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Article

Status and Development of Private Internet Hospitals: Telemedicine Practice of China since COVID-19 Epidemic

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Abstract: Internet hospitals are a telemedicine business model as an important way to improve the effectiveness and sustainability of healthcare services globally. Internet hospitals can be divided into public and private ones. The latter tend to be larger due to the integration of physicians from different regions and hospitals. However, few studies have explored the operations and advantages of private Internet hospitals. Thus, this study is carried out to explore the role of private Internet hospitals in public health emergencies and their use characteristics based on consultation data during the Covid-19 epidemic from China's largest telemedicine platform, Good Doctor Online. Specifically, we analyze the distribution of diseases for online consultations, doctor-patient interactions, and user online visit conversion rates, and discuss the results to provide a solid experience for developing telemedicine programs in other countries with insufficient health resources and inadequate healthcare systems.

Keywords: Internet hospital, Private, Diseases distribution, Doctor-patient interaction, Conversion rate

1. Introduction

1.1. Background

Internet hospital is a new model of medical consultation as an innovative model for medical institutions and doctors to migrate to online platforms through information technology to solve the scarcity and extremely uneven distribution of medical resources in China. To date, China's tertiary care system remains in a dysfunctional state with a lack of referral systems and no gatekeeper in the primary health care system, leaving patients free to choose their providers at any level of medical institutions (Yip et al., 2010). Patients with mild illnesses often use hospital outpatient services for first-contact care, which makes it difficult for severely ill patients to obtain appropriate healthcare services, especially those living in rural areas (Tu, Wang, and Wu, 2015; Wu et al., 2019; Yip and Hsiao, 2014). This is because skilled physicians are reluctant to work at the community level and in remote rural areas due to factors such as career advancement and economics (Hu and Zhang, 2015). In this context, the first officially approved so-called Internet hospital went online on October 25, 2014, which was seen as an important way to improve the effectiveness and sustainability of healthcare delivery in China (Hu and Zhang, 2015; Xie et al., 2017).

The emergence of COVID-19 in 2020 has had a devastating impact on countries' healthcare systems, and there were no signs that it stopped before the vaccine became widely available (Le et al., 2020; Zhou et al., 2020). The COVID-19 outbreak occurred during the Chinese New Year, a time of year when the rate and volume of population movement among various regions of China was much greater than usual. The Chinese government faced a great challenge to raise awareness of COVID-19, informed people about proper prevention and control measures, and prevented individuals from rushing to hospitals due to panic, occupying medical hospitals causing cross-infection among other problems (Li et al., 2020; Zhu et al., 2020). Internet hospitals in China, as a new form of outpatient care, became one of the important initiatives of the Chinese government to stop the spread of the epidemic at the beginning of the Wuhan outbreak (CSC, 2020). In February 2020, the Chinese government issued a decree requiring Internet hospitals to vigorously develop telemedicine services in response to the epidemic (NHC, 2020b), which stimulated the development of Internet hospitals in China to some extent. A recent study showed that the number of new Internet hospitals in China peaked in February 2020, which was probably the period with the highest number of Internet hospitals established in one month due to the epidemic (Xu et al., 2021).

1.2. Telemedicine Business Models in Developing Countries

Telemedicine refers to the use of telecommunication technology by healthcare professionals to evaluate, diagnose and treat patients. Internet hospitals can be considered as one of the telemedicine business models, which is similar to Telemedicine companies in other countries that use information technology to enable the process of online treatment. Telemedicine has been one of the key tools to improve the scarcity and imbalance of healthcare resources in less developed countries and regions (Edworthy, 2001; Pal et al., 2005). The vast majority of the population in these regions has difficulty accessing adequate healthcare services (Jin et al., 2015; Razzak et al., 2015). Due to the different socioeconomic backgrounds and distribution of healthcare resources, telemedicine programs in developing countries have the following characteristics relative to developed countries, including but not limited to.

First, the most important value proposition of telemedicine in developing countries is affordability and accessibility (Chen, Cheng, and Mehta, 2013; Zhang and Zaman, 2020). In other words, the costs associated with time and travel are of more concern to patients from developing countries than the convenience of access.

Second, in terms of target customers, telemedicine services in developing countries prefer the concept of immediate micropayment due to the low penetration of commercial health insurance and the lack of willingness of companies to pay. For example, almost all Internet hospitals in China adopt this form of payment (Xu et al., 2021). In contrast, telemedicine programs in developed countries mainly target companies and organizations (Chen et al., 2013). For example, Teladoc's latest financial report shows that membership subscription fees, rather than scattered individual users, are the main way of profitability for the business (Teladoc Health, 2021).

Third, the convenience of telemedicine services is poor, which corresponds to the first feature. Taking into account the poor level of information technology in rural areas, most previous telemedicine projects in developing countries used hub-and-spoke consultation centers as intermediaries to enable patients to communicate with doctors (He et al., 2018; Khanal et al., 2015; Pal et al., 2005; Vega et al., 2013).

