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# Investigating the effect of online and offline reputation on the provision of online counseling services: A case study of the Internet hospitals in China

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**Abstract** The sustainable development of Internet hospitals and e-health platforms relies on the participation of patients and physicians, especially on the provision of health counseling services by physicians. The objective of our study is to explore the factors motivating Chinese physicians to provide online health counseling services from the perspectives of their online and offline reputation. We collect the data of 141029 physicians from 6173 offline hospitals located in 350 cities in China. Based on the reputation theory and previous studies, we incorporate patients' feedback as physicians' online reputation and incorporate physicians' offline professional status as physicians' offline reputation. Results show that physicians' online reputation significantly and positively influence their online counseling behaviors, whereas physicians' offline reputation significantly and negatively influence their online counseling behaviors. We conclude that physician's online and offline reputations show a competitive and substitute relationship rather than a complementary relationship in influencing physicians to provide online counseling services in Internet hospitals. One possible explanation for the substitute relationship could be the constraints of limited time and effort of physicians.

**Keywords** Internet hospitals, physicians' online counseling, online reputation, offline reputation

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## 1 Introduction

### 1.1 Background

After the new round of healthcare reform released by the Chinese government in 2009, the total amount of healthcare resources has been increasing in recent years (Liu et al., 2016a; Cao et al., 2020). However, compared with the growing demand caused by rising living standards and aging population, the overall supply is still insufficient, and the inequity of health resource distribution is still one of the major challenges faced by China (Anand et al., 2008; Zhu et al., 2020). For instance, according to the *CIA World Factbook*, the number of physicians per 1000 population and number of beds per 1000 population in China are 1.79 and 4.20, respectively, whereas the average numbers in developed countries are 2.75 and 6.56, respectively (CIA, 2019). On the other hand, the health resources in China have also shown relatively small disparities between eastern–western areas but huge gaps between urban–rural regions (Goh et al., 2016; Leng et al., 2019; Cao et al., 2020). For instance, the density of physicians in urban areas is more than twice that in rural areas, with nurse density showing more than a three-fold difference (Anand et al., 2008).

To alleviate the above problems, a series of Internet-based approaches and platforms has been proposed, including various types of online health communities (OHCs). There are patient-oriented platforms, such as PatientsLikeMe, where the participants are patients who want to share their medical experiences and seek support (Wu and Lu, 2016; 2017). There are also physician-oriented platforms, such as Dingxiang Doctor, where the main participants are physicians who are asking for academic interactions and co-operations (Zhang et al., 2017). There are also some platforms attracting both physicians and patients, such as WebMD and MedHelp (Atanasova et al., 2017). As most of these platforms are

set up on social media platforms and used for information and educational purposes, they may not be authorized and supervised by the existing offline medical institutions.

In China, Internet hospitals are one of the important trials attracting and motivating most of the Chinese physicians and patients online (Tang et al., 2019; Lv et al., 2019; Gong et al., 2020; Li et al., 2020a). Physicians who are working in offline medical institutions can register in Internet hospitals and provide online services. Different from the OHCs that are operated on social media platforms, most of the Internet hospitals are operated with the foundation of existing medical institutions and with the authorization of governmental committees. In Internet hospitals, physicians can present their working hours online so that patients can make appointments and visit them in their offline working hospitals. More importantly, physicians can also present their available online working hours so that patients can make online consultations during their online working time, either by textual conversations or by video calls. In this way, physicians can make most of their working time (possibly, also their spare time), enlarging the provision of medical resources (Ameri et al., 2020). After moving the working time online, physicians can also provide their services to patients all over China, especially to those in rural areas (Goh et al., 2016).

Despite the various advantages, patients and physicians have encountered difficulties in using Internet hospitals, and understanding how to facilitate physicians' contribution is crucial (Atanasova et al., 2017; Guo et al., 2017; Li et al., 2019). According to a previous study, there are two types of contributed behaviors of physicians. One is the sharing behaviors of information and professional knowledge, either privately or publicly (Chang and Chuang, 2011; Yan et al., 2016; Huang et al., 2019; Yang and Zhang, 2019; Zhang et al., 2020). The other type is the provision of online counseling services by physicians, either paid or unpaid (Michtalik et al., 2013; Chen et al., 2020; Wang et al., 2020). Extensive studies have been done around the motivations of physicians' sharing behaviors (e.g., money incentives, concern about reputation, and social influence) (Yan et al., 2016; Zhang et al., 2020). However, few studies have investigated the motivations and factors influencing physicians to provide online counseling services, including both free and paid services.

To fill this gap, this study explores the factors of online counseling provision by considering the online and offline environment. Based on reputation theories and previous studies (Jøsang et al., 2007; Lagu et al., 2010; Gao et al., 2015; Liu et al., 2016b; Jabeen et al., 2018), we incorporate patients' online feedback, including patients' comments and satisfaction scores, as the online reputation. We then incorporate physicians' professional status, including their professional title (Yang and Zhang, 2019) and offline hospital ranking (Rothberg et al., 2008),

as the offline reputation. In addition, we characterize the moderating effects of the offline context, which can be comprehensively represented by the levels of the city where the physicians live (Ye et al., 2019; Yu et al., 2019), and the online context, which can be comprehensively represented by the number of online following patients who are paying special attention to the physicians.

Without the active participation of physicians, Internet hospitals cannot play their roles in solving the problems of shortages of medical resources and their unbalanced distributions. Therefore, it is very important and necessary to investigate and understand the factors of physicians' participation for the long-term development of Internet hospitals and e-health platforms. In particular, we aim to address the following questions:

- (1) How do physicians' online reputation influence their online counseling behaviors in Internet hospitals?
- (2) How do physicians' offline reputation influence their online counseling behaviors in Internet hospitals?
- (3) How do physicians' offline living cities and online following patients moderate the effect between their reputations and their online counseling behaviors?

