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# The Effect of Online Follow-up Services on Offline and Online Physician Demand: Evidence from Chronic Disease Physicians

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# The Effect of Online Follow-up Services on Offline and Online Physician Demand: Evidence from Chronic Disease Physicians

*Completed Research Paper*

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## Abstract

*The adoption of online follow-up services by physicians provides their offline patients with an important channel for medical follow-ups. Using detailed service data from a Chinese online healthcare community (OHC), the present study scrutinizes the rarely studied effect of adopting online follow-up services on offline and online physician demand in the context of chronic disease. The results demonstrate that adopting online follow-up services leads to higher offline physician demand. Interestingly, in contrast to the channel substitution effect documented in the literature, we find that providing online follow-up services also increases online physician demand. Furthermore, the results of mechanism tests reveal that online follow-up services affect online demand by boosting physicians' online exposure and increasing the availability of information on their online service characteristics to patients. Our findings offer strategic guidance for physicians, design implications for OHCs, and insights for healthcare policymakers.*

**Keywords:** Medical follow-up, online follow-up services, physician demand, online healthcare communities, chronic disease

## Introduction

Medical follow-ups are vital for patient health outcomes and medical experience (Lewis et al., 2009; Tong et al., 2018). During this post-treatment form of contact, physicians answer patients' questions, monitor patients' health, reinforce treatment plans, confirm medicine regimens, and share lab results. However, a high patient no-show rate for follow-ups—possibly due to heavy travel and time costs—has long been a threat to public health (Lerner, 2014). Meanwhile, the increasing number of patients seeking conventional follow-ups via repeated offline visits has placed a significant burden on already overloaded outpatient clinics. Consequently, healthcare providers and policymakers are increasingly interested in the provision of follow-up services via online channels, which could reduce patient costs and alleviate the pressure on offline medical resources.

Classical online consultations, which are usually provided in online healthcare communities (OHCs), may not be an ideal format for follow-ups for two main reasons. First, to follow up with a physician via online consultations, patients need to provide very detailed offline service records with the physician as well as other health-related information for verification; this burden could prevent them from adopting the online channel. Second, online consultation sessions usually expire within a short time window (e.g., two days),

whereas follow-ups require a rather long duration such that physicians can monitor the health status of patients, especially those with chronic diseases who require long-term care. To overcome these limitations, several OHCs (e.g., Speedoc[1] in Singapore and Amwell[2] in the United States) have initiated a dedicated function—online follow-up services—so that offline patients can follow up with their physicians online through a simplified procedure and an extended service window.

In addition, government agencies are encouraging medical institutions and physicians to provide online follow-up services. For example, the Chinese government is encouraging OHCs to enable online follow-up services, especially for patients with common or chronic diseases (National Health Commission of the People's Republic of China 2020). However, despite the increasing popularity of online healthcare consultations in China,[3] as of July 2022, only one of the eight Chinese OHC platforms had enabled an online follow-up service function, and not all physicians on the OHC platform had provided this service to their offline patients. The hesitation of OHCs and physicians to fully embrace online follow-up services could be the result of lacking a clear understanding of this new service, especially its impacts on patient behavior. Indeed, as an emerging function, online follow-up services have not been carefully investigated in the literature.

The provision of online follow-up services could have opposite influences on offline and online physician demand. Offline demand might decrease because patients who would have followed up with their physicians via offline visits might use online follow-ups instead. However, since online follow-up services are only provided to patients who have consulted the physician via offline channels, patients who would have selected online channels for initial consultations may be attracted to the online follow-ups and switch to offline channels for initial consultations, thereby increasing offline physician demand. Although higher offline demand brings more income for physicians, it could defeat the purpose of alleviating the pressure on offline medical resources.

There could also be mixed impacts on online physician demand, which crucially affects the revenues of OHC platforms. Increased offline physician demand due to online follow-up services might introduce a channel substitution effect—an increase in offline demand could cause a decrease in online demand (Bergmo et al., 2005; Ghose et al., 2022; Wang et al., 2020). Meanwhile, public medical information recorded in online follow-up services could increase a physician's online exposure and inform patients of the physician's online service characteristics, which may lead more patients to use the online channel.

Motivated by this controversy, we aim to address the following research question: *How does the provision of online follow-up services in OHCs affect a physician's offline and online demand?* To answer this question, we collected data on service records and physician characteristics from a leading Chinese OHC that enabled an online follow-up service function in 2010. Of the 330 physicians in the dataset who specialized in lung cancer and were located in Beijing, 233 (71%) adopted the online follow-up services during the observation period of January 1, 2013 to December 31, 2016. Given the heterogeneous adoption timing, we conducted a staggered difference-in-differences (DID) analysis to estimate the causal effect of adopting online follow-up services on offline and online physician demand. We find that providing online follow-up services increases offline physician demand by adding value to offline consultations, prompting online patients to shift to offline interactions. In contrast to the theoretical prediction of the channel substitution effect (Bergmo et al. 2005), the provision of online follow-up services significantly increases online physician demand. Moreover, the results of mechanism tests reveal that the increase in online physician demand was due to the information effect of online follow-up service records. Specifically, providing online follow-up services not only boosts physicians' online exposure but also provides more information on their online service characteristics. In particular, physicians who serve more patients, are more responsive, and respond more promptly to patient inquiries in online follow-up services experience a higher increase in their online demand. Overall, these findings offer useful guidance for physicians on adopting and delivering online follow-up services and have important implications for OHCs and policymakers regarding evaluating the impact of this function, promoting online participation, and making relevant policy changes.

[1] See https://thesmartlocal.com/read/telemedicine-singapore/
[2] See https://www.onlinedoctor.com/best-online-doctor-medical-services/#amwell
[3] There are more than 1,600 online hospitals in China and the market share of online consultations is expected to increase from 6% in 2019 to 42% in 2024 (see https://www.cs.com.cn/ssgs/gsxw/202111/t20211129_6223644.html).

The rest of the paper is organized as follows. The next section summarizes the relevant literature. Subsequently, we introduce our research context and develop our research hypotheses. After describing the data and key variables, we discuss identification strategies and report empirical analyses. We conclude the paper by discussing its implications and limitations.

# Literature Review

## *Relevant Literature on Physician Demand*

The present study closely relates to two streams of literature on the antecedents of physician demand. The first stream focuses on how physician characteristics affect offline and online physician demand. Previous studies have concluded that reputational factors (e.g., physician titles, hospital ranks) and word-of-mouth (WOM) (e.g., online reviews, thank-you letters, gifts, and service stars) positively affect online physician demand (Li et al., 2019; Yang et al., 2015b) and offline physician demand (Liu et al., 2016; Lu & Wu, 2019; Wu & Lu, 2017; Xu et al., 2021). For example, Xu et al. (2021) showed that online reviews about physicians' service features, including bedside manner, the accuracy of diagnosis, waiting time, and service duration, had a significantly positive impact on offline physician demand.

