What Affects Patients' Online Decisions: An Empirical Study of Online Appointment Service Based on Text Mining

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Abstract. The emergence of online health communities enables patients' comments on doctors to express their opinion on service and also make it possible for patients seeking doctors' information before seeing doctor. Making appointment online and then go to see a doctor offline on schedule become popular in China due to its convenience. Both econometric estimations and text mining are used to explore the factors that influence patients' selection of doctors in OAS. The results show that online satisfaction does affect patients to choose doctor, although offline attributes, such as doctor's title and the tier level of hospital, are also considered. We find that overall satisfaction and review volume both have positive impacts on patients' online decisions. As for the specific dimensions of satisfactions extracted from reviews, the service attitude, technical level, explanation clarity, and doctor ethics also positively affect the number of OAS. The moderating effect between doctor's online recommendation and title is negative, as patients care more about doctor's online reviews when she has a low title and vice versa. In addition, the results reveal that patients with high-risk disease are more sensitive to doctor's review volume. Our findings can help doctors design their strategy of online appointment service, and also help online health communities refine their review system so that patients can express their attitudes more specifically.

Keywords: Online health community · Patient satisfaction
Online appointment service · Text mining · Sentiment analysis

1 Introduction

With the explosive growth of internet information resources, more and more patients begin to find health information online. It is universally acknowledged that online information resources are of varying quality, but the emergence and development of online health communities (OHC) solved this problem. People start to rely on OHC to search information, case in point, about 72% American internet users go to OHC for health information [1]. According to iResearch, online health applications (including mobile apps and websites) have more than 2 billion visits monthly in China [2].

Online health community provides a platform on which doctors can better serve and help patients. For example, by participating in online communities, patients can consult

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doctors directly about health problems by telephone and just cost a little. Besides, online appointment service (OAS) is an easy access to patients who require more consultation and treatment [3, 4]. OHC benefits both doctors and patients in that doctors can make full use of their spare times, while patients can find more health information, suggestion and emotional support that help them recover more effectively [5].

However, most of the existing literatures only investigated online service of OHC, in which patients seek answers from each other (patient to patient OHC), or in which doctors provide service to patients (patient to doctor OHC). Little study has been done about OAS where patients make appointment online and take treatments in hospital, and patients can use both online reviews and offline reputation to choose their desired doctors. Our study attempts to fill this research gap.

This paper makes contributions to OHC research by reconciling an important problem: whether online patients' satisfaction and offline attributes affect patients' decision of choosing doctors in OAS. Our data were collected from one of the largest OHC in the world, where there are more than 170,000 doctors from different Chinese famous hospitals. In our study, we used text mining to find more detailed dimensions of patients' satisfaction and calculated the score of specific topics based on emotion dictionaries. Both doctor's online reputation and offline reputation are tested in this paper. What's more, we measured the moderate effect of disease risk on patients' satisfaction and review volume.

2 Research Hypotheses

Existing literatures rarely study reviews' effect on patients' choosing doctors, which is an emerging area of consideration. We divide patients' satisfaction into overall satisfaction and specified satisfaction to test their effects on doctor's appointment. We also test for the moderating effect of disease risk on satisfaction's influence on doctor's appointment, and the interaction between doctor's position rank and online recommendation on patients' choosing doctor behavior online.

In an OAS, there are many factors that affect patients to select a doctor, such as hospital tier level [6], doctor's title [7], patients' satisfaction [8], online reviews, disease risk, and website recommendation. Therefore, we have the following hypotheses:

H1a: *The number of doctor's OAS is positively correlated with her title.*
H1b: *The number of doctor's OAS is positively correlated with the tier lever of her hospital.*
H2: *The number of doctor's OAS is positively correlated with the patients' overall satisfaction.*
H3: *The number of doctor's OAS is positively correlated with the volume of reviews.*
H4a: *The number of doctor's OAS is positively correlated with the score of doctor's service attitude.*
H4b: *The number of doctor's OAS is positively correlated with the score of doctor's technical level.*

H4c: *The number of doctor's OAS is positively correlated with the score of doctor's clarity for explanation.*
H4d: *The number of doctor's OAS is positively correlated with the score of doctor's ethics.*
H4e: *The number of doctor's OAS is positively correlated with the score of service process.*
H4f: *The number of doctor's OAS is positively correlated with the score of hospital infrastructure.*
H5a: *The effect of patients' overall satisfaction on the number of OAS can be moderated by disease risk, and patients with risker disease attach more importance on patients' overall satisfaction.*
H5b: *The effect of review volume on the number of OAS can be moderated by disease risk, and patients with risker disease attach more importance on the volume of reviews.*
H6: *The title and recommendation score can negatively moderate each other's effects* on *number of OAS.*

