Long Island and Rockland and Westchester Counties; or upstate, which includes all other regions) where participants live. A metropolitan statistical area (MSA) consists of the central county or counties containing the core urban area plus adjacent/outlying counties that have a high degree of social and economic integration with the central county as measured by commutation patterns. In our study, we also used subclassification of metropolitan statistical areas to determine a respondent's proximity to geographical areas with a relatively high population density, because the health status can differ significantly between rural populations and populations of those who live in metropolitan areas, and the concepts of place and rurality may be useful in the determinants of population health (Dixon and Welch 2000).

Telephone data collection began in February of each year and was completed in April. The average interview length for all modules was 23 minutes; only demographic and socioeconomic characteristic questions and questions relevant to our research are included in this study. Interviews were conducted in English and Spanish using a computer-assisted telephone interviewing software system. Before conducting each round of data collection, the SRI conducted a pilot survey with 25 participants in January of each year after receiving the Institutional Review Board approval from the Cornell University's Office of Research and Integrity Assurance.

Analysis

We used a mix of quantitative and qualitative methods to first statically test the relationship between sociodemographic characteristics and preferences regarding ICT applications in the delivery of care and then, understand why such relationships might exist. Table 2 shows the quantitative analysis models used in the study. Generalized linear model (GLM) with binomial distribution on a logit link is used on the potential

Table 2. List of Models Used in the Study

Outcome analyzed	Model title	Model outcome
Perceived impact of physician computer use on care	Model 1: positive impact[a]	The impact of sociodemographic characteristics on the odds of having a positive reaction vs. having a negative or impartial reaction
Preferred levels of medical care via technology	Model 2: willingness to use[b]	The impact of sociodemographic characteristics on the odds of being willing to receive care via computer or tablet vs. not being willing to receive such services
	Model 3: preferred level of care[c]	Adjusted probability of selecting each level of care and the impact of sociodemographic characteristics on the probabilities

[a]GLM procedure with binomial distribution on a logit link is used. After removing individuals who reported that their doctor does not use a computer, we grouped responses with positive connotations (very positive impact and somewhat positive impact) and responses with negative connotations (very negative impact and somewhat negative impact). A binary variable indicating the data collection year was include in the model to test if there is any difference between 2016 and 2017 responses.

[b]GLM procedure with binomial distribution on a logit link is used.

[c]This model uses data from respondents who indicated that they would be willing to receive care via computer or tablet technology. The dependent variable was the respondents' selection of each level of care (coded as a binary variable, with one indicating that the care level was selected and zero indicating that it was not). In addition to sociodemographic variables, a categorical variable with three levels (minor, moderate, and major) was entered into the model as a predictor. Estimated marginal means for this categorical variable would indicate the adjusted probability of selecting each level of care. The interaction of the categorical variable with other predictors would indicate the impact of sociodemographic variables on the probability of selecting each level of care. For Model 3, the generalized estimation equation model with binomial distribution on a logit link is used. Respondent's identification was used as the subject variable.

impact of physician computer use and willingness to use telemedicine. For preferred levels of medical care via technology, open-ended responses were coded to identify the levels of care, if any, that respondents would prefer to receive remotely through a computer or tablet; then, the generalized estimation equation model with binomial distribution on a logit link is applied.

In all models, we used estimated marginal means for different levels of categorical predictor variables to compare demographic groups. For example, in Model 1, estimated marginal means were used to understand whether males are more likely than females to have a positive reaction to the physician's use of computers or tablets.

To better understand the results of the quantitative analysis, we used follow-up comments provided by interviewees and applied qualitative content analysis to decode data patterns and cluster similar concepts into categories (Downe-Wamboldt 1992, Ruona 2005). Two members of the research team separately broke comments provided by each interviewee into units of information, which were then organized into categories (themes or topic domains) that emerged inductively from analyzing all responses. The initial coding and categories were evaluated by the entire research team, and then, the frequencies of topic domains and subdomains were calculated.

Results

Sample Characteristics

Eight hundred interviews were conducted each year. Table 3 shows the demographic characteristics of the study participants. The sample composition was almost the same in 2016 and 2017.

Descriptive Statics

Figure 2 shows the breakdown of responses regarding the impact of physician computer or tablet use on the quality of care.