Physicians' service-related characteristics are also important antecedent of physician demand (Chang et al., 2019; Fang et al., 2022; Wang et al., 2020; Xing et al., 2020;Yang et al., 2019). Fan et al. (2022) found that the number of offline appointments for physicians increased after they began offering online consultation services. Similarly, Wang et al. (2020) found that an increase in physicians' online consultations or online articles led to more offline visits in the subsequent periods. As for online physician demand, Yang et al. (2019) found that service quality of initial online consultations, i.e., response time, service content, and depth of interaction, positively influenced patients' decisions of whether to continue consulting the same physician.

The second stream of literature explores environmental characteristics. Yu et al. (2016) found that health insurance policies introduced by the Chinese government to integrate insurance systems between rural and urban areas and between pairwise cities positively affected patient demand for online healthcare consultations. Other studies have shown that platform changes, such as the implementation of e-visits (Bavafa et al. 2018), the provision of free online consultations (Zhang et al., 2019a), and the streamlining of online consultations and offline appointments (Huang et al. 2021), significantly increased online physician demand. However, their effects on offline physician demand were inconclusive.

Regarding offline physician demand, Bavafa et al. (2018) showed that providing e-visits triggered more offline visits due to the direct connection to physicians without gatekeepers (i.e., office staff and nurses). Similarly, Wu et al. (2021) confirmed that participating in an online channel significantly increased physicians' offline outpatient visits. In contrast, Bergmo et al. (2005) found that adopting an e-messaging system resulted in fewer offline visits due to the convenience of the online channel for patients (i.e., the channel substitution effect). Huang et al. (2021) revealed that the integration of online consultations and offline appointments decreased physician offline demand because it helped physicians reduce unnecessary face-to-face visits and alleviate the intensive utilization of offline healthcare resources. Ghose et al. (2022) showed that patients who adopted a mobile health app were more likely to substitute offline visits with telehealth services. In addition, a mixed result by Wu and Lu (2017) suggested that online written consultations complemented offline appointments, while phone consultations substituted for offline appointments.

Our study falls into the second stream of literature on physician demand but differs from existing studies in two ways. First, the present study is one of the few studies that examine both offline and online physician demand. Therefore, the results of the study could enrich the literature's mixed findings on the impact of platform changes on offline physician demand. Second, and more importantly, we investigate a key OHC innovation: online follow-up services. Unlike studies of online platform changes that mainly address pre-diagnosis services, this study focuses on online post-diagnosis services that operate in conjunction with offline visits. The unique nature of online follow-up services allows them to affect physician demand by adding value to the offline channel and providing information regarding the online channel.

### *Relevant Literature on Medical Follow-ups*

The literature on medical follow-ups can be categorized based on the channel through which the service is provided. One stream of literature focuses on the follow-up services that are provided through offline hospital visits. Several studies have documented the effectiveness of offline follow-ups in reducing patient risks and deaths (Vinogradova et al. 2020), the readmission rate (Tong et al. 2018), and patient satisfaction (Koinberg et al. 2001). To improve patients' adherence to offline follow-ups, other studies have examined the preferences of patients and physicians regarding medical follow-ups (Lewis et al. 2009) and proposed strategies accordingly, such as short message service (SMS) or telephone reminders (Lin and Wu 2014) and a delay-time analysis model for optimizing checkup schedules (Liu et al., 2018).

The other stream of literature focuses on telephone follow-ups, especially in comparison with traditional in-person follow-ups. Booker et al. (2004) found that telephone follow-ups were acceptable to most patients as an alternative to in-person follow-ups. Furthermore, several studies empirically validated the advantages of telephone follow-ups, such as a high level of convenience (Williamson et al. 2015) and cost-effectiveness (Lopez-Villegas et al. 2020).

Recently, as an emerging follow-up function, online follow-up services with a more simplified procedure and longer service window start to gain attention. Li et al. (2021) examined how the technical and interpersonal quality of a physician's online services affect the adoption of online follow-up services from the perspective of patients. However, no study examines the effects of online follow-up services from the perspective of physicians, which is the focus of our study.

## Research Context

Our research context is a leading Chinese OHC that was established in 2006. As of July 2022, over 240,000 physicians had registered on the OHC platform and were actively using it to provide healthcare services, such as online consultations and offline appointments, via the platform.[4] Figure 1a displays an example of a physician's platform homepage, which lists physician information (e.g., title, hospital), patient reviews (e.g., ratings), healthcare-related articles shared by the physician, and all service records.

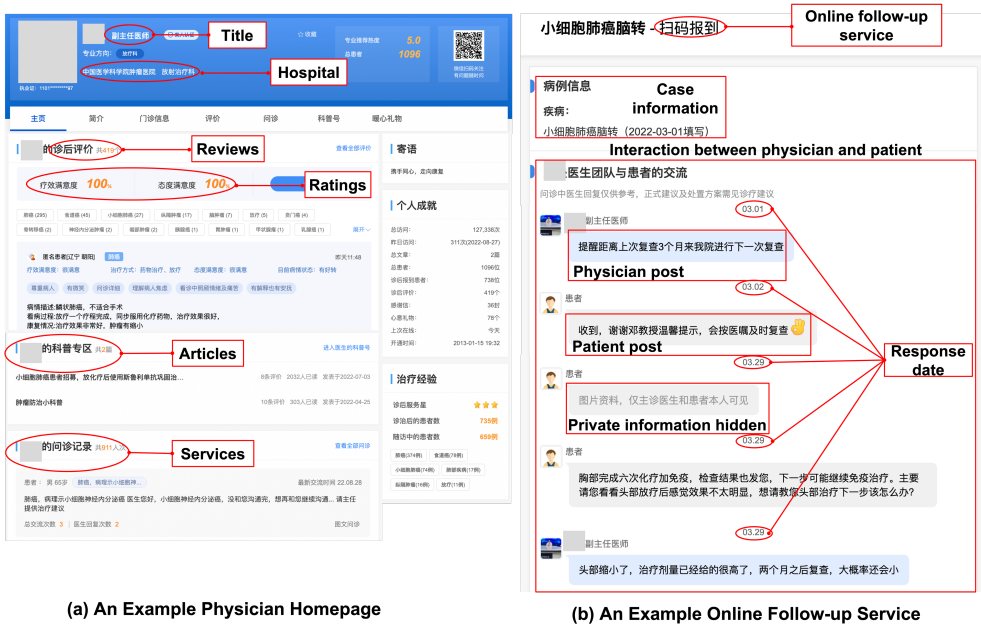



**Figure 1. An Example Physician Homepage and An Example Service Record**

[4] For details, see https://www.haodf.com/info/aboutus.php.

