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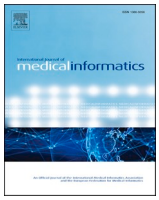

The relationship between telemedicine tools and physician satisfaction, quality of care, and patient visits during the COVID-19 pandemic

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ABSTRACT

Objective: The objective of our study is to investigate the impacts of telemedicine technology and its specific tools on physicians' overall satisfaction, quality of care, and percentage of patient visits in ambulatory care settings after the COVID-19 lockdowns.
Materials and methods: Data for our analysis was sourced from the 2021 annual National Electronic Health Records Survey (NEHRS), which included 1,875 complete questionnaire responses from physicians in the 2021 NEHRS. We used regression models to test the effects of telemedicine on physicians' overall satisfaction, quality of care, and percentage of patients' visits.
Results: We report that telemedicine technology has significant positive effects on physicians' satisfaction with telemedicine and quality of care evaluation, both at an aggregate level and at the disaggregate levels of individual telemedicine features, and partially significant effects on patients' telemedicine visits.
Discussion: Telemedicine features that contributed significantly to physician satisfaction and quality of care evaluation were telephone, videoconferencing, standalone telemedicine platform, and telemedicine platform integrated with EHR, while only telephone and integrated telemedicine platform contributed significantly to patients' telemedicine visits.
Conclusion: For telemedicine research and practice, this study confirms that telemedicine improves physician satisfaction and quality of care perceptions and will therefore be preferred by physicians. However, telemedicine has a mixed impact on percentage of patient visits, which suggests that providers may have to work harder to regularize telemedicine acceptance among patients in the post-COVID era.

1. Introduction

Mandatory lockdowns and shelter-in-place orders during the recent Coronavirus (COVID-19) pandemic have accelerated the adoption of telemedicine for remote consultation, diagnosis, and care [1]. Since the start of the pandemic in the first quarter of 2020, the telemedicine industry has shown significant growth, resulting in 154 % increase in remote appointments compared to the same period one year earlier (first quarter of 2019) [2]. During the pandemic, telemedicine became not only an alternative to traditional in-person care but also the only available mode for delivering healthcare services and the lifeline of many patients, especially those in high-contagion and remote areas [3].

Telemedicine is the use of electronic information and communications technologies to provide and support health care when providers and recipients are separated by distance [4]. It is not a new technology and has been in used over the last two decades for rural care and at the United States Department of Veterans Affairs (VA) [5]. Telemedicine offers many benefits for physicians and patients, including reduced travel time and costs, broader access to clinical specialists, easier sharing of medical records, and reduced costs of facilities management [6]. However, it also has several limitations such as limited scope of physical examination and inadequate interaction between physicians and patients [7], and may require changes in clinical workflows, care team composition, and insurance reimbursement procedures [8]. Not surprisingly, telemedicine adoption remained relatively low before the COVID-19 pandemic [9].

Prior telemedicine research can broadly be divided into five categories: (1) adoption of telemedicine in different healthcare settings or specialties [10], (2) barriers, facilitators, and antecedents of telemedicine adoption [11], (3) patients' experience with telemedicine [12], (4)

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physicians' experiences with telemedicine [13], and (5) comparison of service quality with traditional in-person care services [14]. However, the technological components or features of telemedicine (both communication media and platform) and their impacts on physicians' practices or experiences remain unexplored. Physicians and patients may not want to use this technology if they are dissatisfied with its features [15]. Though prior studies have investigated the impact of telemedicine on quality of care and patients' and physicians' satisfaction [e.g., 16–18], the relationships between specific telemedicine technology features and physicians' satisfaction, and quality of care evaluation or patient visits have received limited attention. Our study addresses this gap in research literature.