## 1.2 Internet hospitals

As a new e-health model, Internet hospitals are distinct but overlap with online health, telemedicine, and mobile health (Han et al., 2020b). In general, Internet hospitals are Internet medical platforms combining online and offline access for medical institutions (e.g., public hospitals) to provide a variety of e-health services. Therefore, Internet hospitals extend medical resources from offline hospitals to the Internet by using information technology, and they also develop new forms of online medical services and online health services (Tu et al., 2015; Han et al., 2020a).

Internet hospitals are booming in China, and it is the joint effort of the government and the medical market to alleviate the coexistence of shortages of medical resources and their unbalanced distributions (Han et al., 2020b). There are three different types of operating models of Internet hospitals. The first type is the government-led Internet hospitals, where the physicians are from different offline medical institutions but are employed by the Internet hospitals and managed by the government. One example of government-led Internet hospitals is the Zhejiang Provincial Internet Hospital, which was set up in 2019 (Hangzhou Daily, 2019). The second type is the hospital-led Internet hospitals, where the physicians are from the same offline hospital, but their jobs are to provide online services on the platforms set up by the hospitals. One such example is the First Affiliated Hospital of Zhejiang University, which is one of the top 10 hospitals in China. The last type is the enterprise-led Internet hospitals, where the physicians are from

different offline medical institutions, but they register on and are managed by the enterprises developing the online platforms. One such example is the WeDoctor, one of the leading enterprises serving most of the medical institutions and public hospitals in China (Han et al., 2020b), which is also our investigated platform.

Although Internet hospitals are online platforms, they need the foundations of existing medical institutions to conduct consistent online and offline service supervision (Han et al., 2020a). Medical and nonclinical services can be provided, but Internet technology can only be used for safe and appropriate medical services. Services provided by Internet hospitals can be categorized into various classifications (Li et al., 2020c), but the online counseling services are the most common and play the central role in attracting patients to the use of other services (Deng et al., 2019). In online counseling, patients can communicate with physicians in order to identify their health conditions and obtain the diagnosis and prescriptions from the physicians. During the COVID-19 epidemic, online counseling services have also played a crucial role in remote medical guidance, which reduced the mobility of people to the hospital and cut off possible transmission routes (Gong et al., 2020; Li et al., 2020b).

### 1.3 Physicians' online counseling services

Online counseling is composed of a Web-enabled system and associated processes, where physicians are able to communicate, disseminate, and share clinical information and to provide healthcare guidance (Li et al., 2019). Depending on their subjective intentions and available time slots, physicians can choose to open up any online counseling channels developed by the platform to answer patients' requests, either paid or unpaid. These channels include textual content conversation, telephone calls, and video calls (Wu and Lu, 2017; Luo et al., 2018). Therefore, physicians' online consultation volume, defined as the total amount of counseling conversations from all channels of the platform, can be used as the measurement of the actual consulting behaviors conducted by the physicians.

The bulk of previous studies on physicians' counseling services have established the direct associations between the motivations and physicians' subjective intentions (Yan et al., 2016; Zhang et al., 2017). The authors separated the subjective intentions into personal factors (e.g., personal compensation and sense of self-worth) and social factors (e.g., building and maintaining better patient–physician relationship) (Yang and Zhang, 2019). The authors have further divided the motivators into extrinsic factors (i.e., extrinsic rewards, and expected patient–physician relationship) and intrinsic factors (i.e., sense of personal compensation and self-worth) (Chen et al., 2020). Although previous studies show that some

factors are related to physicians' online counseling behaviors, they ignored the objective facets of physicians, such as their offline working status. For instance, a previous study has shown that providing consultation services is burdensome for physicians because of their heavy workload in their offline working hospitals (Anand et al., 2008).

In Internet hospitals, the total amount of online counseling services can be generated from the following two ways (Liu et al., 2016b). In the first way, from the perspective of physicians, subjective and objective conditions are needed. On the one hand, physicians' subjective intentions are necessary so that they would like to register on the platforms and start to use the various channels through which online consultation can be provided (Lin and Chang, 2018; Yang and Zhang, 2019; Chen et al., 2020). On the other hand, a series of objective conditions should be satisfied. For instance, physicians should have sufficient time and effort, either spending their spare time or part of their working time as supported by their offline hospitals to provide online consultation services (Tucker et al., 2010; iResearch, 2017). Existing studies have less considered the objective conditions of physicians, which can be reflected by physicians' professional status and reputations in online and offline contexts.

In the second way, from the perspective of patients, patients can have special preference for some physicians (Tang et al., 2019; Han et al., 2020a; Li et al., 2020a). As online counseling services are especially convenient for follow-up visits and the management of common and chronic diseases, patients may ask for their physicians to open up online counseling services. In this case, patients have some offline interaction with physicians, and online counseling services are used for maintaining the subsequent patient–physician relationship. In other cases, if patients know little about physicians but can view their previous online performances and online reputations, they would also like to initiate an online consultation. However, in either case, the number of patient-initiated consultations is relatively small due to the limited knowledge and consulting experiences of the patients and the wide range selection of physicians selected from all over the country. The previous related work is summarized in Table 1.