Fourth, budget shortfalls affect a large number of telemedicine programs in developing countries, which are generally not operated by the healthcare sector (Combi, Pozzani, and Pozzi, 2016). In contrast, some success stories from developed countries suggest that financially stable telemedicine ventures are more likely to be successful in the long term (Acheampong and Vimarlund, 2015) such as the Arizona Telemedicine Program, Amwell, and Tactive.

1.3. Internet Hospitals in China

The Chinese healthcare system is dominated by profit-driven public hospitals (Yip and Hsiao, 2014), and healthcare resources are mainly concentrated in economically developed and densely populated cities (Zhang et al., 2017). Similar to the role of telemedicine programs in other developing countries, the emergence of Internet hospitals has somewhat improved the problem of traditional medical resources failing to meet the demand for public medical services (Tu et al., 2015; Xie et al., 2017). According to the National Health Commission of China, Internet hospitals are divided into two main categories according to the main body of construction: hospital-led and private (NHC, 2018). The former is operated by a public hospital, generally outsourced by a third-party technology company to provide technical support, the doctors providing medical services are basically from the medical institution or medical association, and the construction funds come from the hospital's information construction budget. Due to the extremely low promotion rate of medical commercial insurance in China, the business model of hospital-led Internet hospitals is B2C. Several hospital-led Internet hospitals adopt a central-radial structure (Wu et al., 2019), but most provide telemedicine services through Internet-based access interfaces such as WeChat, Web or App (Xu et al., 2021), and the main profit comes from charging users for a single consultation and drug sales. Users can choose their own doctors, and the sitting doctor is usually the doctor on duty in the hospital network waiting room.

The operating entity of the latter is an enterprise, and the relevant technical department provides technical support. The practitioners come from different medical institutions, and the source of funds is generally venture capital and financing. The biggest difference with hospital-led Internet hospitals is that the latter is an online medical community platform built through Internet technology, which is similar to a combination of AmWell and Doctor on Demand, telemedicine companies from the United States, where users can independently choose doctors from different medical institutions who have registered on the platform and can interact with healthcare providers online (Figure 1). Due to the low penetration of commercial health insurance and poor willingness of companies to pay, the target users of private Internet hospitals are mainly individuals, but they are more profitable than hospital-led Internet hospitals due to differentiated businesses such as membership and family doctors. The business model of private Internet hospitals can provide valuable experience for telemedicine construction in other developing countries and may reduce the gap in

commercial maturity of the telemedicine industry between developing and developed countries. Compared to hospital-led Internet hospitals, it has the following advantages.

First, any doctor with a practicing license can register on the platform, so human resources are more sufficient.

Second, at the e-commerce level, companies are usually more service-conscious than hospitals because they have the appropriate organizational framework for operations, after-sales, and consulting. E-commerce-style healthcare platforms can better coordinate telemedicine players such as doctors, hospitals, pharmaceutical companies, insurance agencies, and logistics platforms, which not only makes telemedicine less costly for users but also has a better user experience.

Third, the same instant micropayments that are most often used in developing countries, but it has broadened profit channels. For example, many Internet hospitals led by Chinese companies have family doctor services, overseas medical services, online pharmacies, and advertising revenue.

Fourth, convenience is improved. Mobile apps and websites are the main interfaces of Internet hospitals for patients which are similar to telemedicine companies in developed countries (Chen et al., 2013). This may not be accustomed to areas where ICT is extremely scarce. However, the application of mobile devices to assist health workers has many advantages, especially with the increasing popularity of mobile devices in remote areas. Health workers can access the same information without having to travel long distances (Khanal et al., 2015). In addition, in the case of a poor healthcare system like China, convenience is also reflected in the help of offline visits. For example, patients with serious conditions can make free appointments in advance for specialist outpatient numbers in brick-and-mortar hospitals without having to wait a long time for registration and queuing.

Fifth, compared to medical institutions, private Internet hospitals are generally funded by venture capital and financing for construction and have more mature financial management systems accordingly. Financial stability is secured by making telemedicine projects successful in the long run.

1.4. Objective

Scholars have addressed the role played by Internet hospitals during epidemics, and most of these findings were positive (Ding et al., 2020; Gong et al., 2020; Li et al., 2020; Zhuang et al., 2021). However, most of the data in these studies originated from Internet hospitals built under the leadership of public hospitals, and most of the research data were collected using questionnaires with limitations in terms of data volume, time, and geographical span. Private Internet hospitals are also an important part of China's Internet hospitals, and most of them do not have offline brick-and-mortar hospitals. The advantage of private Internet hospitals is that they integrate far more physician resources than individual public hospitals and have a nationwide user base and a larger number of online orders. While the public hospital-led construction of Internet hospitals is also positioned for national patients and migrates the resources of medical institutions online through Internet technology. However, Ding et al. (2020) showed that the majority of users using an Internet hospital dominated by a public hospital came from the location of that hospital. Therefore, in the context of the rising number of Internet hospitals being built in China, it is necessary to conduct a study targeting private Internet hospitals.