We focus our telemedicine analysis on ambulatory care (outpatient) settings, which faced particular challenges during, and after COVID-19 because many small physician practices did not have the infrastructure or capability to adopt remote or virtual care models. Rumball-Smith et al. [19] reported that 40 % of ambulatory care practices are "under-users" of health information technology. Relatively few studies have examined the use of telemedicine in ambulatory care settings, in contrast to inpatient settings [20]. In light of the above gaps in the literature, the research question of interest to this study is:

> *What are the relationships between telemedicine technology features (e.g., telephone audio, videoconferencing, telemedicine platform integrated with EHR, etc.) and physicians' satisfaction, quality of care, and percentage of patient visits in ambulatory care settings during the COVID-19 pandemic?*

We answer the above question using data from the 2021 National Electronic Health Records Survey (NEHRS) dataset [21]. This data is analyzed statistically to empirically evaluate the effects of specific telemedicine features on physicians' satisfaction, quality of care and percentage of patients' visit. Our analyses provide full support for the first two dependent variables and partial support for the third. Implications of our findings for theory and practice are discussed.

2. Literature review

Although telemedicine technology has been available for decades, it was never really utilized by physicians or patients until the COVID-19 pandemic, which imposed a severe constraint on in-person patient-physician interactions. Telemedicine can help physicians and/or patients in at least four ways. First, it allows physicians to reach a broader patient population including those with limited access to healthcare services and deliver care regardless of geographical boundaries [6]. Second, virtual consultations can help physicians save time for physical visits, allowing them to serve more patients in shorter time, optimize scheduling, and improve workflow [6]. Third, telemedicine may enable physicians monitor their patients remotely, allowing for proactive and continuous care management, which can lead to early detection of health problems, timely interventions, and improved patient outcomes [6] leading to increased physician satisfaction. Physician satisfaction is affected by physician "burnout", a phenomenon prevalent in physicians which can have a negative influence on patient care [28]. Research shows that physicians at the front line of care, like ambulatory practice, report the highest rates of burnout [29]. There has been scant research on experience from care providers i.e., physicians' point of view particularly in context of ambulatory care facilities. Our research fills this existing gap in physician satisfaction related research. Fourth, telemedicine can help physicians lower their overhead costs by minimizing the need for physical office space, staff, and administrative tasks associated with in-person visits [6]. For patients, telemedicine reduces travel costs and time off work, and increase accessibility of healthcare.

However, the sparse utilization of telemedicine before COVID-19 may relate to its many adoption barriers [22] among physicians and patients. The first barrier to telemedicine adoption among physicians is their resistance to adopting new workflows required by the new technology, relative to traditional face-to-face consultations. Some physicians may worry about the quality of care of remote healthcare services. Since telemedicine visits cannot employ physical examination of patients, physicians will have to make recommendations based on limited information provided by patients, who may be unaware of important signs or symptoms pertinent to their medical condition. Second, there may be uncertainty about reimbursement for telemedicine services. Third, some physicians may lack the necessary resources or technical support to set up and maintain their telemedicine infrastructure, including appropriate hardware, software, and secure internet connectivity. Fourth, physicians may have concerns about the security of electronic health records, video consultations, and transmitting patient information over digital platforms. This is paramount after the 1996 Health Insurance Portability and Accountability Act (HIPAA) that mandates physicians to protect patient data and maintain confidentiality of patients under all circumstances [23]. Lastly, unlike EHRs, telemedicine adoption in the United States was never incentivized by any national policy. Although COVID-19 forced telemedicine adoption, the lack of incentives may have translated into lower utilization of telemedicine beyond the pandemic.

Similarly, patients may also face several barriers [22] to telemedicine adoption. Economic disparities and technological illiteracy can pose significant barriers to adoption. Not all patients are comfortable with telemedicine consultations using smartphones or computers, and some may not have high-speed Internet or data services. Patients unfamiliar with using digital platforms or lacking technological skills may struggle to navigate telemedicine interfaces or unable to resolve technical issues during a telemedicine consultation. Second, some patients may prefer in-person physician interactions, as personal connection, physical examination, and non-verbal cues can be harder to convey through telemedicine. Third, patients may be concerned about the coverage and cost of telemedicine services, such as extent of insurance reimbursement or out-of-pocket expenses for telemedicine visits. Lastly, cultural differences and communication barriers may also affect the effectiveness of remote healthcare interactions.

In the post-COVID-19 world, when much of corporate work has remained online, a significant portion of medical consultations have moved back to the pre-pandemic in-person model. To understand why telemedicine did not remain the main mode of healthcare delivery, at least in the United States, despite its many demonstrated benefits during the pandemic, it is important for us to examine how telemedicine and its individual features have impacted physicians' preferences.