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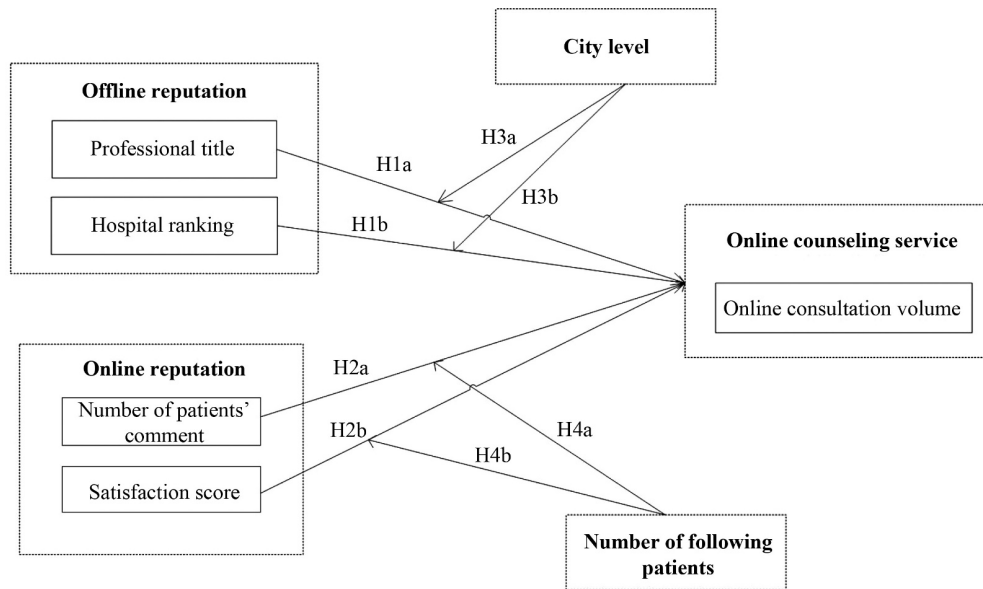
## 2 Data and methodologies

Our study explores the factors driving or impeding physicians to provide online counseling services. After analyzing possible sources generating online counseling services with respect to reputation theory and prior study, we propose our research hypotheses and research model (Fig. 1). We also collect real-world data and apply statistical regression models to verify our hypotheses.

**Table 1** Summary of motivation studies on online medical services

Aspect	Subjective factors	Objective factors
Physicians' activeness of providing online services	Self-efficacy/Self-empowering ★ (Chen et al., 2020; Zhang et al., 2020; Yang et al., 2021) Social interaction ▲ (Lin and Chang, 2018) Physician–patient relationship and trust ▲★ (Chen et al., 2020; Yang et al., 2021) Reciprocity and altruism ▲ (Zhang et al., 2017; Chen et al., 2020)	Professional status Δ (National Health Commission of PRC, 2009; Chen et al., 2020) Extrinsic reward and return (e.g., monetary reward and consultation price) ☆ (Zhang et al., 2020; Chen et al., 2020)
Patients' selection of online physicians	Perceived risk ★ (Li et al., 2020a) Perceived usefulness ★ (Shmueli and Koppius, 2011) Physician–patient relationship and trust ▲★ (Robin DiMatteo et al., 1979)	Hospital rankings Δ Physicians' medical titles Δ

Notes: ▲ indicates the factors that are related to the online reputation; Δ indicates the factors that are related to the offline reputation; ★ indicates the factors that are related to the online context; ☆ indicates the factors that are related to the offline context.



**Fig. 1** Research model.

2.1 Research hypotheses

(1) Physicians' offline reputation

Reputation is generally a belief about a person's character (Jøsang et al., 2007). The American Heritage Dictionary (AHD) defines reputation as follows: "Reputation is the public's overall evaluation of a person, a thing, a unique characteristic, or a trait attributed to the person or the thing" (Kreps and Wilson, 1982). In China, physicians' offline reputation measures their past clinical performances in offline working hospitals and can be reflected by their offline professional status, including their professional title and the level of their working hospitals (Liu et al., 2016b; Jabeen et al., 2018). Physicians' professional title indicates their personal reputation, which has been gradually accumulated by physicians through long-term offline experience and services. The ranking of physicians' working hospitals indicates their collective reputation, which has been inherited from the hospitals' reputation (Liu et al., 2016b).

In hospitals with higher rankings and reputation, physicians' offline working burdens will be generally heavier. It is difficult for higher-ranking hospitals to spare extra health resources online, and it is also difficult for their physicians to spend extra time to participate in online consultations. Thus, the objective conditions of online consultations for physicians of higher offline reputation are weak despite that online patients would like to consult physicians with high reputation. In addition, these physicians have obtained relatively higher income from their offline working hospitals, the incentives of online consultation are weak, and their willingness to provide online consultation services is not high (Zhang et al., 2020). By contrast, in hospitals with relatively lower rankings and reputation, physicians' offline burdens are lower, and they may have more time (either spare time or working time) and effort to contribute to online consultations. Therefore, we propose the following hypotheses:

**H1a:** Physicians' professional title negatively influences the provision of physicians' online consulting services.

**H1b:** The ranking of physicians' working hospitals negatively influences the provision of physicians' online counseling services.

#### (2) Physicians' online reputation

The definition of reputation varies in different fields of research. In online marketplace, online reputation is understood as a conditional probability that an individual will keep behaving in a certain manner. Previous studies showed that most individuals consider their online reputation as important and influential for their lives (Yang, 2015). In the marketplace context, online reputation can improve the interaction between buyers and sellers, thereby increasing the trust and cooperation of both buyers and sellers (Wu and Lu, 2017). In the healthcare context, a physician's online reputation has been found to impact patients' decisions in terms of consulting some specific physicians (Liu et al., 2016b; Wu and Lu, 2016).

Physicians' online reputation measures their past online clinical performance in Internet hospitals and can be reflected by patients' online feedback and ratings, including patients' comments and their satisfaction scores (Duan et al., 2008; Gao et al., 2015; Han et al., 2020a). On the one hand, these feedback and ratings have been gradually accumulated by physicians through long-term online counseling behavior and online treatment experience. If the physicians have accumulated a higher online reputation, the subjective and objective conditions (i.e., strong willingness and enough time) have been satisfied. Moreover, physicians with higher online reputation may be pressured to maintain their positive feedback and ratings and therefore engage in more qualified online consultation services (Yang, 2015). In summary, higher online reputation will induce more online consultations to make the rich get richer. On the other hand, these public feedback and ratings will also promote patient-initiated consultations, and physicians' online effort and reputation will further attract more patients (Jøsang, 2008; Lagu et al., 2010; Yang et al., 2021). Thus, we hypothesize the following:

**H2a:** Patients' online comments positively influence physicians to provide online counseling services.

**H2b:** Patients' satisfaction scores positively influence physicians to provide online counseling services.

#### (3) Moderating effect of city level

Offline context can be comprehensively represented by the levels of the cities where the physicians live. In 2009, the Ministry of Health of PRC put forward a scheme of multi-site medical practice for physicians, which allows qualified medical practitioners to be employed and work in more than two medical institutions after being registered by the health administration department (Anand et al., 2008; National Health Commission of PRC, 2009). Unlike the cases in western countries, most of the excellent physicians are hired at a higher level of public hospitals and at a higher level of cities. Cities with different levels of population and economic development have various

numbers of medical institutions, so that the number of medical institutions that physicians can choose when performing multi-site practice is affected by the level of cities (Yu et al., 2019).

