

Influencing Factors of Physician Performance in Online Health Communities

-- Take the Good Doctor Online Website as an Example

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Abstract. Introduction: With the rapid development of the Internet, online health communities are booming, which can effectively solve the practical problems of "difficulty in registration" and "difficulty of receiving medical treatment", while doctors can get remuneration and reputation from it, achieving mutual benefit of both doctors and patients. Methods: This paper used a two-way fixed effects model, and the number of online inquiries was taken as the first-level index of physician performance, the number of online consultations and post-treat management were the second-level indicators. Online comments, online satisfaction, and articles were selected to construct an influencing factor system. Results: It is found that the number of online comments and online satisfaction have a significant impact on physician performance, while articles have not, and there are different influence mechanisms on physician performance in hospitals and doctors with different characteristics. Conclusion: Doctors need to continuously improve their service level and quality, increase the number of online comments and online satisfaction, provide better medical services, reduce doctor-patient disputes, and meet the patients' health needs.

Keywords: Online Health Community; Physician Performance; Two-way Fixed Effects Model.

1. Introduction

In April 2018, the General Office of the State Council issued the "Opinions on Promoting the Development of 'Internet + Medical Health'", which firstly stated that medical consortium should actively use Internet technology to facilitate the development of appointment diagnosis and treatment, telemedicine and other services[1], pointing out the direction for the development of China's Internet medical industry, and China's online health communities are gradually emerging.

According to the CINI, as of December 2022, the number of Internet users in China reached 1.067 billion, and the Internet penetration rate was 75.6% [2]. With the gradual improvement of residents' living standards, the social demand for health has increased sharply. Additionally, thanks to the wide application of Internet technology and the popularization of network use, the number of Internet online medical consultation is increasing. According to the "Digital China Development Report 2022", as of October 2022, more than 2,700 Internet hospitals have been set up across the country, providing more than 25.9 million Internet diagnosis and treatment services[3].

At the same time, the long-term closure caused by the COVID-19 has made offline medical care unable to meet the growing health needs of residents. Therefore, the attractiveness and development scale of online health communities are increasing [4]. In February 2020, the National Health Commission proposed to vigorously carry out Internet diagnosis and treatment services, and promote it to play a more important role in epidemic prevention and control. Under the new background, the Chinese government pays more attention to the important position of Internet online medical in promoting the equalization of basic public services, continues to introduce new policies to help the healthy development of it and promote the digital supply and network service of public service resources in the field of medical and health in China. On March 23, 2023, the Central Committee of the CPC and the General Office of the State Council issued the "Opinions on Further Improving the Medical and Health Service System", and once again put forward requirements for the high-quality

development of "Internet + Medical Health": Build an industrial Internet platform for the medical field, accelerate the application of artificial intelligence and cloud computing in the medical field, strengthen the construction of health and medical big data sharing and exchange and security system[5].

The online health community (OHC) represents the new development direction of China's medical industry, which is conducive to solving the contradiction between the regional imbalance of China's medical resources and the increasing health needs of the people. Patients can consult the disease, seek medical advice, and doctors can obtain economic and reputational returns. Therefore, on the one hand, this paper wants to explore the influencing factors of physician performance in online health communities, on the other hand, it wants to further explore whether online health communities can use Internet technology to better understand patients' needs and preferences, improve medical services and doctor-patient relationship.

2. Literature Review

Internet medical is a new form of medical service industry, which uses information technology to reshape the information transmission process in traditional medical activities[6]. The online health community is a platform that relies on the Internet to provide users with health information interaction, medical services, health management and other activities[7]. In previous studies on online health communities, most of them studied the impact of doctor response speed and doctor-patient interaction frequency on patient decision-making from the patient's perspective (Zhang et al., 2017)[8]. However, less research starts from the perspective of doctors. More research should focus on doctors and hospitals.

Some scholars have explored the factors that affect the physician performance from two aspects. The first type is from the perspective of platform function. Some scholars have pointed out that the convenience of the Internet platform will improve the efficiency of communication between doctors and patients, which will have a positive effect on physician performance (Umeåfjord et al., 2003[9]). In addition, the information feedback mechanism established by the platform can effectively improve the performance of doctors (Perron et al., 2017)[10]. The second type explores the personal characteristics of doctors, with particular emphasis on the reputation and experience of doctors. The reputation of doctors is the main source of information for patients to understand the quality of physician services (Lu & Rui, 2017)[11]. Some scholars have found that patients usually think that the medical services provided by a low-reputation doctor are also lower, thus reducing the patient's willingness to choose. (Wu & Lu, 2016)[12]. Kelly et al.[13] confirmed that experienced doctors can accurately judge the patient's condition, which is conducive to obtaining the trust of patients, reducing the occurrence of doctor-patient conflicts, thereby improving the work efficiency of doctors and further improving the physician performance.