Figure 2 shows that the responses from the 2016 and 2017 samples are identical. In both years, about 65% of interviewees indicated that the use of tablets or computers by doctors during visits has a very positive or somewhat positive impact on the care that they receive. Less than 11% indicated a negative impact on the quality of care.

As for receiving medical care remotely via technology, 75.9% ($n = 607$) indicated that they would use remote services for receiving some level of care, and 22.5% ($n = 180$) indicated that they prefer to visit a doctor in person. About 1.6% ($n = 13$) of participants did not answer this question. Among those who indicated that they are willing to use remote care services, 73.1% ($n = 444$) indicated that they would use such services for minor health issues, 34.1% ($n = 207$) indicated that they would use such services for moderate health issues, and 18.1% ($n = 110$) indicated that they would use such services for major health issues. Respondents were able to choose more than one level of care.

Impact of Demographic Characteristics on Healthcare ICT Acceptance and Adoption

Before running the models, we ran an ordinary linear regression model and used variance inflation factors to identify potential problematic multicollinearity among predictors. Variance inflation factors for predictor variables were less than three, indicating that

Table 3. Demographic Characteristics of Study Participants in 2016 and 2017

	No. of participants or mean		Percentage or standard deviation	
Demographic characteristics	2016	2017	2016	2017
Gender				
Female	392	394	49.0%	49.3%
Male	408	406	51.0%	50.7%
New York state region (control variable)[a]				
Downstate	400	400	50.0%	50.0%
Upstate	400	400	50.0%	50.0%
MSA (control variable)[b]				
In the center city of an MSA	318	507	39.8%	63.4%
Outside center city of an MSA (but inside county containing center city)	222	41	27.8%	5.1%
Inside a suburban county of the MSA	85	79	10.6%	9.9%
In an MSA that has no center city	99	94	12.4%	11.8%
Not in an MSA	76	79	9.5%	9.9%
Care need and utilization (control variable)[c]				
Never	—	75	—	9.4%
1–2 Times	—	275	—	34.4%
Once every few months	—	297	—	37.1%
Once a month	—	74	—	9.3%
Twice a month	—	48	—	6.0%
Once a week	—	14	—	1.8%
2–3 Times a week	—	15	—	1.9%
Education level				
None or grades 1–8	11	14	1.4%	1.8%
High school incomplete (grades 9–11)	56	29	7.0%	3.6%
High school graduate	185	170	23.1%	21.3%
Technical, trade, or vocational school after high school	20	18	2.5%	2.3%
Some college, no 4-year degree (including 2-year associates degree)	185	173	23.1%	21.6%
College graduate (BS, BA, or other 4-year degree)	192	226	24.0%	28.3%
Postgraduate training or professional schooling after college	149	165	18.6%	20.6%
Hispanic or Latino				
Yes	105	111	13.1%	13.9%
No	695	686	86.9%	85.8%
Race				
White or Caucasian	553	583	69.1%	72.9%
Black or African American	171	144	21.4%	18.0%
Asian or Pacific Islander	47	56	5.9%	7.0%
American Indian	19	39	2.4%	4.9%
Other races	45	27	5.6%	3.4%
Income level				
Less than $10,000	28	24	3.5%	3.0%
$10,000 to under $20,000	42	36	5.3%	4.5%
$20,000 to under $30,000	45	54	5.6%	6.8%
$30,000 to under $40,000	60	49	7.5%	6.1%
$40,000 to under $50,000	107	125	13.4%	15.6%
$50,000 to under $75,000	181	190	22.6%	23.8%
$75,000 to under $100,000	100	81	12.5%	10.1%
$100,000 to under $150,000	122	111	15.3%	13.9%
More than $150,000	89	106	11.1%	13.3%
Age	47.34	47.49	17.18	17.46
No. of adults 65 years old or older in the household[d]	0.26	0.26	0.53	0.62
No. of adults between 18 and 64 years old in the household[d]	1.13	1.14	1.16	1.21
No. of children (under 18 years old) in the household[d]	0.64	0.67	1.02	1.09