In 2010, to attract offline patients using online consultations, the platform introduced an online follow-up service function through which physicians could continue serving patients online after their offline visits. The platform does not charge physicians for such services, and the physicians decide whether and when to enable this function. Figure 1b shows an example of an online follow-up service record that contains patient biographical information, the service type, case information, and communication between the patient and the physician.

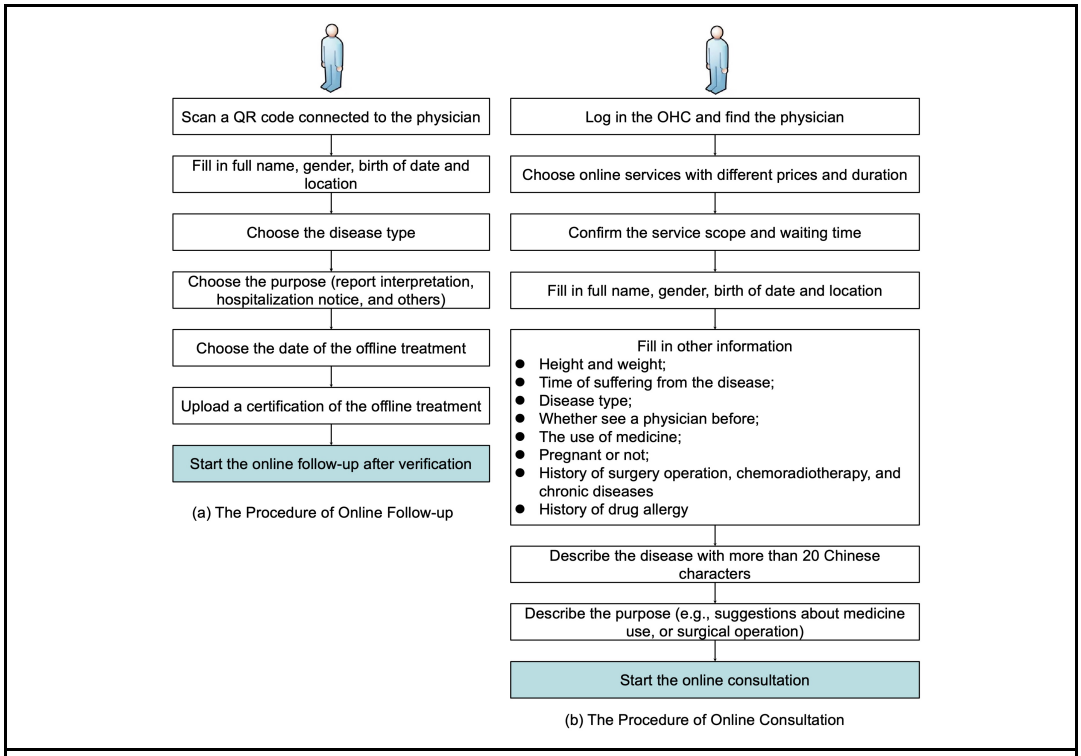



**Figure 2. Procedures of Online Follow-up Services and Online Consultations**

Online follow-up services differ from online consultations in several important ways. First and foremost, the target patients are different. While online consultations are available for any patient, online follow-up services are designed for patients who have already consulted the physician offline. Second, since prior interactions with the physician have been documented, online follow-up service procedures are much simpler than classical online consultation procedures, as illustrated in Figure 2. To participate in online follow-up services, patients scan a QR code; input the demographic information; choose the disease type, purpose, and offline treatment date; and upload certifications of offline treatment (e.g., receipts) with the physician (see Figure 2a). Once patients' identities and relevant documents are verified, they can use online follow-up services to interact with physicians accordingly. In contrast, for online consultations, patients need to provide additional information, including their consultation history, current medication, history of major diseases, drug allergies, and disease description (see Figure 2b). Finally, while patients can only consult their physicians through online consultations within a short time interval (e.g., two days), patients using online follow-up services can reach out to their physicians within a month after offline visits (see Figure 1b for example).

# Hypothesis Development

## *Offline Physician Demand*

Consumers' channel evaluation process consists of three steps: 1) assessment of the existence of channel differentiators, 2) evaluation of the benefits and costs of different channels according to the evaluation criteria, 3) channel selection (e.g., Gensler et al., 2012; Gupta et al., 2004; Lim et al., 2012; Montoya-Weiss et al., 2003; Verhoef et al., 2007). Utilizing this channel evaluation framework, we analyze how online

follow-up services as the channel differentiator affect patients' channel evaluation and preference in the context of healthcare.

Channel differentiators refer to unique characteristics or features of a particular communication channel that distinguishes it from other channels. Services in the post-transaction stage could affect consumers' channel choice in the transaction stage (e.g., Chiang et al., 2006). Therefore, services for future customer interactions that consumers may or may not come across can be considered channel differentiators, such as channel integration services for post-transaction phases (Trenz et al. 2020). In the healthcare context, services in the post-consultation stage such as medical follow-ups are also vital for patient health outcomes and medical experience (Lewis et al. 2009; Tong et al. 2018). Consequently, online follow-up services for offline patients to interact with the same physician could be a channel differentiator for patients' channel evaluation and change patients' channel preferences.

As for evaluation criteria for channel differentiators, the convenience-risk paradigm is used as the key consideration in various theoretical frameworks (e.g., Gensler et al., 2012; Herhausen et al., 2015; Trenz et al., 2020; Wang et al., 2016). Service convenience refers to the speed, effort, and flexibility perceived by a consumer in purchasing and consuming a produce/service (Seiders et al. 2007; Trenz et al. 2020), which seems especially relevant for consumers' choices in the after-sales stage (Gensler et al. 2012) and has a positive effect on consumers' channel choices (Frambach et al. 2007). In our context, online follow-up services make the offline channel more attractive by increasing the convenience of the post-consultation stage. First, physicians choosing physicians who adopt online follow-up services have a broader range of choices for their follow-up needs, which can induce perceptions of flexibility convenience. More importantly, online follow-up services enable a longer service window than follow-up services through either online consultations or offline visits, offering patients more freedom in their post-consultation stage. Second, after visiting a physician adopting online follow-up services, potential forgotten questions or additional medical problems can be posted immediately through a simplified procedure, instead of struggling to schedule an offline follow-up with higher transportation and time costs (Goh et al. 2016; Muñoz 2010; Polinski et al. 2016) or completing the complex form of online consultations, which enable patients to access the same physician with higher speed and lower cost.