In recent years, some scholars have begun to pay attention to the impact of team factors. For example, some people have extended the research on the personal characteristics of doctors to hospital groups, believing that both the reputation diversity and experience diversity of the doctor team will have a positive impact on team performance (Yang et al., 2021)[14]. Si et al.[15] believe that the gender of team members and the diversity of department types positively and negatively affect team performance, respectively.

In summary, the influence mechanism of academic circles is mainly from the perspective of platform function, individual doctors and doctor teams. However, few scholars have studied the influence of doctors and hospitals with different characteristics from the perspectives of doctors' professional titles, multidisciplinary consultations, hospital levels and types.

3. Research Design

3.1. Data Sources

The research data comes from the Good Doctor online website, which is one of the largest online health communities in China. There are two reasons why this paper selects this website as the source of research data: First, the website has detailed data, including the patient side (the detailed records of consultations, and the patient's satisfaction, etc.), the doctor side (professional title, published articles, etc.), the hospital side (level, type), etc. Secondly, the website requires real-name certification of doctors, so the data is reliable. In this paper, Python program is used to collect the relevant data from January to December 2019. The window period is one month. A total of 7872 doctors' relevant data are obtained, of which 4000 doctors' data will be used for model estimation and empirical research, and the remaining data will be used for robustness test. In this paper, the data after 2020 are excluded, and the main purpose is to exclude the impact of Covid-19 on the normal online medical needs of residents.

3.2. Variable Declaration

This paper selects the number of online inquiries as the dependent variable, which is composed of the number of online consultations and post-treat management. Doctors' online income mainly comes from the number of online inquiries. Therefore, it is reasonable to use it as the first-level indicator. Meanwhile, it is feasible to use the number of online consultations and post-treat management as the secondary indicators of physician performance.

The number of patients' comments reflects the doctor's service level to a certain extent, so this paper selects it as the first type of independent variable. The second type is the patient's online satisfaction, and the third is the number of doctors' articles.

At the same time, in order to explore the impact of doctors and hospitals with different characteristics, this paper sets the professional title, whether to open multidisciplinary consultation, hospital level and hospital type as binary variables. Table 1 is the variable name and definition given in this paper. (See Table 1)

Table 1. Variable description

Variable Name	Definition
Online Inquiry Number (OIN)	Total number of online inquiries provided by doctors per month
Online Consultation Number (OCN)	Number of online consultations provided by doctors per month
post-treat Management Number (PMN)	Number of post-treat management provided by doctors per month
Online Comment Number	Monthly number of comments received by doctors on online services
Online Satisfaction	The average number of doctors' monthly online satisfaction, satisfaction = 1, dissatisfaction = 0
Article Number	Number of relevant articles published by doctors per month
Professional Title	Represents the binary variable of doctor's professional title, senior title = 1, non-senior title = 0.
Multidisciplinary Consultation	The binary variable indicating whether the doctor has opened multidisciplinary consultation, opened = 1, not opened = 0
Hospital Level	Represents the binary variable of hospital level, tertiary hospital = 1, non-tertiary hospital = 0.
Hospital Type	Denotes the binary variable of hospital type, general hospital = 1, specialist hospital = 0

The descriptive statistics of the data in this paper are shown in table 2 below. (See table 2) It can be seen that there are significant differences in the number of online inquiries between different doctors; patients' satisfaction is generally high; most doctors have senior titles; only a small number of doctors have opened multidisciplinary consultations; the vast majority of hospitals are tertiary hospitals; most hospitals are general hospitals.