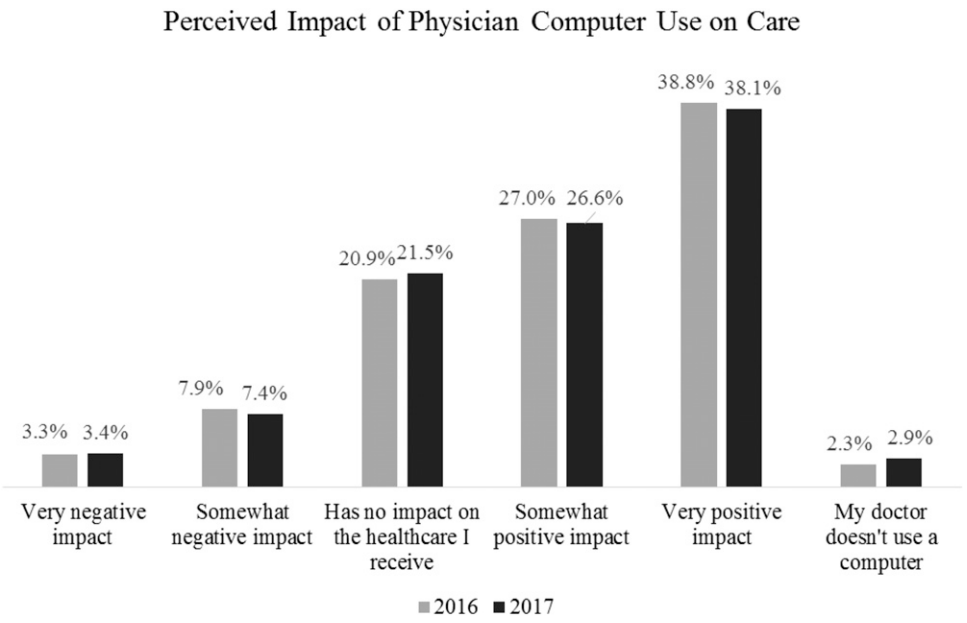
[a]Nine county regions were designated as downstate, including Westchester, Rockland, Bronx, New York, Richmond, Kings, Queens, Nassau, and Suffolk. All remaining counties were considered upstate.

[b]MSAs are delineated by the Office of Management and Budget and consist of a core area containing a substantial population nucleus (an urban area with at least 10,000 but less than 50,000 population) together with adjacent communities that have a high degree of economic and social integration with that core as measured by commutation patterns.

[c]This question was included in 2016, but response choices were coded differently.

[d]Does not include the interviewee.

Figure 2. Breakdown of Responses by the Perceived Impact of Physician Computer Use on Care



multicollinearity among predictors was not an issue in the analysis (O'Brien 2007). Table 4 shows the results of the analyses for each model.

In Model 1, controlling for all other sociodemographic characteristics, the odds of having a positive reaction to the physician's computer or tablet use during a visit becomes 1% lower with each one-year increase in age and 14% lower with the increase in the number of children in the household. Estimated marginal means also indicated that males were about 9% more likely than females to have a positive reaction. Hypotheses 1 and 2 are partially supported by Model 1.

In Model 2, controlling for all other sociodemographic characteristics, the odds of using remote care services becomes about 2% lower with increasing age and about 6% lower with an increase in the number of children in the household. Increases in income level increased the odds of using remote care services by about 11%. Estimated marginal means showed that individuals with the lowest level of education (those who did not complete high school) are 38% less likely than other groups to use remote care services. Hypotheses 1, 4, and 5 are partially supported by Model 2.

Finally, Model 3 results indicated that none of the sociodemographic variables are associated with preferences of care level to be received through remote care services. Adjusted probability for choosing minor health issues is 0.66 (95% confidence interval [95% CI] = 0.52, 0.77), adjusted probability for choosing moderate health issues is 0.26 (95% CI = 0.16, 0.38), and adjusted probability for choosing major health issues is 0.13 (95% CI = 0.07, 0.21). Pairwise comparison indicated that these differences were significantly different from each other at $p < 0.05$. In summary, Model 3 indicated that, across all sociodemographic groups, individuals are about five times more likely to choose remote care services for addressing minor issues than for addressing major issues. They are also about 2.6 times more likely to choose such services for minor issues compared wuth moderate health issues.