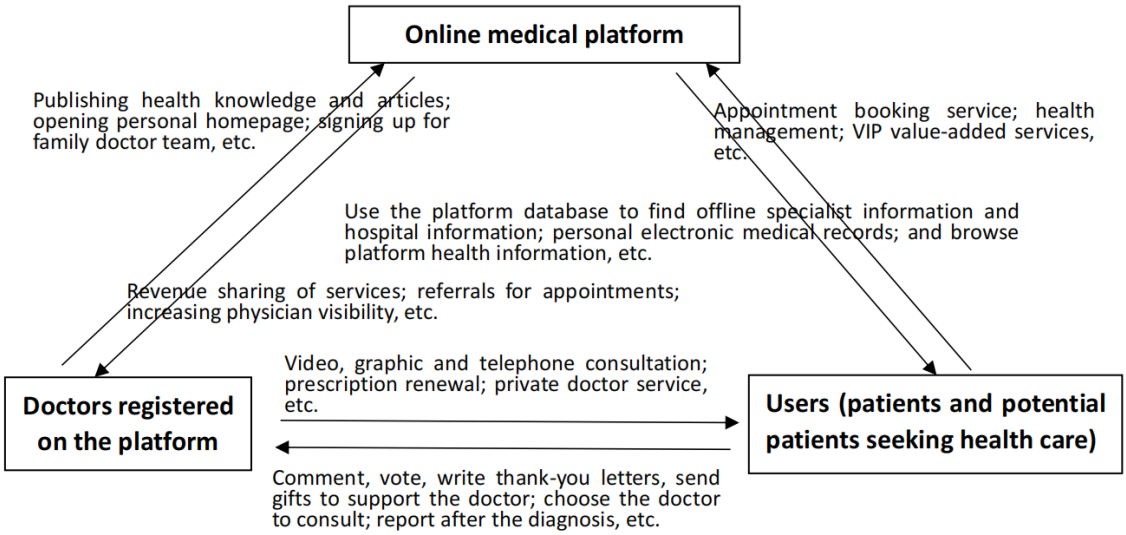

Fig. 1. Schematic diagram of online medical services in a private Internet hospital.

To address the gaps in the existing literature and to enrich the understanding of Internet hospitals in China, we collaborated with the well-known Chinese platform "Good Doctor Online" to explore the role of private platform-based Internet hospitals in public health emergencies and to explore their user characteristics. Based on the data presented, this study ic conducted to answer the following three questions.

RQ 1: What role did telemedicine provided by the private platform-based Internet hospitals play during the COVID-19 pandemic?

RQ 2: When users and physicians interacted in such platform-based medical communities, does users' preferences for physicians with different titles and departments differ?

RQ 3: In the process of users choosing whether to spend for telemedicine, what is the difference in the conversion rate of visits by doctors with different titles and departments?

2. Materials and Methods

2.1. Sources of the Data

The data were collected from the Good Doctor Online data open platform. Good Doctor Online is one of the largest private Internet hospitals in China with information on 780,000 doctors from nearly 10,000 hospitals to date, and over 200,000 public hospital doctors providing telemedicine services on the platform. Users can use the Good Doctor Online Platform App or Web to designate doctors for telemedicine services. Figure 2 shows the user interface of the Good Doctor Online App, which we divided into five modules according to its functions: basic module, remote consultation, information distribution, convenient services, and additional modules. Before using the data for processing, we confirmed with Good Doctor Online that the data was anonymized and did not include sensitive information, such as patient gender and age. The original data from the application contains a total of 3 files: consultation order information (1.21 GB, from January 1, 2019, to December 31, 2020), consultation disease information (1.23 GB, from January 1, 2019, to December 31, 2020) and doctor information (53.1 MB, as of December 31, 2020), which are all in CSV format.

2.2. Data Processing and Analysis

SPSS 22 and Excel 2013 were used to complete the statistics of these data, and JavaScript language was used to draw the statistical graphs. In addition, we processed these data for statistical analysis. Patient diseases were recorded by different physicians and uploaded into the database, and the same type of disease was recorded in different forms. Then, semantically similar and subdivided patient diseases were combined into one category, e.g., the number of pneumonia was the sum of the number of diseases recorded as pneumonia, interstitial pneumonia, lobar pneumonia, mycoplasma pneumonia, and viral pneumonia. In addition, to present a more detailed trend of different diseases over time, any diseases recorded as cancer and pediatrics were extracted to form a separate category, e.g., breast cancer was not included in breast diseases, but was a separate category. A detailed record of the integration of disease categories can be found in Table 1, and any disputes over the classification of the recorded patient diseases were resolved by discussion.