Table 2. Data descriptive statistics

Variable Name	Average Value	Standard Deviation	Minimum Value	Maximum Value
OIN	31.66898	56.50423	0	1708
OCN	9.830875	22.89743	0	703
PMN	16.34692	32.63991	0	1346
Online Comment	2.341125	4.97651	0	114
Online Satisfaction	.9198893	.2297551	0	1
Article Number	.399	3.217163	0	217
Professional Title	.8755945	.330047	0	1
multidisciplinary consultation	.11425	.318118	0	1
Hospital Level	.94875	.2205095	0	1
Hospital Type	.7381727	.4396337	0	1

3.3. Model Construction

Based on the above content, this paper constructs a theoretical model as shown in Figure 1. (See Figure 1)

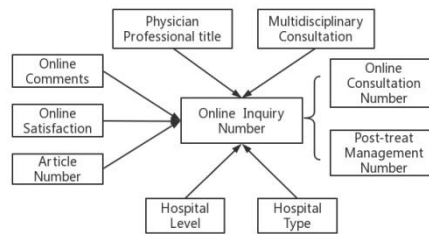


Figure 1. A theoretical model of influencing physician performance in OHC

The empirical model for analysis in this paper is as followed.

$$Y_{it} = \beta x_{it} + \gamma_2 D2_t + \dots + \gamma_t DT_t + u_i + \varepsilon_{it} \quad (1)$$

In this empirical model, i represents the individual, t represents the time, and Y is the independent variable, x is the dependent variable. $T = 12$, which means that the month observed in this experiment is 12 months. From $D2_t$ to DT_t is a dummy variable, for any DM_t , when $M=t$, $DM_t=1$, otherwise is 0. u_i represents individual heterogeneity, ε_{it} is a disturbance term that changes with individual and time. The model introduces the individual fixed effect and the time fixed effect, which solves the problems of missing variables that do not change with time but vary with individuals and do not change with individuals but change with time.

4. Empirical Study

4.1. Model Analysis

First of all, according to the results of the Hausman test, the P value is significant at the 1 % level, strongly rejecting the “no individual effect” null hypothesis, indicating that it should be a fixed effect

model rather than a random effect model. Secondly, the two-way fixed effect estimation is preliminarily carried out, and it is found that some monthly dummy variables are significant and some are not significant. The joint significant test of monthly dummy variables is carried out again, and the results are significant at the 1 % level. The original hypothesis of “no time effect” is strongly rejected, and it is considered that there is time effect, and the two-way fixed effect model should be used. The results are shown in Table 3. (See Table 3)

Table 3. The influence of each influencing factor on different indicators

	OIN	OCN	PMN
Online Comment	2.935051***	1.26303***	1.198326***
Online Satisfaction	3.824176***	1.637619***	2.277963**
Article Number	.0849715	.0934543	-.0066148
Time Effect	√	√	√
Individual Effect	√	√	√
Constant Term	9.81635	1.29316	6.468158
R2	0.4928	0.4380	0.3174

For the number of online inquiries and online consultations, online comments and online satisfaction are outstanding at the level of 1 %, while articles are not significant. For the number of post-treat management, online comments are significant at the 1 % level, online satisfaction is significant at the 5 % level, and articles is not conspicuous.

Therefore, generally, the number of online comments and online satisfaction have a significant impact on physician performance, while the number of articles has not.

Next, this paper conducts group regression on sample data to explore the differences in the impact mechanism of doctors and hospitals with different characteristics on physician performance.

4.2. The Impact of Different Characteristics of Doctors

This paper considers the different characteristics of doctors mainly from two aspects: whether doctors have senior professional titles and whether they open multidisciplinary consultations. The study found that doctors with different characteristics have different mechanisms of action on physician performance.

Table 4. The influence on OIN under different doctor characteristics

	Online Inquiry Number (OIN)			
	Senior Title	Non-senior Title	Multidisciplinary Consultation	Non-multidisciplinary Consultation
Online Comment	2.74771***	3.483136***	2.121214***	3.120549***
Online Satisfaction	3.852229***	2.414374	8.996571	3.603614**
Article Number	.0696645	.6352672**	-.1061094	.1575306
Time Effect	√	√	√	√
Individual Effect	√	√	√	√
Constant Term	14.53932	3.974577	-2.008494	9.145307
R2	0.5132	0.3950	0.4882	0.4939

The impact on online inquiries is shown in Table 4. (See Table 4)

The number of online comments was significant at the level of 1 % for any doctors; online satisfaction is conspicuous at the level of 1 % for senior doctors, but not significant for non-senior doctors; articles is significant for doctors with non-senior titles at the 5 % level, and is not significant for doctors with senior titles. In addition, the intercept of senior doctors is significantly higher than non-senior doctors.

For multidisciplinary consultation, the number of online comments was significant at the level of 1 %, and articles was not conspicuous. Online satisfaction is significant at the 1 % level for doctors who have not opened, but not for doctors who have opened. Additionally, the intercept of doctors without multidisciplinary consultation was significantly higher.