Themes That Emerged as Reasons Behind Preferences and Choices

In 2017, 605 interviewees provided additional explanation of their responses regarding the perceived impact of physicians' use of computer technology during a healthcare visit. From the content analysis of the comments, seven domains emerged covering positive aspects, and six domains emerged covering negative aspects. Table 5 shows the positive and negative domains and examples of quotes from the interviews.

Figure 3 shows the frequency of topics mentioned by interviewees regarding positive and negative aspects of physician use of computer technology during visits.

Discussion

This study focused on two critical aspects of the application of ICT in healthcare: the prevalence of using tablets and computers by physicians during healthcare visits and the growing trend of using such technologies for receiving care remotely. In particular, the analysis explored the role of sociodemographic characteristics on patients' reactions to physicians' computer or tablet use and preferences in using remote care services involving ICTs.

Table 4. Likelihood Ratio Chi-Squared Test Statistics for Model Parameters

Predictor (degree of freedom)	Model 1: positive impact	Model 2: willingness to use	Model 3: preferred level of care
Year (1)	0.98	n.a.[a]	n.a.[a]
Age	4.35 (–0.009)*	9.82 (–0.020)*	3.40
Gender (1)	8.23[b,*]	0.00	0.02
No. of individuals older than 65 years old in the household	0.54	0.13	0.05
No. of individuals between 18 and 65 years old in the household	0.04	0.45	3.42
No. of individuals younger than 18 years old in old in the household	5.98 (–0.155)*	0.52 (–0.065)*	0.70
Education level (4)	4.73	13.26[c,*]	7.27
Hispanic ethnicity (1)	2.14	0.26	0.71
Race: white (1)[d]	0.00	3.39	0.14
Race: black (1)[d]	0.47	1.42	0.07
Race: Asian (1)[d]	0.50	1.25	0.65
Race: other (1)[d]	3.04	1.05	0.52
Income level[e]	0.58	4.05 (0.103)*	0.09
Metropolitan status area (4)	3.74	1.91	2.66
Care need and utilization[f,g]	n.a.	1.92	1.00
Rating of last healthcare facility visit[g]	7.22 (0.162)*	5.65 (0.208)*	1.47
Social ideology (6)[g]	9.12	8.21	12.51
New York state region (1)[g]	0.98	3.42	0.32

Notes. For categorical variables, categories with less than 20 participants were combined with the next category. For example, the first two categories of educational level (none or grades 1–8 and high school incomplete) were merged. Parameter estimates in this table are only interpretable for continuous and ordinal variables. For categorical variables, estimated marginal means (not shown in the table) were used to compare different demographic groups. In Models 1 and 2, the likelihood ratio chi-squared test indicated that the models with explanatory variables included was an improvement over the intercept-only model. Model 1: χ^2 (28) = 52.3, $p < 0.05$; Model 2: χ^2 (28) = 68.6; $p < 0.05$. In Model 1, the interaction terms of year with the other variables were included in the analysis to examine differences between 2016 and 2017 data. None of the interaction terms were statistically significant at $p < 0.05$. Results shown here represent estimates form the more parsimonious model, excluding the interaction terms and with only the variables shown in the table. In Model 3, none of the variables representing the interaction of sociodemographic variables with the categorical variable indicating care levels were significant at $p < 0.05$. The interaction terms are not shown in the table.

[a]Models 2 and 3 only used 2017 data. Year was not included in the model.

[b]Estimated marginal means for males and females are 0.78 and 0.70, respectively. The difference was significant at $p < 0.05$.

[c]Estimated marginal mean for high school incomplete was 0.43. Estimated marginal mean for high school graduates was 0.68. Estimated marginal mean for some college degree and some schooling after high school was 0.70. Estimated marginal mean for college graduates was 0.78, and estimated marginal mean for those with postgraduate degrees was 0.76. Pairwise comparisons indicated that only the difference between the lowest educational level (high school incomplete) and the other groups was statistically significant at $p < 0.05$.

[d]Interviewees were able to select more than one race. Each race was entered in the models as a binary variable.

[e]Income level was included in the analysis as an ordinal variable

[f]Response choices in the question measuring this variable were coded differently in 2016 and 2017 surveys. As a result, it was excluded from Model 1. Two separate analyses were run using 2016 and 2017 data with this variable included in the models. The parameter did not reach the significance level of $p < 0.05$ in any of the two models.