Service risk represents a function of uncertainty regarding the potential outcomes of a transaction and the possible unpleasantness associated with these outcomes (Gensler et al. 2012), which negatively affects consumers' subsequent intention to engage in transactions (Jarvenpaa et al. 2000; Pavlou 2003). Channel integration services offered in the post-consultation stage have been demonstrated to significantly reduce consumers' evaluation of post-transaction risk (Trenz et al. 2020). In our context, if patients visit a physician who has adopted online follow-up services, they can be assured of accessing the same physician during the post-consultation stage, thereby diminishing their perceived risk. Moreover, the availability of online follow-up services conveys a positive signal to patients about the willingness of physicians to resolve problems that stem from offline consultations. This, in turn, helps mitigate patients' concerns about not being taken seriously in the post-consultation stage. Overall, offline physician demand would likely increase after a physician adopts online follow-up services due to the decreased risk perceptions and increased convenience of the post-consultation stage, leading to the following hypothesis:

**Hypothesis 1:** *A physician's adoption of online follow-up services increases offline physician demand.*

## *Online Physician Demand*

Online physician demand after the adoption of online follow-up services may decrease due to the substitution effect of the offline channel (Bergmo et al., 2005; Ghose et al., 2022; Wang et al., 2020). As discussed in the development of Hypothesis 1, a physician's adoption of online follow-up services could prompt some patients who would have chosen an online consultation to shift to an offline consultation because they could take advantage of the additional benefits of the online follow-up option. Moreover, patients who would have followed up with the physician via an online consultation in the post-consultation stage might use online follow-up services instead.[5] Therefore, we would expect a decrease in online physician demand, as captured by the following hypothesis:

[5] We defined online demand as the number of online consultations provided by a physician; online follow-up services were not counted in online demand.

**Hypothesis 2a:** *A physician's adoption of online follow-up services decreases online physician demand.*

However, online physician demand may increase due to the information effect of online follow-up services. Providing online follow-up services can increase a physician's exposure to potential patients during their search for a physician. Before making a selection, patients usually identify relevant physicians by searching for health-related information, such as symptoms and the experiences of others with similar conditions (White and Horvitz 2009). The more online follow-up services a physician has provided, the more likely the physician will appear in patients' search results and thus become their first choice. Furthermore, because OHCs tend to recommend similar medical records to patients, providing more online follow-up services increases physicians' online exposure and the chance that they will be recommended to potential patients.

Online follow-up service records, which contain rich medical information (e.g., a patient's case information, communication with a physician), are valuable sources from which patients can infer details about a physician's online service characteristics in terms of quality and efforts. Although patients are unlikely to accurately judge the online medical service quality of a physician, it is still possible for them to gain useful information by observing other patients' medical records (Lu & Rui, 2018). At a minimum, patients can develop a reasonable understanding of a physician's online service-related characteristics (e.g., style, responsiveness). Thus, the more online follow-up services provided by a physician, the more information patients can collect online, and the less uncertain they feel regarding the physician's online services.

When choosing physicians for online consultations, patients might also consider the level of physicians' willingness to interact online and their service efforts (Fan et al. 2022). A physician's initiation of online follow-up services signals an increasing willingness to communicate with patients via an online channel. Furthermore, observable service performance characteristics, such as response speed (Dong et al. 2019; Xu et al. 2021) and information abundance (Chen et al., 2020; Zhang et al., 2019b), are useful for patients' evaluation of a physician's service efforts.

The information effect of online follow-up services leads to the following competing hypothesis:

**Hypothesis 2b:** A physician's adoption of online follow-up services increases online physician demand.

# Empirical Analysis

## *Data and Variables*

We collected data on physicians' services and characteristics from the OHC platform. In sampling physicians, we focused on those who specialized in a specific chronic disease, lung cancer, because chronic diseases often require regular and repeated treatment and follow-ups. To this end, we identified 330 physicians in Beijing, who specialized in lung cancer and had registered on the platform before 2012. Among those physicians, 233 enabled the online follow-up service function during the observation period (i.e., between January 1, 2013 and December 31, 2016). The final dataset contained all the physician characteristics and service records for their 87,834 online consultations, 6,969 offline appointments, and 11,198 online follow-up services.

Table 1 summarizes the key variables and their definitions. Similar to prior studies (Huang et al. 2021; Xu et al. 2021), we measured offline physician demand using $offline\_appointments_{i,t}$, the number of offline appointments physician $i$ received via the platform in month $t$. To measure online physician demand, we constructed the variable $online\_consultations_{i,t}$ using the number of online consultations that physician $i$ conducted in month $t$. The key independent variable is a dummy variable, $followup_{i,t}$, which indicates whether physician $i$ have adopted online follow-up services by month $t$.

Physician demand can be influenced by patient feedback, as measured by online ratings and reviews (Huang et al. 2021; Khurana et al. 2019), and physicians' other online activities, such as posting articles (Wang et al., 2020). We controlled for these influences using three time-varying physician characteristics. First, $reviews_{i,t}$ represents the number of reviews that physician $i$ received from offline patients at month $t$. Since only offline patients were allowed to post reviews and ratings on the platform during the observation

period,[6] $reviews_{i,t}$ reflects the offline popularity of the physician to a certain extent. Second, $rating\_cum_{i,t}$ measures the average rating score of physician $i$ until month $t$, indicating physician $i$'s offline service quality, as perceived by patients. Third, $articles_{i,t}$, the number of articles that physician $i$ posted on the platform at month $t$, measures the physician's knowledge-sharing activities in the platform.