3. Materials and methods

3.1. Data

Data for our analysis was sourced from the 2021 annual National Electronic Health Records Survey (NEHRS) [21]. NEHRS is a nationally representative survey of office-based ambulatory care physicians that documents EHR adoption and use, physician practice information, practices for controlled substances, use of health information exchanges, use of telemedicine technology, and medical record systems. The survey questionnaire includes 32 primary questions, further divided into many sub-questions. A total of 10,302 responses from physicians were received for the 2021 NEHRS survey. Of the 10,302 responses in the 2021 survey, 1,875 respondents answered one or more telemedicine-related questions, which constituted the data set for this study. The unit of analysis in this study was the provider.

3.2. Variables

The three dependent variables examined in this study are physicians' satisfaction with telemedicine use for patient visits (TelemedSatisfaction), physicians' perception of the quality of care delivered using telemedicine relative to face-to-face patient visits

Table 1
Descriptive statistics.

	Variables	Statistics
Dependent variables	TelemedSatisfaction (5-point Likert scale from Very Satisfied to Very Dissatisfied)	Mean = 3.478; Std. Dev. = 1.158
	TelemedQuality (5-point Likert scale from Fully to Not at All)	Mean = 3.053; Std. Dev. = 0.879
	TelemedVisitPct (5-point scale: 75 % or more, 50 ~~to~~ –74 %, 25 % ~~to~~ –49 %, less than 25 %, None)	Mean = 2.642; Std. Dev. = 0.930
Telemedicine features	TelemedFeatures (Cumulative:)	
	TelemedFeature1: Telephone audio (Binary)	Yes = 67.91 %; No = 32.09 %
	TelemedFeature2: Videoconferencing (Binary)	Yes = 57.42 %; No = 42.58 %
	TelemedFeature3: Telemedicine platform NOT integrated with EHR (Binary)	Yes = 43.37 %; No = 56.63 %
	TelemedFeature4: Telemedicine platform integrated with EHR (Binary)	
	TelemedFeature5: Others (Binary)	Yes = 27.67 %; No = 72.33 % Yes = 1.96 %; No = 98.04 %
Telemedicine barriers	TelemedBarriers (Cumulative:)	
	TelemedBarrier1: Limited Internet access/speed (Binary)	Yes = 35.40 %; No = 64.60 %
	TelemedBarrier2: Difficult to use telemedicine platform (Binary)	Yes = 17.85 %; No = 82.15 %
	TelemedBarrier3: Poor fit between telemedicine and work (Binary)	
	TelemedBarrier4: Limited patients' access to technology (Binary)	Yes = 26.01 %; No = 73.99 %
	TelemedBarrier5: Patients' difficulty in using telemedicine) (Binary)	Yes = 66.20 %; No = 33.80 % Yes = 70.80 %; No = 29.20 %
Telemedicine facilitator	TelemedFacilitator (Easier reimbursement for telemedicine visits: Binary)	Yes = 46.44 %; No = 53.56 %
Physician demographics	PhysSpecialty (Physician specialty: Multinomial)	Primary care = 48.69 %; Surgical = 21.97 %; Medical = 29.33 %
	Gender (Physician gender: Binary)	Female = 32.69 %; Male = 67.31 %
	AgeGroup (Physician age group: Binary)	Under 50 years = 34.88 %; 50 years and above = 65.12 %
Facility characteristics	NumofPhysician (Number of physicians in facility: Ordinal)	1 physician = 23.09 % 2–3 physicians = 19.63 % 4–10 physicians = 29.76 % 11–50 physicians = 15.57 % More than 50 physicians = 11.95 %
	PrivSoloGroupPrac (Type of practice: Binary)	Private solo or group practice = 70.35 % Other = 29.65 %

(TelemedQuality), and percentage of patients visits conducted through telemedicine technology as a proportion of overall ambulatory care visits (TelemedVisitPct). Means and standard deviations of these variables are shown in Table 1.

Independent variables in our study included five telemedicine features that physicians could use during their telemedicine interaction with patients: telephone (audio only), videoconference (e.g., Zoom, Webex, FaceTime), stand-alone telemedicine platform not integrated with EHR (e.g., Doxy.me), telemedicine platform integrated with EHR (e.g., EHR allowing clinical documentation update during telemedicine visit), and "others" (undefined). Proportions of telemedicine technologies that included these features among surveyed physicians are shown in Table 1. In addition, we also examined the overall effect of all five telemedicine features combined as a singular construct (TelemedFeature).