[g]Entered in the analysis as control variables.

*Significant at $p < 0.05$. Values in parentheses shows parameter estimates (log of odds).

Only 11% of the participants reported a negative reaction to the use of computers or tablets by physicians during a visit, with concerns mostly regarding the depersonalization of the medical encounter. Perceived benefits, including improved medical record-keeping, enhanced care coordination, better access to caregivers, and improved reliability of information, outweighed the negative aspects cited by interviewees. Although the qualitative analysis uncovered six domains as reasons behind resistance to the acceptance of healthcare ICT, impersonal communication was by far the most frequently cited concern (expressed in about 14% of interviewees; 13% higher than the percentage of individuals who had a negative reaction to technology use by doctors). Although patients are welcoming and trusting of the use of ICT technology by caregivers, the main reasons behind the resistance to accepting such technology still remain the concerns that 1980s studies have reported, which include impersonal communications with caregivers (Cruickshank 1984, Rethans et al. 1988) and potentially reduced confidentiality (Pringle et al. 1984).

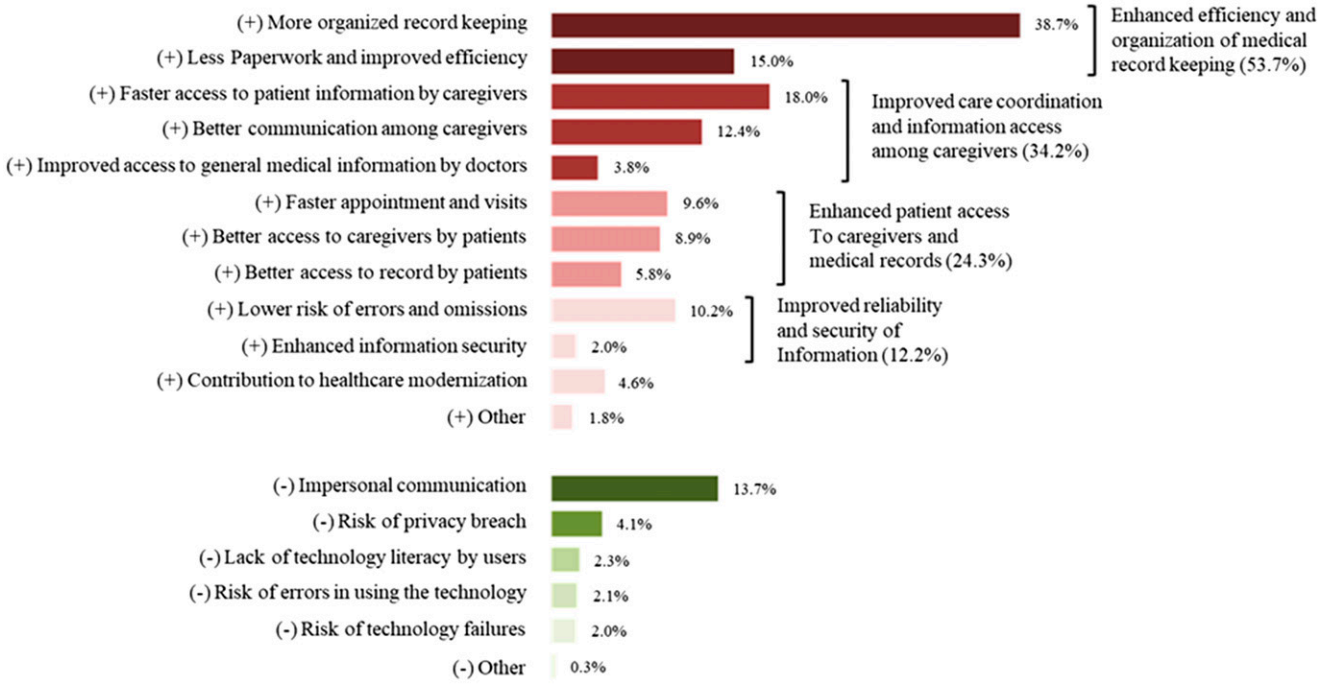
As for the use of ICT to receive care remotely, as expected, the majority of participants (more than 75%) indicated that they would consider using mobile phones or tablets for receiving care remotely, mostly for minor health issues. Willingness to use remote care service becomes considerably lower as the severity of care