In higher-level cities, the population is large, and the number of medical institutions where physicians can practice in is large. Online consultation is just one of many options, which is not very attractive. Especially for physicians who already have a high offline reputation, they have more choices in multi-site practice, and the advantages of online consultation are less obvious. On the contrary, in lower-level cities, where the population is relatively small, physicians have fewer choices in multi-site practice. In this case, online consultation may become an important option, especially for physicians with lower offline reputation. They may pay more attention to an online consultation and regard it as an important source to increase their reputation. In summary, the negative relationship between offline reputation and online consultation service volume can be further enhanced by the city level. Therefore, we hypothesize the following:

**H3a:** The level of cities where the physicians live negatively moderates the relationship between the professional title and the provision of physicians' online counseling services.

**H3b:** The level of cities where the physicians live negatively moderates the relationship between the ranking of physicians' working hospitals and the provision of physicians' online counseling services.

#### (4) Moderating effect of following patients online

Online context can be comprehensively represented by the number of following patients who pay special attention to physicians online. This number refers to patients who have been following the physician for future consultations, either online or offline. In Internet hospitals, there are two scenarios where the patients pay more attention to some specific physicians and follow them. One happens before the consultation, and the other happens after the consultation. In the first case, after online searching and learning about the profiles of the physicians, patients will pay special attention to the physicians if they intend to visit them offline or online. In the second case, after receiving online or offline consultation services from the physicians, patients will follow the physicians for convenient follow-up consultations. To some degree, the number of following patients can reflect the expected volume of consultations received by the physicians, including online and offline consultations. Physicians with higher online reputation may attract relatively more following patients and higher expected consultation volume. However, if the offline consultation takes a larger proportion than the online consultation, the online reputation on the online consultation will be weakened. Thus, we hypothesize the following:

**H4a:** The number of following patients negatively moderates the relationship between the number of

patients’ comments and the provision of physicians’ online counseling services.

**H4b:** The number of following patients negatively moderates the relationship between satisfaction scores and the provision of physicians’ online counseling services.

2.2 Data collection

To test the research hypotheses in this study, we collect related information and data from an Internet hospital platform, WeDoctor, authorized by the National Health Commission of PRC in 2010. It is one of the leading medical service websites in China because of its large database of independent choices of physicians for online appointments and patients’ evaluation of their experiences with the physicians. WeDoctor also provides sufficient data for this study, including physicians’ online and offline reputations as well as their living cities, as shown in the physicians’ homepage in Fig. 2.

In the upper right of the physicians’ homepage, four channels are provided, one for online reservation (i.e., to make an online appointment with the physician and visit him/her in the offline hospitals) and three for online consultation (i.e., graphical/textual consultations, video calls, and packaged services). In the lower right of the homepage, the online reservation volume records the number of patients who use the online reservation channel, whereas the online consultation volume records the number of conversations conducted through the three online consultation channels. We select the physicians’ online consultation volume as the investigated dependent variable, which reflects the actual counseling behaviors of the physicians.

We design a Python program to collect data from the WeDoctor website automatically. In our initial dataset, we obtained all of the 141029 physicians registered on

this website by the end of May 10, 2019. After excluding incomplete records, 24077 physicians (about 17% of the initial sample) are kept. The large volumes of the sample ensure that our dataset is representative. As our study focuses on physicians’ online counseling behaviors, we intentionally filtered out the physicians whose online consultation volume is larger than 50. Other criterion values will also be further discussed in the section of model fitness and robustness test.

According to the research hypotheses, our independent variables contain the physicians’ online and offline reputations (see Table 2). Patients’ feedback and ratings are treated as indicators of physicians’ online reputation, including the number of patients’ comments and their satisfaction scores. The number of patients’ comments records the number of textual comments written by the patients regarding the performance of the physician after consultations. The satisfaction scores are averaged ratings given by patients, which reflect the overall quality of the consultation process and the social recognition that physicians have gained from consultation services. The physicians’ professional status is treated as an indicator of their offline reputation, including their professional title and the ranking of offline working hospitals. Physician’s professional title refers to the physician’s medical status as evaluated by the government according to the physician’s comprehensive abilities. If a physician has clinical and academic titles, we take the clinical titles in our study. The ranking of offline hospitals is evaluated by the government according to the overall conditions of the hospitals, including not only the hardware but also the treatment quality, nursing quality, work quality, and comprehensive quality (National Health Commission of PRC, 2011). Finally, we also delve into the moderated effects of the city levels and the number of following patients.

The level of the cities measures the development of the



Fig. 2 Part of the physician’s homepage on WeDoctor.