| Variables | Mean | S. D. | Definition |
|---|---|---|---|
| **Physician Demand** | | | |
| $offline\_appointments_{i,t}$ | 0.440 | 2.076 | Number of offline appointments for physician $i$ at month $t$ |
| $online\_consultations_{i,t}$ | 5.545 | 16.476 | Number of online consultations for physician $i$ at month $t$ |
| **Online Follow-up Services** | | | |
| $followup_{i,t}$ | 0.403 | 0.491 | A binary variable indicating whether physician $i$ had adopted online follow-up service by month $t$ |
| $followup\_num_{i,t}$ | 0.707 | 5.043 | Number of online follow-up services conducted by physician $i$ at month $t$ |
| **Time-Varying Physician Characteristics** | | | |
| $reveiws_{i,t}$ | 0.453 | 1.643 | Number of reviews received by physician $i$ at month $t$ |
| $rating\_cum_{i,t}$ | 3.885 | 0.138 | Average rating received by physician $i$ until month $t$ |
| $articles_{i,t}$ | 0.165 | 1.113 | Number of articles posted by physician $i$ at month $t$ |
| **Physician Online Performance** | | | |
| $online\_res\_num_{i,t}$ | 0.586 | 1.228 | Average number of responses from physician $i$ in each online consultation at month $t$ |
| $online\_res\_length_{i,t}$ | 26.085 | 81.395 | Average length of responses from physician $i$ in each online consultation at month $t$ |
| $online\_res\_sameday_{i,t}$ | 0.194 | 0.339 | Percentage of online consultations in which physician $i$ replied to patients within the same day at month $t$ |
| ***Note.*** The number of observations is 15,840. S.D. stands for standard deviation. | | | |

**Table 1. Key Variables and Summary Statistics**

Online physician demand is also affected by physicians' online service quality, such as responsiveness and service efforts (Chen et al., 2020; Yang et al., 2015a). Therefore, we constructed three variables based on the online consultations between physicians and patients—$online\_res\_num_{i,t}$, $online\_res\_length_{i,t}$, and $online\_res\_sameday_{i,t}$—to measure the average response number, the average response length, and the percentage of same-day responses to patients' questions by physician $i$ at month t, respectively. We included them as additional control variables for online physician demand.

## *Model Specification*

Because physicians adopted the online follow-up service function at different times (i.e., different treatment timings), we used the staggered DID design as our identification strategy, in accordance with the literature (Ayer et al. 2019; Bavafa et al. 2018; He et al. 2020; Sun et al. 2020). Specifically, we estimated the following two-way fixed effects (TWFE) model to leverage the panel data structure:

$$Y_{i,t} = \beta_0 + \beta_1 followup_{i,t} + \gamma X_{i,t-1} + \alpha_i + \tau_t + \epsilon_{i,t} \quad (1)$$

where $Y_{i,t}$ corresponds to the two outcome variables for physician demand: the number of offline appointments ($offline\_appointments_{i,t}$) and the number of online consultations ($online\_consultations_{i,t}$) for physician $i$ at month $t$. The outcome variables are log-transformed because of dispersed distributions. The coefficient of interest, $\beta_1$, captures the effect of providing online follow-up services on physician demand. We controlled for a set of time-varying physician characteristics, $X_{i,t-1}$, which includes the number of reviews from offline patients, the physician's rating, and the number of articles posted by physician $i$ at month $t-1$. For offline physician demand (i.e., when $Y_{i,t}$ is $offline\_appointments_{i,t}$), $X_{i,t-1}$ also includes the number of online consultations for physician $i$ at month $t-1$. For online physician demand (i.e., when $Y_{i,t}$ is $online\_consultations_{i,t}$), $X_{i,t-1}$ also includes the number of offline appointments for physician $i$ at month $t-1$ and the average response number, length, and speed of the physician in online consultations as additional controls. We also included physician fixed effects ($\alpha_i$) to account for physician heterogeneity as

[6] To ensure the authenticity of online reviews, the platform requires offline patients to upload relevant medical documents for verification purposes before posting/releasing a review.

well as time-specific effects ($\tau_t$), including year fixed effects and month fixed effects, to account for demand seasonality.

### *DID on the Matched Sample*

In an ideal research design, online follow-up services would be randomly adopted by physicians so that the differences in physician demand between the adopted and non-adopted physicians could be causally attributed to service adoption. However, the imbalanced characteristics between the adopted and non-adopted physicians captured in Table 2 suggest that physicians' adoption decisions were unlikely to be random in our context, thereby making their self-selection of the service a major endogeneity concern. In other words, physicians' adoption decisions may be driven by their pre-existing demand and characteristics, the influence of which on post-adoption demand may confound that of the adoption itself. For example, less popular physicians may be more interested in enabling online follow-up services to attract more patients from online and offline channels.

Propensity score matching (PSM) is commonly used to alleviate the self-selection concern (Sun et al. 2020). Therefore, we employed this approach to identify non-adopted physicians in the control group who were very similar to the adopted physicians in the treatment group in terms of all observable physician characteristics which may affect the physician adoption decision of online follow-ups. Physicians with large patient pools from online and with more online activities are more likely to embrace the online platform (and subsequent offerings like follow-ups). In addition, offline operations may also drive a significant part of the decision process of taking up additional online follow-up services. Therefore, we obtained the average physician-level characteristics (i.e., online consultations, offline appointments, reviews, articles, rating, title, and hospital) from a physician's registration month to December 2012 (i.e., prior to the observation period) as the matching variables, which were unlikely to be affected by the adoption decision during the observation period. We conducted PSM with the number of the nearest neighbor specified as three and a caliper of 0.1 standard deviations of the propensity score. The matching procedure led to 74 non-adopted physicians in the control group and 98 adopted physicians in the treatment group. As shown in Table 2, the significant differences in observable characteristics between the treatment and control groups became statistically insignificant after matching, with all standardized differences smaller than 0.10 (Austin 2009).

| Variable | Unmatched | Treated | | Control | | Std. Diff. | t-test |
|---|---|---|---|---|---|---|---|
| | Matched | Mean | S.D. | Mean | S.D. | | |
| *offline_appointments* | U | 0.218 | 0.413 | 0.030 | 0.078 | 0.631 | 4.25*** |
| | M | 0.067 | 0.148 | 0.063 | 0.126 | 0.013 | 0.24 |
| *online_consultations* | U | 1.491 | 1.356 | 0.635 | 0.933 | 0.735 | 5.46*** |
| | M | 1.018 | 1.138 | 0.958 | 1.089 | 0.051 | 0.47 |
| *reviews* | U | 0.250 | 0.239 | 0.094 | 0.083 | 0.869 | 5.99*** |
| | M | 0.140 | 0.096 | 0.140 | 0.100 | -0.000 | -0.00 |
| *articles* | U | 0.137 | 0.276 | 0.087 | 0.371 | 0.151 | 1.29 |
| | M | 0.095 | 0.259 | 0.125 | 0.400 | -0.092 | -0.78 |
| *rating* | U | 3.844 | 0.227 | 3.903 | 0.201 | -0.276 | -2.14** |
| | M | 3.856 | 0.205 | 3.870 | 0.226 | -0.064 | -0.56 |
| *title_dummy* | U | 0.720 | 0.450 | 0.449 | 0.500 | 0.569 | 4.65*** |
| | M | 0.645 | 0.480 | 0.682 | 0.469 | -0.078 | -0.69 |
| *hospital_dummy* | U | 0.942 | 0.234 | 0.753 | 0.434 | 0.544 | 4.98*** |
| | M | 0.928 | 0.260 | 0.930 | 0.257 | -0.006 | -0.07 |

***Note.*** *** p<0.01, ** p<0.05, * p<0.1. U stands for the unmatched sample that includes 330 physicians, M stands for the matched sample that includes 172 physicians. S.D. stands for standard deviation. *offline_appointments, Online_consultations, reviews,* and *articles* are log-transformed.