We controlled physician's demographics (gender and age group), type of practice, number of physicians working in the practice facility, physicians' specialty type, and presence of barriers and facilitators to telemedicine utilization in our analysis. We had data on three types of telemedicine barriers faced by physicians (technical limitations such as speed or bandwidth of Internet access, difficulty in using the telemedicine platform, and lack of fit between telemedicine and physicians' work), two barriers faced by patients (limited patient access to technology and patients' difficulty using technology or telemedicine platform), and one telemedicine facilitator (easier third-party reimbursement for telemedicine visits). Descriptive data on these variables are also provided in Table 1.

3.3. Data analysis

We used ordinary least squares (OLS) regression to test the effects of telemedicine on physicians' satisfaction, quality of care, and percentage of patients' visits, while controlling for other variables which might influence the dependent variables. Equation (1) shows the estimated model for the aggregate effects of all telemedicine features, while Equation (2) shows the disaggregated effects of each telemedicine feature considered separately.

$$y_i = \beta_0 + \beta_1 TelemedFeatures_i + \beta_2 TelemedBarriers_i + \beta_3 TelemedFeatures_i{*}TelemedBarriers_i + \beta_4 TelemedFacilitator_i + \beta_5 TelemedFeatures_i{*}TelemedFacilitator_i + \beta_6 Gender_i + \beta_7 AgeGroup_i + \beta_8 PrivSoloGroupPrac_i + \beta_9 NumofPhysician_i + \beta_{10} PhysSpecialty_i + \varepsilon_i \quad (1)$$

$$y_i = \beta_0 + \beta_1 TelemedFeature1_i + \beta_2 TelemedFeature2_i + \beta_3 TelemedFeature3_i + \beta_4 TelemedFeature4_i + \beta_5 TelemedFeature5_i + \beta_6 TelemedBarrier1_i + \beta_7 TelemedBarrier2_i + \beta_8 TelemedBarrier3_i + \beta_9 TelemedBarrier4_i + \beta_{10} TelemedBarrier5_i + \beta_{11} TelemedFacilitator_i + \beta_{12} Gender_i + \beta_{13} AgeGroup_i + \beta_{14} PrivSoloGroupPrac_i + \beta_{15} NumofPhysician_i + \beta_{16} PhysSpecialty_i + \varepsilon_i \quad (2)$$

Table 2
Beta coefficients (standard errors) for aggregate models.

Variable	TelemedSatisfaction	TelemedQuality	TelemedVisitPct
TelemedFeatures (count)	1.597*** (0.340)	1.167*** (0.255)	0.813** (0.281)
TelemedBarriers (count)	−0.987*** (0.266)	−0.704*** (0.200)	0.106 (0.223)
TelemedFeatures * TelemedBarriers	−0.712 (0.617)	−0.353 (0.465)	−0.114 (0.519)
TelemedFacilitator	0.566*** (0.136)	0.388*** (0.103)	0.143 (0.115)
TelemedFeatures * TelemedFacilitator	−0.233 (0.312)	−0.096 (0.236)	−0.032 (0.263)
Specialty: Surgical (vs Primary care)	−0.215** (0.076)	−0.276*** (0.058)	−0.065 (0.064)
Specialty: Medical (vs Primary care)	0.183** (0.061)	0.231*** (0.046)	0.498*** (0.052)
Gender: Male (vs Female)	−0.189*** (0.058)	−0.025 (0.044)	−0.134** (0.049)
Age: 50+ years (vs Under 50 years)	−0.109 (0.057)	−0.085* (0.043)	0.055 (0.048)
Number of Physicians:			
2–3 physicians (vs 1 physician)	−0.305*** (0.087)	−0.187** (0.065)	−0.123 (0.073)
4–10 physicians (vs 1 physician)	−0.243** (0.078)	−0.156** (0.059)	−0.185** (0.066)
11–50 physicians (vs 1 physician)	−0.281** (0.092)	−0.206** (0.069)	−0.126 (0.078)
50 + physicians (vs 1 physician)	−0.263** (0.101)	−0.194* (0.076)	−0.139 (0.085)
Practice Type:			
Other (vs Private solo or group)	0.113 (0.061)	0.069 (0.046)	0.117* (0.051)
Intercept	3.541*** (0.155)	2.970*** (0.117)	2.235***(0.129)
Adjusted R-squared	0.1582	0.1631	0.104
Number of observations	1618	1621	1562
F Score	22.7	23.55	13.95