Fig. 2. Platform of a private Internet hospital - take the "Good Doctor Online" app as an example. The orange service is the remote consultation module, the green service is the information dissemination module, the blue service is the convenience service module, the red service is the additional module, and the yellow service is the platform base module.

3. Results

3.1. Disease and Order Information during the COVID-19 Epidemic

Diseases recorded by physicians in the database as "don't know how to choose" are not included in the statistics. Fig. 3 shows the top 20 diseases with the highest number of physician-recorded patient diseases in 2019 and 2020, using quarterly intervals. Pneumonia was the most recorded disease (N = 812,741) and was significantly higher in number than other patient diseases. The time in which number of users performing telemedicine on the platform due to pneumonia climbs in the first quarter of 2020. This corresponds to the timing of the novel coronavirus outbreak in China, while the number of pneumonia patients who tend to choose Internet hospitals to obtain healthcare is not high during the other periods. It is also noteworthy that the number of patients suffering from symptoms similar to COVID-19 infection such as cough (N = 6872, Q4 2019; N = 91,230, Q1 2020) and fever (N = 6947, Q4 2019; N = 71,644, Q1 2020). Bronchitis in children also increased substantially in Q1 2020 compared to other periods. Maternity consultations (N = 517,849) and skin diseases (N = 517,644) ranked second and third in number, indicating that such patients prefer to receive healthcare through platform-based Internet hospitals. While the rate of increase in the first quarter of 2020 was not as fast as for several categories of diseases closely associated with COVID-19, they also showed a significant increase in the recorded frequency. Most of the 20 diseases with the highest frequency of occurrence were recorded more frequently in 2020 than in 2019, which may be the result of the epidemic. In addition, an interesting phenomenon is a significant decrease in the number of users. Both adults and children chose to use the platform in the third and fourth quarters of 2020 because they had a disease associated with COVID-19. Possible explanations are the easing of offline medical pressure, improved nucleic acid testing capabilities, and the Chinese government's strict policy on outbreak prevention and control to make these potential users use medical facilities more with more accurate diagnoses to access healthcare services.

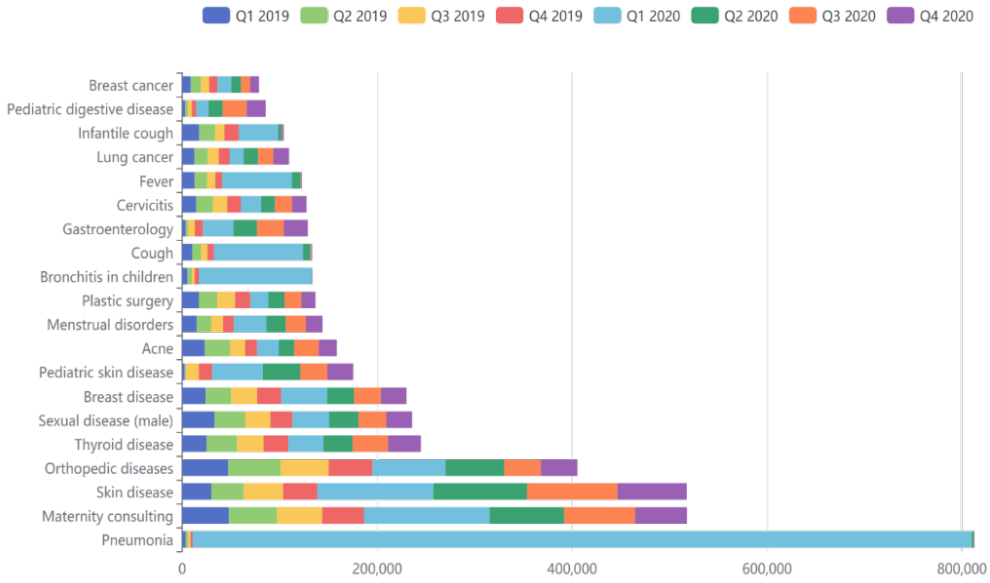

Fig. 3. Top 20 diseases with the largest number of patients in the database of consultation disease information in 2019 and 2020.

In addition, to determine whether the digital divide affects residents' choice of private Internet hospitals for health care services when COVID-19 is most severe, 10 provinces above China's GDP per capita (approximately 11,000 USD) are considered high-income regions, while the other 21 provinces are considered low-income and regions. It is worth noting that Hong Kong, Macau, and Taiwan are not included in the statistics. The baseline volume of visits is defined as the volume of visits in the first quarter of 2019, and Supplementary Fig. 1 shows the change in the volume of online consultations between 2019 and 2020 for high-income and low-income regions. The peak of visits in both high-income and low-income areas occurs in the first quarter of 2020, above the baseline of 146.99 and 145.54%, respectively. Although the decrease in visits in the remaining quarters of 2020 was significantly faster in low-income areas than in high-income areas, there was little difference in the incremental telehealth visits for patients from low-income areas compared to high-income areas during the most severe period of the COVID-19 pandemic.