3 Data and Methods

3.1 Data Collection

To test our research hypotheses, we collect data once a week from one of the largest online medical platforms, "Good Doctor Online (http://www.haodf.com/)". It is a data set of 3,191 doctors, from July 7, 2017 to August 27, 2017, and includes 23,722 records after deleting the records with some information missing. For each doctor in our data set, we collected her personal information, hospital information, satisfaction information and patients' reviews. This data set also consists of 10 specific kinds of diseases, with 5 high-risk diseases and 5 low-risk diseases according to the mortality and relevant data for major diseases from the China Health Statistics Yearbook 2016. According to the yearbook and other's studies [9], we choose 5 kinds of lethal diseases as high-risk disease (leukemia, lung cancer, cirrhosis, coronary heart disease and diabetes) and 5 kinds of non-lethal diseases as low-risk disease (hypertension, rheumatoid arthritis, gastritis, depression and menoxenia).

3.2 Measures for Reviews Topics and Sentiments

There are a vast number of reviews in OAS platform. They vary in topic, sentiment and volume. For this study, we collected and downloaded more than 79,800 patients' reviews about 3,191 focal doctors. Further, we analyzed the topics and sentiments of patients' reviews by Latent Dirichlet Allocation (LDA) and sentiment lexicons and used the sentiment score as the patients' satisfaction of focal doctor. In the process of topic identification, there are fifty themes and can be divided into three categories: patient, doctor and hospital. By summing up all themes, we selected the most often discussed topics: Service, Technical, Explanation, Ethics, Process and Infrastructure. Then we calculated the sentiment score of each topic identified in each review based on

Hownet sentiment lexicon and obtained the satisfaction scores of each doctor in six different topics.

3.3 Model Specification

Our empirical variables are shown in Table 1. The dependent variable *NumOAS* is defined as the number of OAS received by the focal doctor in a week, which refers to how many patients choose to use this OHC to make appointments with the doctor for services. The independent variables include doctor's idle time (*IdleTime*), doctor's title (*Title*), the tier level of her hospital (*Level*), the number of reviews given by the patients (*ReviewNum*), the overall satisfaction on the platform (Satisfaction), the score of satisfaction's specific dimensions (Service, Technical, Explanation, Ethics, Process, Infrastructure). We control the number of people in the province where the doctor works (Population), the virtual gifts patients gave to doctors (*Gifts*), the recommendation score given by the website (*Recommend*), the number of years that a doctor registered on website (*Year*), the number of articles which a doctor has published on her homepages (*Article*), as well as patients' disease risk (*Risky*).

The correlation analysis indicates that the correlation coefficients between each pair of independent and control variables. We can find that the four dimensions of doctors' satisfaction obtained by text mining are highly correlated (service attitude, technical level, explanation clarity and ethics), so we build regression models separately when testing their impacts. To test our hypotheses, we formulate the following empirical models, as shown in Eqs. (1), (2), (3) and (4).

$$\begin{aligned} NumOAS_t = {} & IdleTime_t + Title_{t-1} + Level_{t-1} + ln(ReviewNum)_{t-1} \\ & + Satisfaction_{t-1} + Recommend_{t-1} + Service_{t-1} \\ & + Process_{t-1} + Infrastructure_{t-1} + Year_{t-1} + Risky_{t-1} \\ & + ln(Gift)_{t-1} + ln(Population)_{t-1} + ln(Article)_{t-1} \\ & + TimeDummy_i + DiseaseDummy_i + Constant + \varepsilon \end{aligned} \tag{1}$$

$$\begin{aligned} NumOAS_t = {} & IdleTime_t + Title_{t-1} + Level_{t-1} + ln(ReviewNum)_{t-1} \\ & + Satisfaction_{t-1} + Recommend_{t-1} + Technical_{t-1} \\ & + Process_{t-1} + Infrastructure_{t-1} + Year_{t-1} + Risky_{t-1} \\ & + ln(Gift)_{t-1} + ln(Population)_{t-1} + ln(Article)_{t-1} \\ & + TimeDummy_i + DiseaseDummy_i + Constant + \varepsilon \end{aligned} \tag{2}$$

$$\begin{aligned} NumOAS_t = {} & IdleTime_t + Title_{t-1} + Level_{t-1} + ln(ReviewNum)_{t-1} \\ & + Satisfaction_{t-1} + Recommend_{t-1} + Explanation_{t-1} \\ & + Process_{t-1} + Infrastructure_{t-1} + Year_{t-1} + Risky_{t-1} \\ & + ln(Gift)_{t-1} + ln(Population)_{t-1} + ln(Article)_{t-1} \\ & + TimeDummy_i + DiseaseDummy_i + Constant + \varepsilon \end{aligned} \tag{3}$$

$$\begin{aligned} NumOAS_t = {} & IdleTime_t + Title_{t-1} + Level_{t-1} + ln(ReviewNum)_{t-1} \\ & + Satisfaction_{t-1} + Recommend_{t-1} + Ethics_{t-1} + Process_{t-1} \\ & + Infrastructure_{t-1} + Year_{t-1} + Risky_{t-1} + ln(Gift)_{t-1} \\ & + ln(Population)_{t-1} + ln(Article)_{t-1} + TimeDummy_i \\ & + DiseaseDummy_i + Constant + \varepsilon \end{aligned} \tag{4}$$