The impact on online consultations is shown in Table 5. (See Table 5)

For doctors' professional titles, the number of online comments and online satisfaction have different effects, while the number of articles has no significant effect. In addition, the intercept of senior doctors is significantly higher, which is consistent with the results of Table 4. for multidisciplinary consultation, the number of online comments, online satisfaction, and articles have significant differences in the number of online consultations.

Table 5. The influence on OCN under different doctor characteristics

	Online Consultation Number (OCN)			
	Senior Title	Non-senior Title	Multidisciplinary Consultation	Non-multidisciplinary Consultation
Online Comment	.9056191***	2.323408***	.5386305***	1.433384***
Online Satisfaction	1.565162***	.6237651	3.31186***	1.465613**
Article Number	.0953524	.2569977	-.1445957	.1719834***
Time Effect	√	√	√	√
Individual Effect	√	√	√	√
Constant Term	5.140766	-1.26722	2.739444	.9731804
R2	0.4553	0.3522	0.3352	0.4639

The impact on post-treat management is shown in Table 6. (See Table 6)

Table 6. The influence on PMN under different doctor characteristics

	Post-treat Management Number (PMN)			
	Senior Title	Non-senior Title	Multidisciplinary Consultation	Non-multidisciplinary Consultation
Online Comment	1.39808***	.6042565***	1.354574***	1.1621***
Online Satisfaction	2.516297**	1.466033	7.267637	2.09309*
Article Number	-.0140362	.0827567	.0160444	-.0095017
Time Effect	√	√	√	√
Individual Effect	√	√	√	√
Constant Term	5.848134	4.425418	9.581813	6.176347
R2	0.3266	0.2930	0.3676	0.3001

For doctors' professional titles, the number of online comments and online satisfaction have the same impact, but there are differences of articles. Additionally, there is little difference in the intercept between doctors with senior and non-senior titles. For multidisciplinary consultation, there are conspicuous differences in the impact of online satisfaction. In addition, the intercept of multidisciplinary consultation is conspicuously higher than doctors who have not opened, which is different from the results in Table 4.

In summary, there is a big difference in the mechanism of whether doctors have senior titles on online inquiries and consultations, but there is little difference in post-treat management. For multidisciplinary consultation, there are small differences in the number of online inquiries, online consultations and post-treat management.

4.3. The Impact of Different Characteristics of Hospitals

The different characteristics of hospitals mainly consider two aspects : hospital level and hospital type. The study found that hospitals with different characteristics have different mechanisms on physician performance.

The impact on online inquiries is shown in Table 7. (See Table 7)

The results show that online satisfaction has a greater impact on tertiary hospitals, while online comments and articles have a greater impact on non-tertiary hospitals. The number of online comments and online satisfaction have a significant impact on general hospitals, but articles has a strong impact on specialized hospitals. In addition, the intercept of tertiary hospitals is lower than that of non-tertiary hospitals, and the intercept of specialized hospitals is higher than that of general hospitals.

Table 7. The influence on OIN under different hospital characteristics

	Online Inquiry Number (OIN)			
	Tertiary Hospital	Non-tertiary Hospital	General Hospital	Specialized Hospital
Online Comment	2.885364***	3.99377***	3.138963***	2.395984***
Online Satisfaction	3.733172**	2.67252	4.15749**	2.912984
Article Number	.0691125	1.092152*	.0262251	.3728384***
Time Effect	√	√	√	√
Individual Effect	√	√	√	√
Constant Term	10.02238	13.97633	9.776132	11.19884
R2	0.5067	0.5707	0.4853	0.5116

The impact on online consultations is shown in Table 8. (See Table 8)

Table 8. The influence on OCN under different hospital characteristics

	Online Consultation Number (OCN)			
	Tertiary Hospital	Non-tertiary Hospital	General Hospital	Specialized Hospital
Online Comment	1.300171***	.5753561***	1.440596***	.7796386***
Online Satisfaction	1.623382**	1.791577**	1.994097***	.5318216
Article Number	.0893193	.2698762	.0557522	.2754278***
Time Effect	√	√	√	√
Individual Effect	√	√	√	√
Constant Term	1.123659	1.76128	-.3892917	6.097634
R2	0.4424	0.3048	0.4599	0.3914

For hospital level, the results of all influencing factors are consistent. For hospital types, online satisfaction and articles have different effects. Moreover, the intercept difference between tertiary hospitals and non-tertiary hospitals is small, but the intercept of specialized hospitals is significantly higher than that of general hospitals, which is consistent with the results of table 7.