**Table 2. Balance Test on the Treatment and Control Groups**

### *Main Results*

Table 3 reports the TWFE estimates based on the full sample and the matched sample. Columns (1) and (2) show the estimation results when the dependent variable is the number of offline appointments. Regardless of the difference in sample construction, the coefficients of $followup_{i,t}$ are significantly positive, indicating that the adoption of online follow-up services increases the number of offline appointments via the platform,

thereby supporting **Hypothesis 1**. In terms of the magnitude, Column (2) suggests that the number of offline appointments increases by 4.7% on average after the adoption of online follow-up services.

Columns (3) and (4) report the estimation results when the dependent variable is the number of online consultations. The coefficients of $followup_{i,t}$ are consistently positive and statistically significant, suggesting that providing online follow-up services increases online physician demand. Therefore, **Hypothesis 2b** is supported and **Hypothesis 2a** is rejected. In terms of the magnitude, the matched sample results in Column (4) suggest that physicians who adopt online follow-up services experience an average increase of 16.2% in patient demand for online consultations.

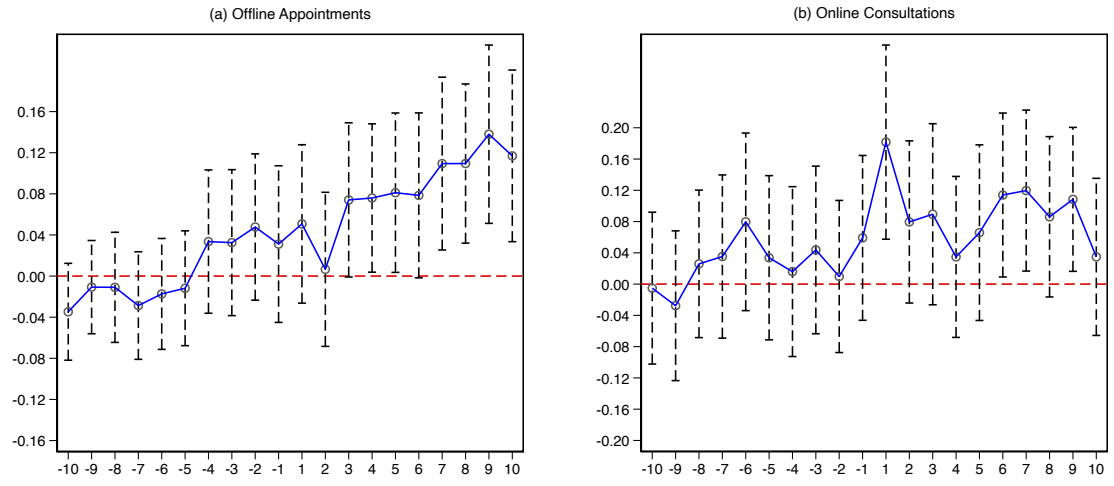
| | $offline\_appointments_{i,t}$ | | $online\_consultations_{i,t}$ | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Full Sample | Matched Sample | Full Sample | Matched Sample |
| $followup_{i,t}$ | 0.091*** | 0.047*** | 0.140*** | 0.162*** |
| | (0.029) | (0.016) | (0.047) | (0.050) |
| **Time-varying Controls** | | | | |
| Physician characteristics | Yes | Yes | Yes | Yes |
| Physician online performance | No | No | Yes | Yes |
| Observations | 15,574 | 8,256 | 15,574 | 8,256 |
| $R^2$ | 0.043 | 0.032 | 0.211 | 0.241 |

***Note.*** *** p<0.01, ** p<0.05, * p<0.1. The dependent variables are log-transformed. All specifications include physician and time fixed effects. Clustered standard errors at the physician level are in parentheses.

**Table 3. The Effect of Online Follow-up Services on Offline and Online Demand**

## *Robustness Checks*

A critical assumption underlying the DID estimation is that the treatment and control groups would have the same trend with respect to the outcome variable(s) in the absence of treatment. We validated the parallel trend assumption following Angrist and Pischke (2009). Specifically, we adopted an event study design by adding treatment leads and lags to the econometric model (1). We created 10 binary indicators (*1 ~ 10*) that are equal to one only in the corresponding pre-treatment months as well as 10 indicators for the first 10 months after adoption (1~10). Figures 3a and 3b present the results of the pre-trend analysis for offline appointments and online consultations, respectively. We find no significant differences in either outcome variable in any pre-treatment month between the treated and control groups, suggesting that the parallel trend assumption is valid for the DID specification.




***Note.*** These two figures plot the coefficient estimates for the lead and lag indicators in the pre-trend analysis. Error bars show 95% confidence intervals.

**Figure 3. Pre-trend Analysis**

To enhance the generalizability of our findings, we replicated our empirical analyses with another type of chronic disease, depression, which is a common psychiatric disorder and not a life-threatening illness in the same way that physical conditions like lung cancer can be. Moreover, depression has been extensively studied in previous research focusing on chronic diseases, making it a suitable choice for enhancing the generalizability of our findings (e.g., Liu et al. 2020). Specifically, we collected data from January 2013 to December 2016 about 192 physicians in Beijing, who specialized in depression and had registered on the platform before 2012. Among these physicians, 139 enabled the online follow-up service function during the observation period. The PSM procedure results in 37 non-adopted physicians and 54 adopted physicians. As shown in Table 4, similar to the main findings based on lung cancer physicians, the adoption of online follow-up services has a significantly positive effect on the number of offline appointments and online consultations for the physicians who specialized in depression.

| | $offline\_appointments_{i,t}$ | | $online\_consultations_{i,t}$ | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Full Sample | Matched Sample | Full Sample | Matched Sample |
| $followup_{i,t}$ | 0.108** | 0.066** | 0.174*** | 0.140** |
| | (0.043) | (0.031) | (0.064) | (0.057) |
| **Time-varying Controls** | | | | |
| Physician characteristics | Yes | Yes | Yes | Yes |
| Physician online performance | No | No | Yes | Yes |
| Observations | 8,509 | 4,368 | 8,509 | 4,368 |
| $R^2$ | 0.032 | 0.040 | 0.447 | 0.534 |

***Note.*** *** p<0.01, ** p<0.05, * p<0.1. The dependent variables are log-transformed. All specifications include physician and time fixed effects. Clustered standard errors at the physician level are in parentheses.