***p < 0.001, **p < 0.01, *p < 0.05.

where y_i represents *TelemedSatisfaction* or *TelemedQuality* or *TelemedVisitPct* for physician *i*, *TelemedFeatures* in Equation (1) represents the aggregate of all five telemedicine features, and $TelemedFeature1_i$ through $TelemedFeature5_i$ in Equation (2) represent the five telemedicine features in Table 1. Note that Equation (1) has two interaction terms, which were dropped from Equation (2) on account of their non-significance. The results of these analyses are shown in Tables 2 and 3.

Because the dependent variables were measured using a 5-point Likert or interval scales, it may be questioned whether OLS regression is the ideal technique for our study. To counter this argument, we also evaluated our model using ordered logit and ordered probit regression models. The results of these analysis are largely consistent with that of OLS regression, attesting to the robustness of our observed OLS results. To conserve space, the ordered logit and ordered probit results are not reported in the paper but are available from the authors upon request. To check the robustness of our observed OLS results we also conducted multiple robustness tests.[1] The outcomes of these robustness tests are largely consistent with our OLS results. To conserve space, results are not reported in the paper but are available from the authors upon request.

4. Results

Parameter estimates for aggregate models, shown in Table 2, suggest that telemedicine features, in aggregate, have significant positive main effects on physicians' satisfaction with telemedicine, physicians' perceptions of telemedicine quality, and proportion of patient visits via telemedicine, when controlled for other variables. The interaction effects of telemedicine tools, with telemedicine barriers and telemedicine facilitators, are non-significant. In addition, telemedicine barriers have significant negative main effects on physician satisfaction and physician perceptions of telemedicine quality, while telemedicine facilitator has significant positive main effects on these dependent variables. Neither telemedicine barriers nor telemedicine facilitator has a significant effect on patient telemedicine visits.

Parameter estimates from disaggregate models (Table 3) shows that telephone, videoconference, stand-alone telemedicine platform, and telemedicine platform integrated with EHR have significant positive effects on physicians' satisfaction with telemedicine and physicians' quality of care evaluation. While telephone and stand-alone telemedicine platform have significant positive effects on patients' telemedicine visit, these effects were non-significant for videoconferencing and telemedicine platform integrated with EHR. The lack of significance of the relationship between videoconferencing and patient visits was unexpected but may be attributed to several reasons such as inadequate communication speeds and/or technological difficulties with setting up video connections during the early days of the COVID pandemic, especially among elderly or less technology-savvy patients [24]. This was not the case for telephone interaction, given the long history of telephone use in the USA and prior use of telephone consultations with physicians. The lack of significance of the relationship between EHR-integrated telemedicine and patient visits may reflect patients' lack of knowledge of whether a telemedicine system is integrated with EHR. Survey data from patients may provide us further insights about lack of significant effects for videoconference and telemedicine platform integrated with EHR.

For the disaggregated model (Equation (2)) our OLS estimations suggest that in comparison to the ambulatory care facility operated by a single physician, facilities with 2–3 physicians and 11–50 physicians had significant negative impact on physicians' perception of the quality of care delivered using telemedicine relative to face-to-face patient visits. Therefore, we observe a differential impact of these two groups on physicians' perception of the quality of care. However, there is no impact on 4–10 and 50+ physicians' groups. This variation can be attributed to the effect sizes for different facilities (number of physicians). Further research may be able to explain this phenomenon. However, we didn't observe any such differential impacts for the aggregated model (Equation (1)) where all four groups had significant negative impacts on physicians' perception of the quality of care.