**Table 2** Description of variables

Variables	Explanation
<b>Dependent variable</b>	
Online consultation volume	The online consultation volume is the number of online conversations between the patients and the physicians. For example, the consultation volume of the physician in Fig. 2 is 2339, meaning that he has conducted 2339 pieces of counseling conversations with patients online
<b>Independent variable</b>	
Professional title	The professional titles include senior titles, associate senior titles, intermediate titles, junior titles, and non-titles, which are assigned values of 4, 3, 2, 1, and 0, respectively
Hospital ranking	Hospitals have several rankings, including ranking I (ranking IA, IB, and IC), ranking II (ranking IIA, IIB, and IIC), and ranking III (ranking IIIA, IIIB, and IIIC). Ranking III is better than ranking II, and ranking II is better than ranking I, which are encoded as 3, 2, and 1, respectively. Hospitals with no ranking are denoted as 0
City level	According to the 2019 City Business Charm Ranking distributed by YiMagazine on May 20, 2019, the city levels are divided into first-tier cities, new first-tier cities, second-tier cities, third-tier cities, fourth-tier cities, fifth-tier cities, and unlisted cities, encoded as 6, 5, 4, 3, 2, 1, and 0, respectively (Mao and Che, 2019)
Number of patients' comment	This number contains all the textual comments written by the patients for the specific physician. For example, the number is 2368 in Fig. 2, meaning that 2368 pieces of textual comments have been written by the patients
Satisfaction score	The satisfaction score is an average rating given by the patients after online consultations on the platform, ranging from 0 (null values) to 10 (indicating 100% satisfied)
Number of following patients	This number refers to those patients who have been following the physician for future possible consultations, either online or offline. For example, the number is 3866 in Fig. 2, meaning that there have been 3866 patients who are following this physician online

city where the physicians live, reflecting the possible choices of medical institutions for multi-site practice and the probability of physicians to gain medical resources. The number of following patients is the number of patients who have been following the physician on the physician's homepage for future possible consultations, either online or offline, reflecting the physician's popularity and the expected volume of consultations from the online patients. Detailed explanations of these variables are shown in Table 2.

The descriptive statistics of the dependent and independent variables used in the analysis are presented in Table 3. We can see that only 17.1% of the physicians had more than one piece of online consultation with the maximum number of 37000 and an average of about 22. Most of the physicians might not open any channels of the online consultation on the platform and have no online counseling experiences. However, they might also attract patients to follow them online and obtain patients' comments, possibly for future consultations if the physicians open any channels for online consultations. For the three categorical independent variables, their pie charts are shown in Fig. 3. We can see that more than 60% of the physicians have associate senior or higher professional titles, almost 80% are from hospitals with ranking III, and more than 70% are living in second-tier or higher level cities. The readers should note that as this study delves into the motivating factors of online consultation, it is necessary to set up some criteria and intentionally filter out the physicians who have provided consultation services more than the criteria. In Section 3, we set up the criterion as 50 and focus on the physicians who have provided more than 50 pieces of online consultations. We also try other criterion values of 20, 35, 65, and 80 to have a broader view of the results and applicability of the findings.

**Table 3** Descriptive statistics of variables

Variables	Min	Max	Mean	Standard deviation
Online consultation volume	0	37000	22.11	373.98
Professional title	0	4	2.86	1.13
Hospital ranking	0	3	2.74	0.56
City level	0	6	4.31	1.43
Number of patients' comment	0	14081	26.81	188.91
Satisfaction score	0	10.00	1.73	3.67
Number of following patients	0	20509	56.36	341.76

### 3 Results

We first present the results of variable correlations, both dependent and independent variables, from which we obtained the initial findings. Then, we present the results of model estimation to further verify the initial findings and our research hypotheses. Finally, the results of model testing are given to justify the fitness and robustness of the models and our research hypotheses.

#### 3.1 Variable correlations

The results of variable correlations are presented in Table 4. We can see both variables of offline reputation and the offline moderate variable of city level are negatively correlated with physicians' online consultation volume, as is highlighted by the red colors in column 2. These three variables have a strong positive correlation (higher than 0.3). By contrast, both variables of online reputation and the online moderate variable of the number of following patients are positively correlated

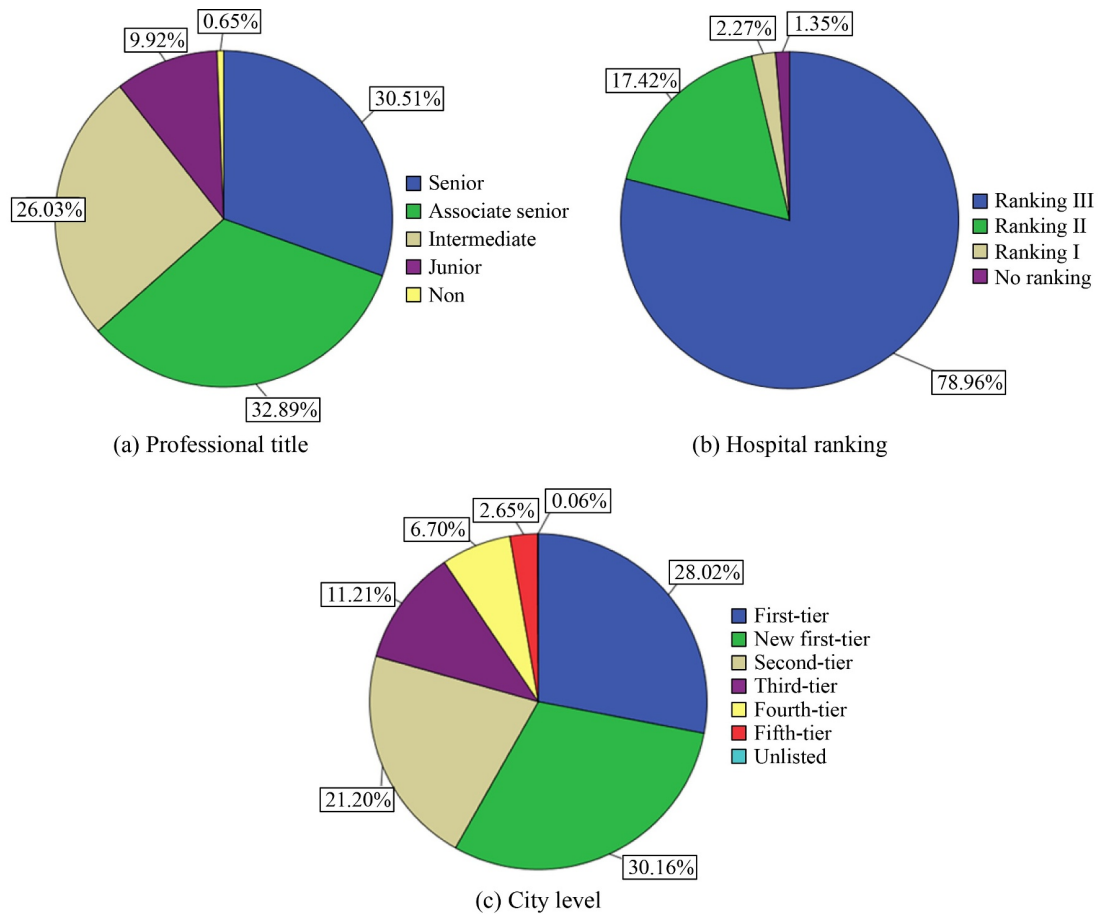


Fig. 3 Pie charts of the categorical variables.