Table 5. Domains and Themes That Emerged from the Content Analysis of the Comments Covering Positive and Negative Aspects of the Technology Use by Physicians During Visits

Major domains/themes	Subdomains	Example quotes from the interviews
Enhanced efficiency and organization of medical recordkeeping (+)	More organized recordkeeping	"My family doctor can record my documents in their system, where they can find my documents quickly and they can diagnose me very efficiently and professionally."
	Less paperwork and improved efficiency	"It allows him [my physician] to save information and is more efficient. We are past the paper age. Now records can be stored for years and years when we use a computer as opposed to paper."
Improved care coordination and information access among caregivers (+)	Faster access to patient information by caregivers	"All of my doctors are connected into the same system on the computer. Each provider is able to get an overall picture of our health from different offices."
	Better communication among caregivers	"I recently went to an eye doctor, and he was able to communicate with another physician about my records. It helps all doctors to work together."
	Improved doctor access to general medical information	"The physician has the ability to look up medication information and recent information on drugs that they might not know."
Enhanced patient access to caregivers and medical records (+)	Faster appointment and visits	"It's less time-consuming than taking handwritten notes. The appointments are quicker so you're in and out faster."
	Better patient access to caregivers	"My primary care physician uses an online portal, so we can communicate with each other that way, even if I'm not in her office."
	Better access to record by patients	"In terms of my medical records, doctors inputting that information gives me easier access to it. I can sign in online and access my records."
Improved reliability and security of information (+)	Lower risk of errors and omissions	"One thing that it's really good at is, the program will diagnose medical interferences. If someone's on a drug with one doctor, and the other doctor prescribes a different one, the computer will recognize that and say you can't prescribe it."
	Enhanced information security	"All of the medical information is in one place. It is very secure and you do not have to worry about others getting it."
Contribution to healthcare modernization (+)	—	"We live in a tech era now, so a lot of doctors need that."
		"These things have come along because they have proven their value."
Other reasons (+)	—	"It makes the process for the doctors easier for them."
		"In general it just makes the process easier and faster."
Impersonal communication (–)	—	"Each person is not an object, they're a human being. It needs a human touch. I'm not too much on computer."
Risk of privacy breach (–)	—	"The banks and government are being hacked. I don't think my healthcare practitioner is an expert on firewall."
Lack of technology literacy by users (–)	—	"I'm not much of a tech person. I hate computers so I have to call my daughter to ask her to help me."
		"The doctors still struggle with the technology occasionally."
Risk of errors in using the technology (–)	—	"They get a lot of things wrong because they are typing so fast. They got a lot of things incorrect in medical records. If one doctor gets one thing wrong, it is very hard to correct."
Risk of technology failure (–)	—	"It should all be written down on paper. Computers can crash and stop working and then everything is gone."
Other reasons (–)	—	"They had my records almost 50 years and on paper they have only had 5 years on the computer."

needs increases. Although remote care services may improve fast access to care, studies have shown that willingness to use such services for moderate and significant health issues is influenced by a complex mix of factors that dwarf fast access, because patients might still prefer to wait longer to see their doctor of choice rather than having a speedy appointment (Gerard et al. 2008).

Figure 3. (Color online) Positive and Negative Aspects of Physician Use of Computer Technology During Visits



Although the majority of our study participants had a positive reaction to physician computer or tablet use during a visit and indicated their willingness to use remote care services, statistical analysis found essential differences based on sociodemographic characteristics. Among predisposing characteristics suggested by Andersen and Newman (1973), age and gender affect reactions to physicians' computer or tablet use. As expected, females in our sample were less likely to have a positive reaction, and age had a negative relationship with the patient's acceptance of such technology during visits. Although the analysis of comments submitted by interviewees showed no difference between males and females or among age groups in their concerns regarding the breach of privacy, we found that females are twice as concerned with the depersonalization of their encounters as males (18.6% versus 8.9%), and individuals 50 years old and older were three times more concerned with this issue than individuals between 18 and 29 years old (17.9% versus 6.7%).