For both aggregated and disaggregated model we found that in comparison to ambulatory care facility operated by a single physician, facilities with 4–10 physicians had a significant negative impact on percentage of patients' visits conducted through telemedicine technology as a proportion of overall ambulatory care visits. In this case we clearly find a significant impact of one physicians' group (facilities with 4–10 physicians) on percentage of patients' visits conducted through telemedicine technology in comparison to other groups. Though the direction of the impact is negative for all the groups, for this group it is significant. This suggests that for this group most of the patient visits

[1] We thank the reviewer for suggesting certain robustness checks to ensure consistent interpretation of our aggregated model outcomes. We conducted multiple robustness checks across all different combinations of the independent variables (telemedicine features) and found the results to be consistent with our prior findings.

Table 3
Beta coefficients (standard errors) for disaggregated models.

Variable	TelemedSatisfaction	TelemedQuality	TelemedVisitPct
TelemedFeature: Telephone	0.149** (0.055)	0.154*** (0.041)	0.166*** (0.049)
TelemedFeature: Videoconference	0.146** (0.054)	0.146*** (0.040)	0.092 (0.048)
TelemedFeature: Telemedicine platform NOT integrated with EHR	0.158** (0.055)	0.114** (0.041)	0.156*** (0.049)
TelemedFeature: Telemedicine platform integrated with EHR	0.285*** (0.059)	0.171*** (0.044)	0.084 (0.053)
TelemedFeature: Other	0.152 (0.182)	0.074 (0.135)	0.197 (0.159)
TelemedBarrier: Limited internet access and/or speed issues	0.024 (0.056)	0.060 (0.042)	0.117* (0.050)
TelemedBarrier: Difficult to use or does not meet needs	−0.496*** (0.068)	−0.231*** (0.051)	−0.033 (0.060)
TelemedBarrier: Isn't appropriate for my specialty/ type of patients	−0.947*** (0.060)	−0.774*** (0.045)	−0.235*** (0.053)
TelemedBarrier: Limitations in patients' access to technology	−0.020 (0.062)	−0.072 (0.047)	0.035 (0.055)
TelemedBarrier: Patients' difficulty using technology/ telemedicine platform	−0.191** (0.065)	−0.097* (0.049)	0.054 (0.058)
TelemedFacilitator	0.354*** (0.052)	0.251*** (0.039)	0.085 (0.047)
Specialty: Surgical (vs Primary care)	0.051 (0.074)	−0.049 (0.056)	0.025 (0.066)
Specialty: Medical (vs Primary care)	0.192*** (0.058)	0.242*** (0.043)	0.498*** (0.052)
Gender: Male (vs Female)	−0.215*** (0.055)	−0.056 (0.042)	−0.141** (0.049)
Age: 50+ years (vs Under 50 years)	−0.110* (0.054)	−0.081* (0.040)	0.058 (0.048)
Number of Physicians:			
2–3 physicians (vs 1 physician)	−0.247** (0.082)	−0.131* (0.061)	−0.099 (0.073)
4–10 physicians (vs 1 physician)	−0.182* (0.073)	−0.098 (0.055)	−0.159* (0.065)
11–50 physicians (vs 1 physician)	−0.259** (0.087)	−0.176** (0.065)	−0.109 (0.078)
50 + physicians (vs 1 physician)	−0.202* (0.096)	−0.135 (0.072)	−0.105 (0.085)
Practice type:			
Other (vs Private solo or group)	0.080 (0.058)	0.046 (0.044)	0.118* (0.052)
Intercept	3.741*** (0.103)	3.097*** (0.077)	2.272*** (0.092)
Adjusted R-squared	0.2571	0.2691	0.1192
Number of observations	1618	1621	1562
F Statistic	28.98	30.82	11.56

***p < 0.001, **p < 0.01, *p < 0.05.

happened in person and only a few patient visits happened through telemedicine technology. This can possibly be attributed to different effect sizes for different ambulatory care clinics, suggesting a nonlinear relationship between the number of physicians practicing in a facility and percentage of patients' visits conducted through telemedicine technology. However, future research should investigate these possibilities.

Apart from that, comparison between three of our dependent variables also reveals that the dependent variable percentage of patients' visits conducted through telemedicine technology, TelemedVisitPct, is quite different from the other two dependent variables which are more subjective in nature.