The impact on post-treat management is shown in Table 9. (See Table 9)

For any hospitals, the impact of online comments is small. The impact of online satisfaction on tertiary hospitals is more significant, and the influence of articles is not conspicuous. in addition, the intercept of tertiary hospitals is significantly lower, which is consistent with the results of table 7; the intercept of general hospitals was significantly higher, contrary to the results in table 7.

Table 9. The influence on PMN under different hospital characteristics

	Post-treat Management Number (PMN)			
	Tertiary Hospital	Non-tertiary Hospital	General Hospital	Specialized Hospital
Online Comment	1.210871***	.9894925***	1.179047***	1.264451***
Online Satisfaction	2.423623**	-.026698	2.312002*	2.101614
Article Number	-.0120751	.2537126	-.0002326	-.0311911
Time Effect	√	√	√	√
Individual Effect	√	√	√	√
Constant Term	5.819565	10.3879	7.366468	4.769222
R2	0.3178	0.2786	0.3073	0.3457

In general, the impact of non-tertiary hospitals on online inquiries and post-treat management is significantly higher than tertiary hospitals, while there is no significant difference in online consultations; the impact of general hospitals on online inquiries and online consultations is lower, but it is significantly higher than that of specialized hospitals on the number of post-treat management.

4.4. Robustness Test

In order to improve the universality and persuasiveness, this paper replaces the data source and the variable measurement. The results are basically consistent with the original results. This paper also selects the number of effective post-treat management (doctor-patient calls 3 times or more are regarded as valid) as the dependent variable (EPMN). By re-estimating the model, the results are consistent with the original model, indicating that the robustness test is passed. The specific results are shown in Table 10. (See Table 10)

Table 10. Robustness test results

	OIN	OCN	PMN	EPMN
	New sample data			Original sample data
Online Comment	2.485524***	1.147564***	.8224335***	.8682294***
Online Satisfaction	5.676397***	3.118279***	1.700913**	1.443325**
Article Number	.1011445	.0184566**	.0085471	.0152886
Time Effect	√	√	√	√
Individual Effect	√	√	√	√
Constant Term	4.227963	-.6990329	9.163492	4.166605
R2	0.3652	0.3425	0.2295	0.3138

5. Conclusion and Foresight

Based on the data of Good Doctor online website, this paper constructs a two-way fixed model, and found that articles have no conspicuous impact on the physician performance, and the number of online comments and online satisfaction have a significant impact. In the course of treatment, patients are more inclined to senior doctors, non-tertiary hospitals and specialist hospitals. However, in the process of post-treat management, patients are more inclined to doctors Who open multidisciplinary consultation and general hospitals in order to obtain more comprehensive and systematic treatment and health care services.

This paper has made some contributions in theory. First of all, this paper provides a multi-level solution for the study of physician performance, that is using two-level indicators to explore the overall and partial influencing factors of online inquiry. Secondly, this paper comprehensively studies the influencing factors of doctor performance from multiple dimensions. Finally, this paper discusses whether there are different mechanisms for the impact of physician performance from the perspective of doctors and hospitals with different characteristics.

This article hopes to make practical contributions to the sustainable development of online health communities. First of all, at the doctor level, on the basis of improving the level and quality of the service, doctors focus on factors that can improve their own performance, not only to bring more help to patients, but also to create higher income for themselves. Secondly, at the hospital level, hospitals should give full play to the advantages of their own characteristics, take reasonable measures to improve the overall service quality, and attract more patients. Finally, the online health community should display the information of doctors and hospitals as comprehensively as possible to reduce the information asymmetry between patients and doctors, so as to better meet the needs of patients for online medical care.

This article also has the following shortcomings. First, whether doctors choose multidisciplinary consultation is not random, which may lead to endogenous results. Further research can take more detailed and in-depth measures to solve this problem. Second, this paper only considers the number of patient comments, but does not consider the emotional orientation. Follow-up studies can use sentiment analysis and other methods to study the impact of the emotional orientation of patient comments (positive and negative reviews) on physician performance. Third, the data used in this paper is only from an online health community, so the general conclusions may not be well evidenced. Subsequent studies can enhance the universality of the conclusions by collecting more data from online health communities.

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