**Table 4. TWFE Estimates for Depression**

Besides the above analysis, we also conduct a series of robustness checks to alleviate the self-selection concern about online follow-up services. First, we validate our results with two alternative balancing methods for treatment endogeneity: coarsened exact matching (CEM) and entropy balancing (EB). Second, we employ the look-ahead propensity score matching (LA-PSM) to account not only for the observed characteristics, but also for time-invariant, unobserved characteristics. Third, instead of employing common time-fixed effects for all physicians in the main specifications, we use physician-specific time trends to account for time-varying confounders that may affect both physicians' adoption decisions and physician demand. Finally, we conduct a placebo test to determine whether a random implementation of online follow-up services would yield effect sizes that are comparable to those observed in the main analysis. All the results show the robustness of our main findings.

## Mechanism Test of The Effect on Online Physician Demand

As discussed in Section Hypothesis Development, the positive effect of adopting online follow-up services on online physician demand is driven by the information effect, which works by increasing the online exposure of a physician to patients and informing patients of a physician's online service characteristics. We dedicate this section to empirically validating these mechanisms.

### *Online Exposure*

Due to the public nature of online follow-up services, physicians who provide more online follow-up services have a higher chance of appearing in patients' online searches and being recommended by OHCs to potential patients, thereby increasing their online exposure. In other words, if an increase in treated physicians' online demand is caused by the increasing online exposure, we would expect a larger increase in online demand for treated physicians who provide more online follow-up services to patients. To test this mechanism, we constructed a continuous variable to capture the intensity of online follow-up services. Specifically, we replaced the binary treatment variable (i.e., $followup_{i,t}$) with the number of online follow-up services provided by a physician per month (i.e., $followup\_num_{i,t}$) in the TWFE model. As shown in Table 5, the significantly positive coefficients of $followup\_num_{i,t}$ confirm that the more online follow-up services a physician provides, the more online demand increases. Therefore, providing online follow-up

services can have a positive information effect on online physician demand by increasing a physician's online exposure to potential patients.

| | *online_consultations*$_{i,t}$ | |
|---|---|---|
| | (1) | (2) |
| | Full Sample | Matched Sample |
| *followup_num*$_{i,t}$ | 0.277*** | 0.358*** |
| | (0.047) | (0.058) |
| Physician characteristics | Yes | Yes |
| Physician online performance | Yes | Yes |
| Observations | 15,574 | 8,256 |
| $R^2$ | 0.236 | 0.268 |

***Note.*** *** p<0.01, ** p<0.05, * p<0.1. The dependent variables and *followup_num*$_{i,t}$ are log-transformed. All specifications include physician and time fixed effects. Clustered standard errors at the physician level are in parentheses.

**Table 5. The Effect of Online Follow-up Service Intensity on Online Physician Demand**

### *Service Characteristics*

To test whether online follow-up services can inform patients of physicians' online service characteristics, we measured two aspects of those characteristics: *response status* and *service performance*. First, due to the voluntary nature of online follow-up services, physicians may not necessarily respond to all patients' queries raised in online follow-up services. Online follow-ups in which patients raise questions but physicians do not respond cannot signal the physicians' willingness to interact online or inform patients of their online service characteristics, thus generating no information effect. To this end, we split online follow-up services into two categories: online follow-up services *with* and *without* responses from physicians. We constructed two continuous variables to measure the quantity of these two types of services—*followup_res*$_{i,t}$ and *followup_nores*$_{i,t}$—and re-estimated the TWFE model. The results in Columns (1) and (2) of Table 6 show significantly positive coefficients of *followup_res*$_{i,t}$ and insignificant coefficients of *followup_nores*$_{i,t}$. That is, the positive effect of online follow-up service adoption on online physician demand is driven by online follow-up services with medical responses from physicians rather than those without any responses. This finding confirms the informational value of online follow-up services for driving online physician demand.

| | *online_consultations*$_{i,t}$ | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Full Sample | Matched Sample | Full Sample | Matched Sample |
| *followup_res*$_{i,t}$ | 0.326*** | 0.466*** | | |
| | (0.051) | (0.067) | | |
| *followup_nores*$_{i,t}$ | 0.059 | -0.042 | | |
| | (0.060) | (0.081) | | |
| *followup_res_num*$_{i,t}$ | | | -0.080 | 0.269 |
| | | | (0.118) | (0.193) |
| *followup_res_length*$_{i,t}$ | | | 0.094** | -0.004 |
| | | | (0.043) | (0.056) |
| *followup_res_sameday*$_{i,t}$ | | | 0.475*** | 0.689*** |
| | | | (0.118) | (0.196) |
| Physician characteristics | Yes | Yes | Yes | Yes |
| Physician online performance | Yes | Yes | Yes | Yes |
| Observations | 11,091 | 4,704 | 11,091 | 4,704 |
| $R^2$ | 0.260 | 0.318 | 0.249 | 0.313 |

***Note.*** *** p<0.01, ** p<0.05, * p<0.1. The analysis focused on the physicians who adopted online follow-up services. The dependent variables, *followup_res*$_{i,t}$, *followup_nores*$_{i,t}$, *followup_res_num*$_{i,t}$, and *followup_res_length*$_{i,t}$ are transformed logarithmically. All specifications include physician and time fixed effects. Clustered standard errors at the physician level are in parentheses.

**Table 6. The Effect of Online Follow-up Performance on Online Physician Demand**

Second, the informational value of online follow-up services for patients suggests that better physician performance leads to higher perceived online service quality. Studies have shown that prompt responses indicate physicians' online availability (Dong et al. 2019) and detailed treatment suggestions signal their expertise and caring for patients (Chen et al., 2020; Zhang et al., 2019b). We constructed three variables—$followup\_res\_num_{i,t}$, $followup\_res\_length_{i,t}$, and $followup\_res\_sameday_{i,t}$—to reflect a physician's performance in online follow-up services by measuring physician $i$'s average response number, length, and speed (i.e., the number of same-day responses to patients' questions) in online follow-up services at month $t$, respectively. Columns (3) and (4) of Table 6 report the estimation results. The coefficients of $followup\_res\_num_{i,t}$ and $followup\_res\_length_{i,t}$ are not consistently significant, while the coefficients of $followup\_res\_sameday_{i,t}$ remain significantly positive. The results suggest that, compared to physicians' average response number and length, response speed in online follow-up services is a more critical consideration for patients when selecting physicians for online consultations.