3.2. Analysis of Doctor-patient Interaction

The doctor-patient interaction on the "Good Doctor Online" platform can be divided into doctor-initiated interaction and patient-initiated interaction according to the initiator. The doctor-initiated interaction is in the form of sending scientific articles to the platform for users to read, and the form of the articles includes medical science, academic frontier, and treatment guidelines. Patient-initiated interaction usually refers to contacting doctors, thanking them, and evaluating them through the Internet medical community after a doctor's consultation. For example, if a doctor has opened an account on an online medical platform, the patient can contact the doctor again online through post-visit reports online on the platform after the patient has been seen by the doctor offline. Patients vote, send thank-you letters and give heartfelt gifts as interactive activities. Gifts require payment similar to the reward in online live streaming. Table 1 shows the metrics of the doctor-patient interaction of registered doctors with different titles, and the higher the title, the more online consultation services are provided by the group of doctors. Doctors with senior titles ranked first in the frequency of five types of doctor-patient interactions: volume of posts, number of patients reported after consultation, patient votes, thank-you letters, and heartfelt gifts, followed by doctors with associate high titles. If the smaller number of physicians with unclassified titles is not taken into account, the senior and associate senior physicians still rank first and second in terms of the number of consultations per capita and the frequency of the interactions. Table 2 shows the analysis of physician-patient interactions for the top 10 departments in terms of consultation volume, and full information on the 175 departments can be found in Supplementary Table 2. Among the top 10 departments in terms of online consultation volume, plastic surgeons posted the highest number of articles (N = 59,454), dermatologists had the highest number of patients reporting after consultation and the highest number of patient votes (N = 1,581,419 and N = 198,110), urologists received the highest number of thank you letters (N = 91,613), and gynecologists received the highest number of heartfelt gifts (N = 174,177).

Although the number is smaller than that of intermediate and associate senior doctors, senior doctors rank first in online consultation volume and frequency of doctor-patient interactions, indicating that patients' needs are mainly focused on a few expert doctors both online and offline. The much higher number of patient votes, thank-you letters, and heartfelt gifts than other titled

doctors indicates the higher quality of online consultation services of chief physicians. Dermatology had the highest number of online consultations, which corresponds to the ranking of the number of recorded patient diseases. In addition, plastic surgeons posted the highest number of articles, which may be related to the current state of the plastic surgery industry, an industry that relies heavily on advertising (Ashikali, Dittmar, and Ayers, 2017; Spilson et al., 2002). The highest number of post-visit reported patients in dermatology may be due to the high number of registered doctors (N = 6631). Also, the treatment of dermatology is a long-term process, so users tend to contact doctors through online medical platforms to facilitate the follow-up process. The highest number of online consultations generated more patient votes for dermatologists. Urologists received the most thank-you letters, which may be related to the nature of the disease in question. Compared to developed countries such as the United States and the United Kingdom, hospitals in China lack in-patient privacy protection, and many problems such as exposing patients' conditions, being listened to by others during consultations, medical observation for education that violates privacy, and lax management of medical record systems still exist. In this context, the urology department of the Internet hospital, compared with offline hospitals, allows patients to seek treatment at home as the consultation space is relatively private, and the doctor can be contacted by telephone or video chatting to minimize the patient's sense of shame. Gynecologists received the most heartfelt gifts as gynecology patients tend to have longer treatment cycles and a greater likelihood of establishing a good doctor-patient relationship with online physicians.

Table 1. Doctor-patient interaction analysis of different titles (mean counts, %).

Title	Number	Online Consultation Volume	Types of Doctor-patient Interaction				
			Articles	Post-consultation Report Patients	Patient Voting	Thank You Letters	Heartfelt Gifts
Senior	50,876	31,845K(626, 44.47%)	613K(12, 40.92%)	8915K(175, 41.39%)	1971K(39, 47.26%)	826K(16, 47.06%)	1909K(38, 49.34%)
Associate High	67,655	22,384K(331, 31.26%)	540K(8, 36.07%)	7882K(117, 36.60%)	1434K(21, 34.39%)	632K(9, 35.24%)	1299K(19, 33.57%)
Intermediate	76,487	14,098K(184, 19.69%)	245K(3, 16.39%)	4046K(53, 18.78%)	659K(9, 15.81%)	290K(4, 16.16%)	575K(8, 14.86%)
Junior	37,472	2900K(77, 4.05%)	39K(1, 2.64%)	614K(16, 2.85%)	93K(2, 2.23%)	40K(1, 2.22%)	71K(2, 1.84%)
Unclassified	3502	390K(111, 0.54%)	60K(17, 3.99%)	82K(23, 0.38%)	13K(4, 0.32%)	6K(2, 0.31%)	15K(4, 0.39%)
Total	235,992	71,617K(303, 100%)	1497K(6, 100%)	21,538K(91, 100%)	4170K(18, 100%)	1794K(8, 100%)	3869K(16, 100%)

Table 2. Physician-patient interaction analysis of the top 10 departments in terms of consultation volume.