4 Results

We estimated our models using negative binomial regression and all our empirical models were done by STATA. The empirical results in Table 1 contain the interaction effect of doctor's title and website recommendation and the moderate effects of disease

Table 1. Regression results

	Model 1	Model 2	Model 3	Model 4
IdleTime	0.035***	0.034***	0.035***	0.034***
Title	1.916***	1.909***	1.927***	1.934***
Level	0.443***	0.441***	0.439***	0.444***
ln(ReviewNum)	0.357***	0.357***	0.356***	0.356***
Risky	−0.068	−0.061	−0.059	−0.057
Satisfaction	0.729***	0.715***	0.719***	0.719***
Recommend	2.072***	2.066***	2.086***	2.090***
Service	0.105*			
Technical		0.154**		
Explanation			0.125**	
Ethics				0.117*
Process	−0.013	−0.022	−0.014	−0.020
Infrastructure	0.007	−0.004	−0.002	−0.012
Title × Recommend	−0.383***	−0.381***	−0.386***	−0.387***
Risky × ReviewNum	0.088**	0.087**	0.085**	0.084**
Risky × Satisfaction	−0.220	−0.215	−0.227	−0.227
Year	−0.049***	−0.049***	−0.048***	−0.049***
ln(Gift)	0.039*	0.041*	0.037	0.040*
ln(Population)	−0.064**	−0.066**	−0.063**	−0.064**
ln(Article)	−0.004	−0.005	−0.005	−0.004
Constant	−10.493***	−10.447***	−10.506***	−10.549***
Time dummy	√	√	√	√
Disease dummy	√	√	√	√
Log likelihood	−31047.2	−31044	−31043.6	−31043.6
Wald chi2	2111.09	2118.16	2118.19	2113.91
Prob > chi2				
Observations	23,722	23,722	23,722	23,722
Number of x_id	3,191	3,191	3,191	3,191

***p < 0.01, **p < 0.05, *p < 0.1

risk on the number of reviews and overall satisfaction. Hypotheses H4a–H4d were tested respectively in the four models.

It is shown that all the variables have significant influences on the number of OAS received by the focal doctor except for medical process ($p > 0.1$), hospital infrastructure ($p > 0.1$) and the moderate effect of disease risk on overall satisfaction ($p > 0.1$). Therefore, we should reject H4e, H4f and H5a. The results show that the doctors with a high score of overall satisfaction ($p < 0.01$) and a large review volume ($p < 0.01$) are more popular among patients. Furthermore, the doctor's title ($p < 0.01$) and hospital's tier level ($p < 0.01$) have positive effect on OAS. As for the effect of detailed dimensions for satisfaction, the results reveal that service attitude ($\beta = 0.105$, $p < 0.1$), technical level ($\beta = 0.154$, $p < 0.05$), explanation clarity ($\beta = 0.125$, $p < 0.05$), and doctor ethics ($\beta = 0.117$, $p < 0.1$) positively affect the OAS. Therefore, H1a, H1b, H2, H3, H4a–H4d and H5b are all supported.

The results show that the interaction effect between doctor's title and website recommendation score is significantly negative ($p < 0.01$). It indicates that although the doctor's title is inferior, a high website recommendation still can bring a higher OAS to her. This provides doctors an opportunity to get more OAS by raising the recommendation score, for example, participating in the various online activities can increase word of mouth in patients. Besides, the disease risk can moderate the effect of review volume on OAS ($p < 0.05$), indicating that patients with risky diseases are more sensitive to the number of reviews for doctor.

In summary, this paper investigates factors that influence patients' selection of doctors in OAS. Except for H4e, H4f and H5a, all the other hypotheses are supported.

5 Conclusions

This paper investigates what affect patients to select doctors in online booking service in hospitals (OAS). The main finding is online satisfaction such as overall satisfaction, service attitude, technical level, explanation clarity and medical ethics do affect patients choose doctor positively, although offline attributes such as doctor's title and the tier level of her hospital are also considered. Furthermore, the results indicate that review volume has positive effect on the number of OAS and patients with high-risk diseases are more sensitive to that. Therefore, doctors should encourage their patients to comment on the website and attach more importance to their attitude and expression when serving online and offline. Our findings also help OAS platform to refine their system design. Because of the moderate effect of recommendation, the system need to encourage doctors with low professional title or without title to pay more attention to online services in order to get good online reviews, which can attract more patients to make appointments. In the future, we will take the doctor's online consultation services into account and model it to explore the supply and demand in OAS.

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