Table 4 Correlations of variables

Variable	1	2	3	4	5	6	7
1 Online consultation volume	1						
2 Professional title	-0.15**	1					
3 Hospital ranking	-0.23**	0.39**	1				
4 City level	-0.19**	0.38**	0.42**	1			
5 Number of patients' comments	0.57**	-0.004	-0.07**	0.03	1		
6 Satisfaction score	0.06**	-0.08**	0.009	-0.05**	0.04**	1	
7 Number of following patients	0.18**	0.25**	0.09**	0.25**	0.54**	-0.05**	1

Notes: \*\* $P < 0.01$ , where  $P$  indicates the significance level. There are 4907 observations.

with physicians' online consultation volume, as is highlighted by the blue colors in column 2. The above findings are also consistent in the samples filtered out by other criterion values. The readers may refer to [Supplementary Table S1](#) (the results of the original sample) and [Supplementary Tables S2–S5](#) (the results under other criterion values) for the detailed values.

### 3.2 Estimation model

To test the hypotheses regarding what motivate physicians

to provide online consultation services, we develop two empirical models to test the moderating roles of the offline context and online context separately. The models are as follows:

$$\begin{aligned}
 & \text{OnlineConsultationVolume}_i \\
 &= \beta_0 + \beta_1 \times \text{ProfessionalTitle}_i + \beta_2 \times \text{HospitalRanking}_i \\
 &+ \beta_3 \times \text{PatientsComments}_i + \beta_4 \times \text{SatisfactionScore}_i \\
 &+ \beta_5 \times \text{CityLevel} \times \text{ProfessionalTitle}_i \\
 &+ \beta_6 \times \text{CityLevel} \times \text{HospitalRanking}_i + \varepsilon_i,
 \end{aligned}$$

(1)



$$\begin{aligned}
 & \text{OnlineConsultationVolume}_i \\
 = & \beta_0 + \beta_1 \times \text{ProfessionalTitle}_i + \beta_2 \times \text{HospitalRanking}_i \\
 & + \beta_3 \times \text{PatientsComments}_i + \beta_4 \times \text{SatisfactionScore}_i \\
 & + \beta_5 \times \text{FollowingPatients} \times \text{PatientsComments}_i \\
 & + \beta_6 \times \text{FollowingPatients} \times \text{SatisfactionScore}_i + \varepsilon_i, \tag{2}
 \end{aligned}$$

where  $i = 1, 2, \dots, n$ , and parameters  $\beta_0, \beta_1, \dots, \beta_6$  are the coefficients to be estimated.  $\varepsilon_i$  is the error term associated with observation  $i$ . Model (1) focuses on the moderating role of the offline context, and Model (2) tests the moderating role of the online context. According to the statistics on means and variances in Table 3, the distributions of the dependent variable and some independent variables are not normal. We use their logarithm forms instead.

### 3.3 Regression results

We perform stepwise linear regression models, which introduce independent variables one by one. In Step 1, only four independent variables are included. In Step 2, the moderated effects of the control variables are tested in Model (1) and Model (2) separately. During the process of stepwise regression, variables that have the interaction of multicollinearity will be removed. The final results are shown in Table 5.

In Step 1, we estimate the relationships between the online/offline reputation and the provision of online counseling services. The number of patients' comments (with  $\beta_3 = 0.558, P < 0.001$ ) is first introduced into the model, and it significantly and positively influences the online consultation volume. Then, the professional title (with  $\beta_1 = -0.084, P < 0.001$ ) is added, followed by the hospital ranking (with  $\beta_2 = -0.163, P < 0.001$ ) and the satisfaction score (with  $\beta_4 = 0.034, P < 0.01$ ). In summary, online and offline reputations may significantly

influence the provision of physicians' online counseling services. The influence of online reputation is positive, supporting H2a and H2b. However, the influence of offline reputation is negative, supporting H1a and H1b.

Next, in Step 2, we estimate the moderating effect of the offline context on the provision of online counseling. We find the offline context, represented by the variable of the city level, negatively moderates the relationships between the hospital ranking and the provision of physicians' online counseling services (with  $\beta_6 = -0.177, P < 0.001$ ), which supports H3b. Its moderating role on the professional title is not significant; thus, H3a is not supported.

Finally, we estimate the moderating effect of the online context, which is represented by the variable of following patients. We find that the number of following patients negatively moderates the relationships between the number of patients' comments and the provision of physicians' online counseling services (with  $\beta_5 = -0.216, P < 0.001$ ), supporting H4a. Its moderating role on the satisfaction score is not significant; thus, H4b is not supported. One possible justification for H4b is that the majority of following patients using the platform for online reservation visit the physicians offline rather than consulting them online. This can also be verified by the high correlation coefficient between the number of online reservations and the following patients (around 0.84).

In summary, the moderating role of the city level on offline reputation and the online consultation provision and that of the following patients on the online reputation and the online consultation provision are partially supported. All the standardized coefficients and  $P$  values of each explanatory variable are shown in Table 5.