Standard Departments	Number	Online Consultation Volume	Types of Doctor-patient Interaction				
			Articles	Post-consultation Report Patients	Patient Voting	Thank You Letters	Heartfelt Gifts
Dermatology	6631	5,184,561	46,534	1,581,419	198,110	78,162	162,955
Gynecology	5253	3,073,308	21,079	1,000,899	144,117	60,078	174,177
Pediatrics	8584	2,591,638	37,229	768,004	100,858	36,320	148,860
Reproductive Center	2742	2,396,334	21,478	942,801	112,268	46,431	163,087
Urology	8167	2,373,180	43,806	896,888	195,606	91,613	154,099
Ear, Nose and Throat	6023	2,331,530	31,123	686,238	127,720	55,827	94,411
Obstetrics and Gynecology	5550	2,078,849	20,519	535,335	72,807	28,911	91,403
Orthopedics	9669	2,057,386	51,526	523,887	132,280	60,412	89,191
Ophthalmology	5583	1,948,409	26,950	523,105	105,727	44,829	89,461
Plastic Surgery	2353	1,925,389	59,454	451,999	105,717	45,402	55,876

3.3. Analysis of User's Visit Conversion Rate

The conversion rate analysis of user visits shows the percentage of visits on the online medical community platform that are converted into online consultations for patients. The rate is calculated as the number of online consultations divided by the number of online visits. A higher conversion rate indicates that the services offered in the online medical community are more fully utilized and have a greater impact on the offline behavior of patients. As shown in Table 3, senior physicians had the lowest visit conversion rate, and intermediate-level physicians had the highest visit conversion rate. In contrast, senior doctors have the highest number of online inquiries, online visits, and an average number of inquiries per person. A similar situation occurred for the associate-level doctors, who ranked second in terms of online consultations, online visits, and an average number of consultations per person, but ranked second to last in terms of conversion rate. Table 4 shows the online consultation conversion rate for the top 10 departments

in terms of online consultation volume. The online consultation conversion rate for all 175 departments is presented in Supplementary Table 3. Among the top 10 departments in online consultation volume, dermatology had the highest number of online consultations and online visits (N = 5,184,561 and N = 3,646,915,268), the reproductive center had the highest average number of physician consultations (N = 873.74), and pediatrics had the highest online consultation conversion rate (N = 0.147%). In addition, plastic surgery had the second-highest average number of physician consultations in the TOP 10 of online consultations (N = 818.27), but the conversion rate ranked last in the list.

Although doctors with high titles have excellent medical skills and a high praise rate, the conversion rate of orders from online information into payment behavior is the lowest. Instead, doctors with intermediate levels have the highest order conversion rate. The possible reason for this is that the order fees of senior doctors are higher than those of physicians with lower titles, whether it is graphic consultation, telephone consultation, or video consultation. The highest online consultation volume for the group of senior doctors indicates that users are "shopping around" when choosing chief doctors for online consultation. Patients browse a lot of doctors' information before deciding on doctors who choose knowledge-based online medical payment. Compared with doctors with an associate or senior title, doctors with intermediate titles tend to charge lower prices and have relatively guaranteed medical skills, making them a relatively cost-effective choice.

Table 3. Online consultation conversion rate analysis of doctors with different titles.

Title	Number	Online Consultation Conversion Rate Analysis		
		Online Consultation Volume	Online Visits	Conversion Rate
Senior	50,876	31,845K (44.47%)	33,770,287K(53.22%)	0.094%
Associate High	67,655	22,384K(31.26%)	18,302,136K(28.84%)	0.122%
Intermediate	76,487	14,098K(19.69%)	9,002,943K(14.19%)	0.157%
Junior	37,472	2900K(4.05%)	2,067,074K(3.26%)	0.140%
Unclassified	3502	390K(0.54%)	315,183K(0.50%)	0.124%
Total	235,992	71,617K(100%)	63,457,623K(100%)	0.113%

Table 4. Online consultation conversion rate analysis of the top 10 departments in terms of online consultation volume.