For both aggregated and disaggregated model while other practice type (in comparison to private solo or group practice) have a significant positive impact on percentage of patients' visits conducted through telemedicine technology, it does not have any significant impact on both physicians' satisfaction and physicians' perception of the quality of care delivered using telemedicine. The dependent variable percentage of patients' visits conducted through telemedicine technology is quite different in nature from the other two dependent variables–physicians' satisfaction and physicians' perception of the quality of care delivered using telemedicine. While the other two dependent variables incorporate a lot of subjective evaluation and perception of physicians, patients' visits conducted through telemedicine technology is more objective in nature and it also depends on physicians' desire and ease of offering healthcare services through telemedicine. The value of this variable also indirectly depends on the number of other choices available to patients residing in an area. Therefore, though this outcome is surprising it is not completely implausible.

Besides that, it is quite likely that the other practice type incorporates government medical offices and clinics, ambulatory surgery centers, large government hospital outpatient departments, etc. which are better equipped with resources related to telemedicine technology and related informaticians which offers a better experience for patients, resulting higher percentage of patient visits through telemedicine technology. However, such resources don't necessarily significantly improve physicians' satisfaction and physicians' perception of the quality of care delivered using telemedicine.

5. Discussion and Conclusion

This study is one of the earliest to examine the effects of telemedicine technology on physicians' satisfaction with telemedicine, physicians' quality of care evaluation, and patients' telemedicine visits during the COVID-19 pandemic. The rationale for this analysis is that if telemedicine usage is to continue after the pandemic, we must understand how it impacts physicians. It would be useful in identifying telemedicine features or capabilities which benefit and/or hinder physicians' utilization of this technology.

Based on our analysis of the data, we report that telemedicine technology has significant positive effects on physicians' satisfaction with telemedicine and quality of care evaluation, both at an aggregate level and at the disaggregate levels of individual telemedicine features, and partially significant effects on patients' telemedicine visits. Telemedicine features that contribute significantly to physician satisfaction and quality of care evaluation are telephone, videoconferencing, stand-alone telemedicine platform, and telemedicine platform integrated with EHR, while only telephone and stand-alone telemedicine platform seem to contribute significantly to patients' telemedicine visits.

Although there may have been some initial reservations about telemedicine-mediated online physician visits during the early stages of COVID, given the long-held tradition of face-to-face visits in the US healthcare system, our study confirmed that physicians are satisfied with this technology and believe that it increases quality of care. Our physician results are consistent with Saiyed et al.'s [25] study of telehealth at University of Pittsburgh Medical Center (UPMC) Pinnacle, which reported that 65 % of the physicians were satisfied with the physician–patient relationship during telehealth visits, and only 29 % were dissatisfied with that interaction. This study also found that physicians who experienced good video and audio quality were 3.68 times more likely to enjoy telehealth visits than those with less-than-optimal

video and audio quality. In a similar vein, Alqahtani et al. [26] reported that 59.6 % of the physicians in a sample of Saudi Arabian hospitals found telemedicine to improve their job effectiveness and performance although only 27.8 % of those physicians were satisfied with their telemedicine services (28.5 % were not satisfied and 43.7 % were neutral). However, these studies considered telemedicine as a homogeneous technology and did not consider variations in telemedicine features, as examined in our study.

Like most of the empirical studies our study also has certain limitations. Our second dependent variable, physicians' quality of care evaluation, only represents physicians' point of view and can possibly be one sided. In this research each physician has access to multiple telemedicine features, and they might have used them differentially. Because of the limitations our dataset used for the research it is not possible to know which one they have used more frequently and which one rarely. This is also a limitation of our current research. Hence, more studies are needed to examine both physicians' and patients' response to telemedicine, like what types of patients (e.g., old vs young, white vs nonwhite) prefer telemedicine-based healthcare delivery, and which telemedicine features (e.g., video, audio only, etc.) are favored by these populations.

Given that telemedicine will likely continue to be an important mechanism for healthcare delivery in the post-COVID era [27], it is important for us to understand how technology features within the same, can be designed/improved to elicit positive responses from both physicians and patients. As the landscape of telemedicine technologies and their design features evolves, we call for deeper exploration in future studies into the relationship between telemedicine features and physician and care outcomes.

CRediT authorship contribution statement

Avijit Sengupta: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Sumantra Sarkar:** Writing – review & editing. **Anol Bhattacherjee:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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