### 3.4 Model fitness test

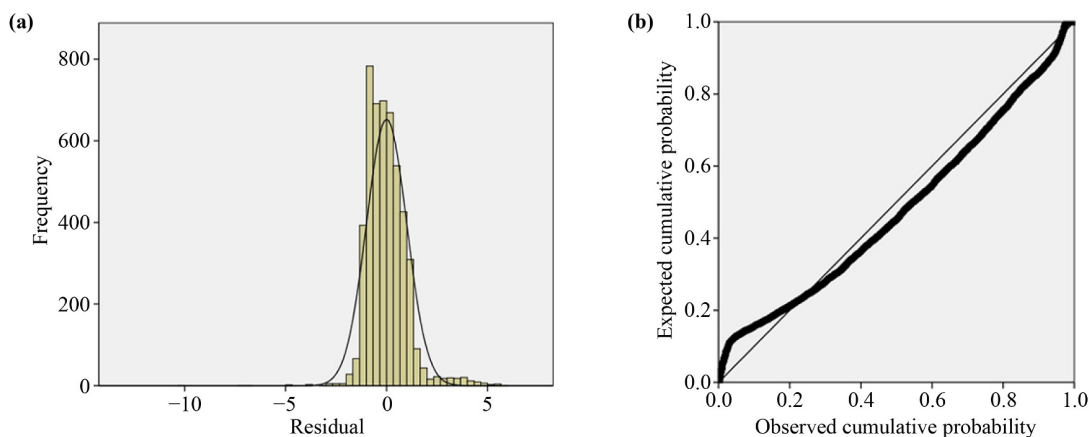
For the fitness of the models, we can see that in Step 1, the  $R$ -square is 0.371, explaining more than 37% of the variance of the dependent variable. In Step 2, the  $R$ -squares in Model (1) and Model (2) are higher than that in Step 1. The change of  $R$ -squares between Model (1) and Model (2) verifies the effectiveness of the moderating factors of online context and offline context on the online counseling volume. The Durbin-Watson (DW) statistics in Step 1 and in both models of Step 2 are close to 2, indicating that the residuals are independent of each other. The independence of residuals can also be verified by their distributions shown in Fig. 4, which is near normal.

Readers may have doubts about the criterion value in selecting the physicians whose online consultation volume is higher than 50. We also test other criterion values and find our selection produces the best model of higher  $R$ -square (Table 6). Our models can explain almost 40% of the variances, which is higher enough considering the small number of independent variables and the large sample of 4907 observational data. Readers

**Table 5** Results of stepwise regression models

	Step 1	Step 2	
		Model 1	Model 2
FollowingPatients*SatisfactionScore			0.025
FollowingPatients*PatientsComments			-0.216***
CityLevel*ProfessionalTitle		-0.096	
CityLevel*HospitalRanking		-0.177***	
Satisfaction score	0.034**	0.030**	0.024*
Professional title	-0.084***	-0.049***	-0.073***
Hospital ranking	-0.163***	-0.052**	-0.153***
Number of patients' comments	0.558***	0.564***	0.679***
Adjusted $R$ -square	0.371	0.385	0.402
Durbin-Watson (DW) statistics	1.756	1.792	1.760

Notes: \*\*\* $P < 0.001$ , \*\* $P < 0.01$ , \* $P < 0.05$ . There are 4907 observations, and the online consultation volume of each physician is bigger than 50. The values in the table are the standardized coefficients.



**Fig. 4** The residuals estimated by the models of Step 1, where (a) shows the distribution of the residual values, and (b) shows the expected cumulative probability versus the observed cumulative probability of the residual values.

**Table 6** Comparison of the results using different criterion values in selecting physicians

Criterion value	DW statistics	Adjusted <i>R</i> -square
20	1.766	0.361
35	1.774	0.369
50	1.756	0.371
65	1.722	0.367
80	1.669	0.365

may note that there are many other factors in Table 1 that are also related to the online consultation, such as the prices and physician–patient trust, but these factors are out of our scope in this study.

### 3.5 Robustness test

To ensure the reliability of our statistical significance, robustness testing is conducted in our model. In the main analysis, we use a sample of 4907 physicians (with the online consultation volume larger than 50) to test the proposed hypotheses. In the robustness test, we enlarge the criterion value, with the online consultation volume being increased from >20 to >35 and >65 to >80. The results are presented in Table 7. We also take a stratified sampling of the original sample based on the city levels. We randomly select 80% of the original sample in each level of cities and combine them to form a new sub-sample. Then, we use the sub-sample data with the same model to test the robustness of our findings. We repeat the above process 100 times, and the average coefficients are presented in Supplementary Table S6.

From the results of the robustness test, we find that the values of the coefficients have little change, but the sign of coefficients of the same variable is consistent with that in the results of the original model. The exception occurs with the effect of the professional title under criterion value of 80. In this scenario, although the sign of the

professional title coefficient becomes positive in Model 1, it remains negative in Model 2. Besides, the overall effect of the city level and the professional title remains negative and the significance level becomes higher, from  $P < 0.05$  to  $P < 0.001$ . In summary, the results show that most of the effects are consistent with our main findings, verifying the robustness of our models and the previous findings.

## 4 Discussions

This study develops a model to investigate how online reputation and offline reputation affect the provision of physicians' online counseling services and then draws on empirical data to test the hypotheses. By doing so, this study provides several key findings and contributions to the literature and implications for practitioners.

### 4.1 Key findings

This study presents four significant key findings. First, physicians' online reputation can induce more online counseling services. We use patients' online feedback and ratings as physicians' online reputation. Higher online reputation indicates that the physicians have more positive attitude and stronger willingness to provide online counseling services. On the other hand, higher online reputation also indicates that it is feasible for the physicians to spend enough time and effort on online counseling, either during their spare time or during their working time as supported by their offline working hospitals. We find that higher online reputation positively influences physicians to provide more counseling services online.