Standard Departments	Number	Online consultation conversion rate analysis		
		Online consultation volume	Online Visits	Conversion rate
Dermatology	6631	5185K	3,646,915K	0.142%
Gynecology	5253	3073K	2,413,436K	0.127%
Pediatrics	8584	2592K	1,763,011K	0.147%
Reproductive Center	2742	2396K	1,949,328K	0.123%
Urology	8167	2373K	1,887,391K	0.126%
Ear, Nose, and Throat	6023	2332K	1,867,950K	0.125%
Obstetrics and Gynecology	5550	2079K	1,688,545K	0.123%
Orthopedics	9669	2057K	1,789,590K	0.115%
Ophthalmology	5583	1948K	1,508,386K	0.129%
Plastic Surgery	2353	1925K	1,778,278K	0.108%

Among the top 10 departments, pediatrics has the highest conversion rate of online consultation. Generally, users who need to see pediatricians are often seeking online healthcare services for their children, and these users are not so sensitive to price, but rather want their children to receive a high-level medical service. The plastic surgeon has the lowest conversion rate. Unlike other departments, the online treatment of plastic surgery plays more of a consulting role, and users have concerns or doubts about plastic surgery and consult with professional doctors through the Internet platform. Therefore, it is not as time-sensitive as other diseases. Browsing the information of various hospital doctors and screening the doctors' specialty may be the reason for the low order conversion rate.

4. Discussion

Previous studies on Internet hospitals in China showed that telemedicine can save time and costs and increase rural patients' access to healthcare resources compared to traditional means of care (He et al., 2018; Tu et al., 2015; Xu, 2016). After the COVID-19 outbreak, Chinese scholars have conducted numerous studies on Internet hospitals in terms of relieving medical pressure and spreading viral knowledge, affirming the positive role of telemedicine provided by Internet hospitals (Ding et al., 2020; Gong et al., 2020; Li et al., 2020; Zhuang et al., 2021). The findings in this research are largely consistent with previous studies, but data originating from private Internet hospitals present more detailed results that differ from the small number of previous studies. These results are presented to answer the three questions posed in the introduction.

4.1. Answer to RQ 1

Telemedicine services provided by private Internet hospitals played a positive role in the fight against the epidemic during the COVID-19 epidemic. These positive effects were seen in at least three ways.

First, public awareness of the new virus needs to be raised. In the first quarter of 2020 when COVID-19 was the most serious stage in China, the number of orders on the Good doctor online platform increased significantly, and pneumonia contributed to the main increase. This is different from the results of a study conducted by Uscher-Pines et al. (2020) based on the experience of Doctor on Demand in the United States. Although Doctor on Demand experienced a significant increase in total visits during the pandemic, this increase was caused by concerns about COVID-19. Rather, behavioral health and chronic disease visits appeared to contribute more to the increase in visits. Furthermore, in addition to the dramatic increase in the number of illnesses recorded as pneumonia, increased public awareness of the novel virus was found in February 2020 which was the worst month of the epidemic in China. More than 70% of healthcare services provided by the Good Doctor Online platform were free with a much higher percentage than in adjacent months and on average. In addition to the Good Doctor Online platform, many Chinese private Internet hospitals offered voluntary clinics for new coronavirus pneumonia (InterfaceNews, 2020). This suggests that online consultations play a positive role in maximizing timely patient service, eliminating psychological fears associated with the outbreak, and effectively avoiding cross-infection in the hospital.

Second, online services are provided for patients who cannot obtain medical care from offline medical institutions. In the first quarter of 2020, the number of patients who had little to do with COVID-19-related symptoms also increased significantly, indicating that patients indirectly affected by COVID-19 could not obtain offline medical care and shifted their needs to Internet hospitals such as dermatology patients. However, the departments that issued a higher volume of prescriptions in this study differed from a study by Ding et al. (2020), which showed the data from a hospital-led Internet hospital after the outbreak of COVID-19. The possible reason for this is that the motivation for choosing an Internet hospital may differ for users with different needs, and future research needs to be conducted to address what determinants influence users when choosing different telemedicine services.

Third, it has improved the inequitable distribution of healthcare resources, especially in major public health crises. China's healthcare resources are concentrated in developed coastal cities, and Supplementary Figure 3 shows the locations of doctors or hospitals providing telemedicine services as of December 31, 2020. Most of the 10 provinces with high income are coastal regions, and orders from these provinces account for more than half of the national order volume each month. However, during the most severe period of the COVID-19 pandemic, there was little difference in incremental telemedicine visits for patients from low-income areas compared to high-income areas, which is consistent with the findings of Uscher-Pines et al. (2020). Therefore, private Internet hospitals have improved the inequitable distribution of healthcare resources, which is consistent with the findings of a study by He et al. (2018), which presented the data from a hospital-led Internet hospital in China before the outbreak. In addition, the average price of orders in 2019 and 2020 (approximately 7 USD) was much lower than the average cost of outpatient visits to secondary and tertiary hospitals assessed by the Chinese Health Care Commission (approximately 36 and 58 USD) (NHC, 2020a). Thus, telemedicine can save costs for patients living in areas with poorer healthcare resources, which is consistent with the findings of Russo, McCool, and Davies (2016) and Spaulding et al. (2010), but contradicts the results of Upatising et al. (2015).