In our study, age also had a negative relationship with the willingness to use remote care services. Other than the role of better skills in using the technology in younger age groups, the analysis of comments provided by interviews seems to support the notion that younger individuals have lower resistance toward using the technology because of perceived norms (Roettl and Bidmon 2016). About 28 interviewees indicated that technology had proven its benefits and that using it in healthcare is necessary to enhance the quality of care services and modernize it. Although this is not even 5% of participants, the majority of the individuals who pointed to the need for adopting the technology as a norm belong to the younger age groups (11 individuals between 18 and 29 years old and 8 individuals between 30 and 49 years old). Although it was expected to see more willingness among males than females to use technology for receiving care remotely, we found no difference. This finding, although unexpected from the technology acceptance model perspective, is consistent with healthcare ICT studies noting that, although perceived behavioral control in using technology might be lower among women, men and women might not be different in seeking care remotely via technology (Adamson and Bachman 2010, Jung and Padman 2014).

Regarding the role of household size, although we expected this variable to have a positive relationship with the acceptance of healthcare ICTs, only the number of children (individuals younger than 18 years old) in the household was a significant (inverse) predictor of ICT acceptance. Analyzing comments submitted by interviewees, we found that an increase in the number of children in the household has a positive correlation with the number of times that the interview participants cited the risk of privacy breach or technology failure as their concerns. The relationship between the number of children in the household and use of remote care services is not well investigated in the literature, and the number of children at home is mostly included in previous ICT studies as a control variable that often

does not reach significance levels in the statistical tests (Goldfarb and Prince 2008, Hambidge et al. 2011, Homko et al. 2012). Nevertheless, health behavior studies suggest that living in smaller households is associated with more regular checkup care visits (Arcury et al. 2005). In our study, the majority of participants will use remote care services for minor health issues. From the health behavior perspective, it is understandable that more parenting responsibilities lower the possibility of seeking care for their minor issues. Note that our study only includes individuals older than 18 years old and asked them to indicate whether they use remote care services for their own health needs.

We found that education and income levels have a positive relationship with the likelihood of using remote care services, but care need had no impact, indicating that, when it comes to the use of ICT technology, care need plays a less important role than enabling factors. First, those with lower income or education level might not have health insurance that covers remote care services. Second, from the perspective of the technology acceptance model, perceived usefulness and perceived ease of use tend to be higher in economically advantaged individuals with higher education levels and more literacy in using the technology. Commonly known as a digital divide between low-income and high-income populations, the disparity on economic and educational lines in using online resources for receiving health information has been documented and reported in previous studies (Brodie et al. 2000, Yamin et al. 2011). However, our study did not provide any evidence on the disparity based on the race or ethnicity of participants or proximity to population centers, suggesting that age, income, and education are ultimately more important barriers to using remote care services than the place of living and race.

Finally, we found no differences in the acceptance of physician computer or tablet use based on income, education level, proximity to a population center, or ethnicity of interviewees. In other words, none of those enabling factors were significant in the presence of such essential factors as age and gender. We conclude that, unlike the adoption of ICT for receiving care remotely in which evidence of disparity existed based on income and education levels, no such divide was found in participants' acceptance of ICT use by doctors during visits.

Practical Implications

Although providers might be concerned that the introduction of computers or tablets into patient consultations might lead to a breakdown of patient-caregiver communications, our study found that the majority of participants had a positive reaction to physician computer or tablet use. Females, older individuals, and those with children in the household held less favorable attitudes toward the physician computer or tablet use during a healthcare visit. To reduce this gap and maximize the benefits of using tablets or computers during the visit, providers serving populations with such characteristics may consider providing information to patients regarding the potential benefits of using ICT, including cost- and time-saving opportunities. More important, providing training for caregivers on the proper use of computers and tablets can help providers improve patient-centered communications while using such technologies for integrating electronic health records into the medical visit (Duke et al. 2013). Ultimately, computers and tablets are merely tools in the hand of doctors, and it is the personality of the doctor that makes him or her more or less personable to patients (Rethans et al. 1988, Levinson et al. 2010). Physicians should be trained to always explain to patients what they are doing when using such devices (McCord et al. 2009). For example, comments by our study participants and findings from previous studies indicate that using tablets or computers to show and share information regarding care and treatment with patients can enhance patient learning, efficacy, and satisfaction with care (Reychav et al. 2016). Moreover, using electronic medical records for faster access to patients' background and history can help physicians spend more time communicating with patients regarding their current health state and enhance satisfaction with care (Mwachofi et al. 2016). In contrast, if physicians spend excessive time on tablets or computers entering and documenting records during the visit, it will negatively impact satisfaction with care.