# Conclusions

This study investigates how physicians' adoption of online follow-up services influences offline and online physician demand. Using data from a leading Chinese OHC, we have consistently demonstrated that providing online follow-up services leads to higher offline physician demand, confirming that online follow-up is a value-adding service for patients that consult physicians offline. Furthermore, we find that the adoption of online follow-up services also increases online physician demand despite the possible theoretical prediction that an increase in offline physician demand could cause a decrease in online physician demand (i.e., the channel substitution effect). To understand the mechanisms underlying the increase in online physician demand, we conduct a series of mechanism tests, the results of which reveal the information effect of online follow-up services. Specifically, due to the public nature of online follow-up service records, providing this new service not only increases physicians' online exposure but also provides more information on their online service characteristics. In particular, physicians' responsiveness and response speed in online follow-up services are important considerations for patients when choosing physicians for online consultations.

## *Theoretical Contributions*

Our study contributes to the healthcare literature on OHCs by examining a new online service function—online follow-up services—which leads offline patients to utilize medical services online. Prior studies have attributed the complementary effect of online consultations on offline visits to direct interactions with physicians (Bavafa et al. 2018), online information for evaluating physicians' quality (Wu et al. 2021), prompt feedback on patients' health conditions (Wang et al., 2020), and strong relationships with patients (Fan et al. 2022). The present study enriches this literature by extending the complementary effect from online initial consultations to online follow-up services and, more importantly, by validating the critical supplementing role of online healthcare services to offline healthcare services.

Furthermore, contrary to the expectation of a substitution effect of increased offline visits on online services (Bergmo et al., 2005; Ghose et al., 2022; Wang et al., 2020), we find providing online follow-up services can significantly increase online physician demand. Mechanism tests reveal that such an increase is the result of the information effect of online service records, which increase physicians' online exposure and signal their online service characteristics. By unpinning the mechanisms underlying the positive effect of online follow-up services on online demand, this study greatly deepens the understanding of the value of information in OHCs for patients' decision-making.

This study contributes to the literature on the impact of online service characteristics. In contrast to prior studies on online healthcare services, which mainly focus on patient satisfaction (e.g., Chen et al., 2020; Yang et al., 2015a) and the physician-patient relationship (e.g., Liu et al., 2020; Zhang et al., 2019), we investigate how online service characteristics affect online physician demand, which are critical yet rarely studied outcomes. Moreover, we find that physician response speed can significantly increase online physician demand. Therefore, it is important to use different online service characteristics to manage online healthcare service demands.

As the first examination of how online follow-up services influence physician demand, this study enriches the literature on medical follow-ups in a uniquely important way. Previous studies on medical follow-ups

have almost exclusively focused on in-person and telephone follow-ups and examined their impacts on patient health outcomes. Although Li et al. ( 2021) discussed the factors underlying patients' use of online follow-ups, no study has attempted to empirically examine the practical impact of online follow-ups, which is of the utmost importance for government agencies, OHCs, and physicians seeking to understand this new service function. Moreover, by examining why online follow-up services influence offline and online physician demand, we have demonstrated the advantages of online follow-up services in adding value to offline visits and providing information for online consultations, both of which are absent in offline and telephone follow-ups.

## *Practical Implications*

Our paper provides two-fold implications for physicians. First, physicians should carefully deliberate on whether to adopt online follow-up services in OHCs. Although increased offline and online physician demand as a result of providing online follow-up services may contribute significantly to physicians' economic returns, it would also increase their workload. Therefore, enabling online follow-up services may not be beneficial for physicians who have already been burdened with high demand. However, for physicians with extra capacity, providing more online follow-up services is a good strategy for attracting more patients, both online and offline, and managing offline patient care more effectively. Second, for physicians who have adopted online follow-up services, our findings suggest that online follow-up service performance also matters. Specifically, to increase online demand, physicians should not only respond to patients' requests but also respond promptly.

Regarding OHCs, our results indicate that the adoption of online follow-up services can generate spillover demand for online consultations. Although the added value for offline services swings certain online patients to offline interactions, online follow-up services also generate useful information about online services provided via the OHC. Enabling the online follow-up service function for free does not bring direct revenue to the OHC. However, the revenue gained from an increase in online consultations might compensate for any costs incurred by offering the free function, especially when more and more physicians adopt this function. As such, OHCs can benefit from providing the online follow-up service function to physicians and encouraging its wide adoption and frequent use, especially by those specializing in chronic diseases.

Finally, this study is also of interest to healthcare policymakers. Contrary to policymakers' expectations, our results indicate that providing online follow-up services may not alleviate the burden on offline medical resources. However, it does promote the utilization of online channels for patients seeking healthcare services. Therefore, policymakers should re-evaluate the influence of online follow-up services by comparing the benefits, such as shaping patients' follow-up-seeking behaviors and promoting OHC development, and the losses, such as increasing pressure on offline medical resources. To reduce the pressure on offline medical resources while promoting online follow-up services, policymakers should consider multi-level policy incentives. For example, policymakers can provide physicians who have extra offline capacity offline with more incentives to adopt online follow-up services.

## *Limitations and Future Research*

This study has several limitations. First, because the research context is based in mainland China, a natural concern is whether the findings can be generalized to OHCs based in other countries. As such, we call for future studies to evaluate the findings by examining OHCs in various research contexts, such as *healthtap.com* in the United States, *askthedoctor.com* in Canada, and *practo.com* in India. Second, we chose physicians specializing in chronic diseases because medical follow-ups and channel choices are more applicable to patients with chronic diseases. However, it would be worthwhile for researchers to empirically evaluate our findings by studying other types of diseases. Third, physicians may be active in multiple OHCs; however, we cannot observe physicians' activities and demands in other OHCs due to data unavailability. Consequently, we cannot examine how providing online follow-up services in an OHC might affect a physician's demand in other OHCs. An interesting extension of this study would be to explore this multihoming issue and investigate how online follow-up services affect physician demand across multiple platforms. Finally, because the estimation window of this study is relatively short (i.e., five years), the effect of online follow-up services that dissipates with time cannot be fully examined. Future studies may probe the long-term impact of this service function.

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