4.2. Answer to RQ2 and RQ3

When using Internet medical platforms for doctor-patient interaction, users prefer doctors with higher titles, probably because the title level represents the doctor's technical level to a certain extent. However, a higher level of doctor does not mean a higher conversion rate. Also, the frequency of interaction and the conversion rate of visits between users and different departments differed significantly, which may be related to the motivation of users to choose telemedicine. When putting the analysis to all 175 departments of the platform, we found reliable ways to improve the service quality of telemedicine.

The department with the highest average number of consultations per physician was the HIV department with only 29 physicians providing relevant medical services on the platform. They had a total of 94,246 online consultations with an average of 3250 consultations each. In addition, 17 departments had an average of more than 1000 consultations per doctor (Supplementary Table 2). The small proportion of the relevant patient population may be one reason, but it also indicates that there is a shortage of physician resources in the specialty that provides telemedicine services. Among the departments with more than 50,000 online consultations, the specialty medicine department had the highest average number of posts by physicians (N = 149) but the lowest visit conversion rate (N = 0.053%), which may be related to the scope of the department's care. According to the department information search of Good Doctor Online, the counterpart of the specialty medical department has a smaller number of patients in the Hair Medicine Center of China-Japan Hospital, the Strabismus and Amblyopia Specialist of Zhongshan Eye Center of Sun Yat-sen University and the Vertigo Disease Department of Shandong Provincial Hospital. The department with the highest average number of post-visit reports was gynecologic endocrinology (N = 761). The hospitals with such a subdivision department are a few well-known domestic hospitals with a small number of related physicians (N = 129), and the difficulty of registering offline may be one of the reasons that prompted patients to choose the Internet platform and contact the physician twice. The top 5 departments in average patient votes were pediatric urology (N = 113), gynecologic endocrinology (N = 109), neonatal surgery (N = 109), pediatric cardiac surgery (N = 97), and pediatric dermatology (N = 88), four of which are subcategories of pediatrics. This corresponds to the lack of resources for pediatricians in China (Wu, Zhao, and Ye, 2016). On the other hand, highly skilled pediatricians can still provide quality medical services online and ideas to solve the problem of lack of pediatricians in China. The top 5 departments in terms of the average number of thank-you letters were Pediatric Urology (N = 54), Pediatric Cardiac Surgery (N = 53), Neonatal Surgery (N = 53), Gynecologic Endocrinology (N = 48), and Functional Neurosurgery (N = 45). The top 5 departments in the average number of heartfelt gifts were AIDS (N = 244), Pediatric Urology (N = 138), Pediatric Cardiac Surgery (N = 136), gynecologic endocrinology (N = 135), and neonatal surgery (N = 100). This result proves that the telemedicine services provided by pediatricians are recognized by users. In addition, each HIV physician received the highest average number of heartfelt gifts which was much higher than pediatric urology which ranked second, suggesting that providing medical assistance through Internet hospitals may help the few vulnerable members of society with terminal illnesses. The department of Gynecology and Urology had the highest visit conversion rate (N = 0.516%), but there were only three physicians in the departments. The department is a subdivision of gynecology and surgery. This indicates that specialized, refined, and differentiated medical services by segmenting the departments have a positive impact on improving the visit conversion rate. The top five departments with the highest average number of online visits were AIDS (N = 5,746,710), lithotripsy center (N = 1,592,384), TCM male (N = 1,444,226), male (N = 1,405,328), and pediatric ophthalmology (N = 1,403,599). The much higher average number of visits in AIDS than the second place again indicates the lack of resources for physicians in related specialties. At the same time, male patients may be more willing to use telemedicine, and the future telemedicine industry can start by improving the conversion rate of male disease patient visits to improve performance.

5. Conclusions and Limitations

Internet hospitals are an innovation that has emerged in the telemedicine industry in China in recent years. Similar to other developing countries, China has a low number of doctors per capita and a doctor-to-patient ratio that is largely skewed toward urban areas, and Internet hospitals are seen as an important way to improve the effectiveness and sustainability of healthcare delivery in China. However, few scholars have conducted data-based studies of private Internet hospitals. With one of the largest private Internet hospitals in China - the Good Doctor Online platform, the platform's order information on doctors registered on the platform was analyzed during the COVID-19 pandemic to provide reliable information on telemedicine programs in other countries with scarce healthcare resources and inadequate healthcare systems. In this research, it was found that private Internet hospitals play a positive role in major public crisis events, effectively relieving pressure on offline care and facilitating many types of patients during crises. However, private Internet hospitals are still in the development stage in China and still have issues to address such as the lack of specialized physician resources and low visit conversion rates in several departments.

One limitation of this study is the lack of more detailed patient data on the age, gender, and mode of accessing medications in the database. Using the information would provide more detailed characteristics of the users and consultation service. Another limitation is that this study focused only on private Internet hospitals and did not compare with hospital-led Internet hospitals. Indeed, as major providers of telemedicine in China, the two different types of Internet hospitals have strengths and weaknesses in the market-oriented online healthcare industry. These aspects must be explored in future studies.

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