Our study specifically showed the role of healthcare ICT as a viable tool for providing care remotely, especially for minor health issues. From a financial perspective, virtual services can help providers combat loss of revenues from the reduction of visits to physician offices or hospital clinics for minor health issues or primary care needs. Providers may consider a patient's home as an extension of the physician's office or examination room, where a patient's history may be taken and diagnostic tests can be performed (Saver and Peterfreund 1993). Other than home-based diagnostics, such as allergy symptoms, pregnancy tests, and tests for conditions like high blood pressure and blood glucose, sinusitis and urinary tract infection are among the most common reasons that patients might use remote care services (Shrank 2017). Some interviewees who provided an additional explanation regarding the type of conditions for which they prefer to receive care via technology named a skin condition, the common cold, routine checkups or

follow-ups, prescription refills, consultations with caregivers regarding laboratory test results, and minor infections that can be alleviated using medications. However, it should be noted that patients, especially older adults (whom we found to be more resistant to using remote care services), are willing to use novel methods of receiving care only when they trust their physician or care provider and have an established medical relationship with them (Husebo and Storm 2014). This is evident in our study, because we found that experience of previous visits has a robust positive relationship with the acceptance and use of healthcare ICT by consumers controlling for the effect of all sociodemographic variables. Similarly, for moderate and major health issues, patients might still prefer to wait longer to see a doctor of choice than receive care sooner from whichever physician is available (Gerard et al. 2008).

Finally, our study found that people at lower income and educational levels probably experience more barriers to using remote care services than other groups. In other words, although the main idea behind providing such services has been to serve timely, affordable, and convenient care (Prinz et al. 2008), our study found that healthcare disparities continue on income and educational lines in New York state. The impact of expected changes to healthcare coverage on healthcare disparities should be investigated in future studies.

Limitations and Future Research Directions

Our study has its limitations. Although the large sample size permitted us to investigate the impact of various demographic characteristics on the choice of an outpatient care setting and a patient's perception of physicians' computer use, our study focuses on New York state residents. Although the sample was demographically and geographically diverse, generalization of findings should be made with caution. Also, we did not have data on health insurance coverage of our study participants, and although we included self-reported income level in the analysis as a variable that would highly correlate with insurance status, it was difficult to draw accurate conclusions regarding the effect of health insurance on the willingness to use remote care services.

Lastly, one thing to be noted is that some of our findings confirmed previous research, whereas others are conflicted with them. Because our findings are limited to our research scope, implications may be further broadened if future study pushes the research boundary to generalize those findings.

Conclusions

This study highlights the growing interest in and acceptance of healthcare ICT by consumers. Perceived benefits, such as improved medical recordkeeping, enhanced care coordination, better access to caregivers, and improved reliability of the information, outweighed concerns, which included depersonalization of interactions with caregivers. For minor health issues and primary care services, using ICTs can be a viable option for delivering convenient and timely care to a larger population, and ICTs can help providers combat part of the loss of revenue from reductions in visits to physician offices or clinics. However, our analysis indicated that age, income, and education are substantial barriers to the use of remote care services by consumers and that they are even more important than gender, residence, race or ethnicity, and care need. As for the acceptance of ICT use by doctors during visits, no divide based on income or education was found, and the majority of participants indicated that such technology enhances the quality of care.

Nevertheless, females and older participants expressed more concerns regarding the lack of personal interactions with caregivers when ICT is used during visits. An increase in the number of children in the household seems to lead to more concerns regarding the security of information and technology failure. Providing training to caregivers in communicating the nature and purpose of using computers and tablets during visits can help reduce these concerns.

Endnote

[1] See https://www.healthsystemtracker.org/indicator/spending/health-expenditure-gdp/ (accessed January 31, 2019).

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