Second, physicians' offline reputation may impede them to provide online counseling services. Physicians with higher offline reputation always have more choices in conducting multi-site practice, and the offline burdens

**Table 7** Results of the robustness test (with the samples under the criterion values of 20, 35, 65, and 80, respectively)

	Under criterion value of 20 <sup>a)</sup>			Under criterion value of 35 <sup>b)</sup>		
	Step 1	Step 2		Step 1	Step 2	
		Model 1	Model 2		Model 1	Model 2
FollowingPatients*SatisfactionScore			0.081***			0.049**
FollowingPatients*PatientsComments			-0.264***			-0.249***
CityLevel*ProfessionalTitle		-0.029			-0.019	
CityLevel*HospitalRanking		-0.104***			-0.138***	
Satisfaction score	0.098***	0.097***	0.089***	0.060***	0.058***	0.051***
Professional title	-0.072***	-0.054***	-0.078***	-0.076***	-0.051***	-0.076***
Hospital ranking	-0.136***	-0.071***	-0.126***	-0.156***	-0.069***	-0.145***
Number of patients' comments	0.549***	0.553***	0.651***	0.557***	0.562***	0.670***
Adjusted R-square	0.361	0.367	0.396	0.369	0.378	0.403
DW statistics	1.766	1.780	1.766	1.774	1.797	1.778
	Under criterion value of 65 <sup>c)</sup>			Under criterion value of 80 <sup>d)</sup>		
	Step 1	Step 2		Step 1	Step 2	
		Model 1	Model 2		Model 1	Model 2
FollowingPatients*SatisfactionScore			0.004			0.008
FollowingPatients*PatientsComments			-0.216***			-0.208***
CityLevel*ProfessionalTitle		-0.163*			-0.325***	
CityLevel*HospitalRanking		-0.091*			-0.092	
Satisfaction score	0.017	0.013	0.006	0	-0.004	-0.011
Professional title	-0.096***	-0.056	-0.083***	-0.091***	0.172***	-0.079***
Hospital ranking	-0.159***	-0.080**	-0.150***	-0.155***	-0.112***	-0.147***
Number of patients' comments	0.557***	0.567***	0.678***	0.559***	0.571***	0.674***
Adjusted R-square	0.367	0.386	0.399	0.365	0.389	0.394
DW statistics	1.722	1.766	1.727	1.669	1.724	1.673

Notes: \*\*\* $P < 0.001$ , \*\* $P < 0.01$ , \* $P < 0.05$ . There are a) 7716, b) 5941, c) 4223, and d) 3705 observations, respectively. The values in the table are the standardized coefficients.

from their working hospitals are usually very heavy. Although higher offline reputation can attract more patients to initiate more online consultations, physicians may not have enough time and effort to respond. Therefore, we find that physicians' professional title and the ranking of their offline hospitals negatively affect their online counseling services. This explanation can also be verified by the third and the last findings.

Third, the positive effect of physicians' online reputation on the provision of online counseling services is partly weakened by the online context, which is comprehensively represented by the number of following patients. Patients can pay special attention to the physicians and follow them for future consultations, either online or offline. From the result, we find that part of the online patients go back to the offline consultation, and the positive effect of online reputation on online counseling services has been decreased after considering the moderated effect of the online context.

Finally, the negative effect of physicians' offline

reputation on their online counseling services is partly strengthened by the effect of the offline context, which is comprehensively represented by the level of the cities where the physicians live. Most of the hospitals of higher rankings are located in cities of higher levels and physicians usually have many possible choices of medical institutions to conduct multi-site practice. In the cities of higher levels, physicians usually have more choices and relative higher offline workload, and they will pay less attention and effort to online counseling. From the result, we find that the negative effect of offline reputation has been enhanced after considering the moderated effect of the offline context.

#### 4.2 Contribution and implication

This study provides several contributions to the literature. First, this study contributes to the literature of physicians' contributing behaviors by distinguishing online counseling behaviors from knowledge-sharing behaviors. Second,

some previous studies that investigated online counseling behaviors have focused on either the factors of subjective behaviors of physicians from the online context or the objective factors of physicians from the offline context. Our research enriches the literature by combining the factors of online reputation from the online context and the offline reputation from the offline context. Both online and offline contexts should be considered when the acting physicians have a constraint of limited time and effort.

This study also has some important implications for healthcare practitioners. First, the managers of Internet hospitals can pay more attention to encouraging eligible physicians who have a relatively lower offline reputation as these physicians may have special preference and dedication to online counseling. For example, platform managers can cooperate with low ranking hospitals and move their physicians online. Second, managers of offline hospitals should consider to set aside more physicians for online counseling as this will become one of the important sources of offline visits. Finally, as physicians have moved online, and online counseling services have been gradually promoted in practice, policy makers should consider physicians' online reputation and online performance into the overall evaluation of physicians' reputation.

### 4.3 Conclusions and future research

As one Internet-based approach to solve the problems of shortage and unbalanced distribution of health resources in China, Internet hospitals have attracted and moved many of the Chinese physicians online. Understanding how to promote physicians' contributions is crucial for the development of Internet hospitals. In the present work, we explore the factors motivating Chinese physicians to provide online counseling services in Internet hospitals by combining the factors of online reputation from the online context and the factors of offline reputation from the offline context. We conclude that physician's online reputation and offline reputation show a competitive and substitute relationship rather than a complementary relationship in influencing physicians to provide online counseling services in Internet hospitals. One possible explanation for the substitute relationship could be the constraints of the limited time and effort of the physicians. In this way, this study contributes to understanding the motivated factors of physicians' online counseling behaviors.

Although this study has produced interesting findings and practical implications, there are still some limitations. First, readers may note that there are many other factors that are also related to the online consultation, such as the prices and physician–patient trust. These factors may also be used to explain the variances of online consultation volume. Second, the physicians investigated in our study are from the overall platform covering many different

clinical departments. Future research may extend the current research to exploring the effects of clinical departments or diseases. Finally, in our study, we use the total number of patients' comments but do not delve into the detailed content of the comments. The comments could encode patients' positive or negative emotions, and future studies can adopt text-mining techniques to further understand the commented contents.

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