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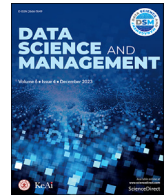
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Research article

Understanding the antecedents of patients' missed appointments: the perspective of attribution theory

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ARTICLE INFO

Keywords:

Online healthcare
Outpatient appointment system
Patients' missed appointments
Moderating effect

ABSTRACT

The occurrence of missed appointments from online outpatient bookings significantly hinders the operational efficiency of outpatient services. This study aimed to investigate various factors influencing patients' missed appointments from online outpatient bookings. Drawing on attribution theory, an empirical analysis was conducted using 382,004 authentic online outpatient appointments. The empirical findings revealed that appointment lead-time, appointment time, weekday appointments, online doctor rating, appointment doctor's expertise, patient distance, and previous outpatient visit experience significantly influenced patients' missed appointment behaviors from online outpatient bookings. Importantly, previous outpatient experience positively moderated the relationship between the appointment doctor's expertise and patients' missed-appointment behavior. This study provides insights into the factors influencing patients' missed-appointment behavior from online outpatient bookings. It further offers a theoretical foundation for medical institutions in China to mitigate the likelihood and adverse effects of patients' missed-appointment behavior from online outpatient bookings.

1. Introduction

Missed medical appointments pose significant challenges to healthcare systems. Missed-appointments reduce the opportunity for other patients to secure appointments, resulting in decreased access to healthcare services (Alaeddini et al., 2015) with the delays in diagnosing and treating the disease (Barrera Ferro et al., 2020; Zebina et al., 2019). Furthermore, it increases the risk of complications and poorer outcomes in subsequent treatments for patients (Lynn et al., 2012; Rosenbaum et al., 2018), and can contribute to increased morbidity and mortality rates (McQueenie et al., 2019), among other negative consequences. In addition, patients who missed appointments significantly impaired the operational efficiency of healthcare providers. It disrupts the normal flow of outpatient services, creating disorders and inefficiency (Home-de-Mello et al., 2022). Furthermore, it places an increased burden on physicians and healthcare departments, leading to additional workload and challenges in resource allocation (Lee et al., 2018). Lastly, missed appointments result in financial losses for the healthcare system, posing economic challenges and affecting the sustainability of healthcare

services (Liu, 2016).

The concern that it is “too difficult to see a doctor” stands in stark contrast to patients' missed-appointment behavior and has become a significant social concern in many tertiary public hospitals in China (Liu, 2009; Yip and Hsiao, 2008; Zhang et al., 2014). The concentration of medical investments, resources, and expertise in urban areas has created a situation in which highly respected doctors and advanced facilities are primarily located, leading to fierce competition among patients for limited medical resources (Sun et al., 2016; Zhang et al., 2014). In recent years, China's healthcare industry has made notable advancements coinciding with the rapid development and utilization of information and communication technologies (ICTs) in health services. In response to the challenges faced by hospitals in meeting the growing demand for medical services, the adoption of ICTs to provide remote health services has gained significant popularity (Zhang et al., 2017). Online outpatient appointment systems that have emerged as new appointment systems based on the Internet have garnered considerable attention and have been widely implemented in public tertiary hospitals (Cao et al., 2011). Since 2009, all public tertiary hospitals in China have

Peer review under responsibility of Xi'an Jiaotong University.

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<https://doi.org/10.1016/j.dsm.2023.09.004>

Received 18 July 2023; Received in revised form 26 September 2023; Accepted 26 September 2023

Available online 27 September 2023

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implemented online outpatient appointment systems (Zhang et al., 2014). For patients, in addition to the traditional options of on-site outpatient appointments and telephone appointments, they now can access appointment-based diagnosis and treatment services through hospital-specific mobile applications (apps), hospital WeChat public platforms, or third-party service platforms. These advancements aim to alleviate pressure on hospital outpatient appointment systems and enhance the convenience and accessibility of healthcare services for patients.

Online outpatient appointments offer several advantages over traditional ones. They eliminate the constraints of fixed time and location and provide convenient healthcare services for patients. Online appointments reduce waiting times for outpatient services, saving both the time and costs associated with medical treatment. Furthermore, they contribute to the improved allocation of medical resources. However, the issue of patients' missed appointments in online booking is a significant concern for the healthcare system. The rate of missed appointments ranged from 10% to 20%, with some hospitals experiencing rates exceeding 30% (Barrera Ferro et al., 2020; Ding et al., 2018; Fiorillo et al., 2018; Kheirkhah et al., 2016; Lenzi et al., 2019). The high rate of missed appointments has become a crucial problem that must be addressed by the healthcare system.

Previous research has identified several important factors that predict patients' missed-appointment behavior. These factors include distance to the healthcare facility (Daggy et al., 2010; Dantas et al., 2019), appointment time (Cronin et al., 2013; Dantas et al., 2019; Peng et al., 2016), appointment lead-time (Chang et al., 2015; Lee et al., 2005; Liu et al., 2017; Rosenbaum et al., 2018) and previous outpatient visit experience (Fiorillo et al., 2018; Jain and Chou, 2000; Lee et al., 2005) are important predicting factors of patients' missed-appointment behavior. There is a lack of consensus regarding the impact of demographic factors, such as age and gender (Cronin et al., 2013; Fiorillo et al., 2018; Liu et al., 2017; Whiting et al., 2015; Zhou et al., 2018). It is important to note that previous studies have primarily focused on the direct influence of these predictive variables on patients' missed-appointment behavior, overlooking the potential interaction effects. Moreover, most studies have primarily examined patients' missed-appointment behavior within the context of traditional appointment systems, with limited research conducted specifically on online appointments. As a result, in the context of healthcare in China, it remains unclear which specific factors influence patients' missed appointments from online bookings. Further research is needed to address these gaps and provide insights into the unique dynamics of patients' missed appointments from online bookings.

This study aimed to explore the factors influencing patients' missed-appointment behavior from online outpatient bookings in China and provide a theoretical basis for promoting online medical treatment in China. In this study, we posed the following questions:

- (1) What factors influence patients' missed-appointments in online outpatient bookings in China?
- (2) Does online doctor rating play a role in patients' missed-appointment behavior?
- (3) How does previous outpatient visit experience moderate patients' missed-appointment behavior caused by the external environment and reduce the probability of missed-appointment behavior?

To answer these questions, this study used data from a large general hospital in central China to discuss the main factors influencing missed online outpatient appointments. Our study provides a new perspective for understanding patients' missed-appointment behavior, delivering a theoretical foundation for hospitals to adopt appropriate measures aiming at diminishing the occurrence of missed-appointments. This in turn enhances the operational efficiency of hospital outpatient services, leading to improved economic and social outcomes for healthcare facilities.

2. Literature review and theoretical background

2.1. Online appointment system

The lack of a reliable referral system and the uneven distribution of medical resources across regions in China have resulted in overcrowding in major hospitals (Zhang et al., 2014). Conventional methods of outpatient appointments, such as manual windows and telephone appointments, have notable drawbacks in terms of timeliness and efficiency (Su et al., 2020). Consequently, patients frequently encounter challenges, such as lengthy queues and diminished satisfaction while striving to access limited medical resources (Habibi et al., 2019; Zhang et al., 2014). Fortunately, with the rapid advancement of information and communication technology, online appointment systems have emerged as an important method for scheduling outpatient appointments (Fan et al., 2021). Online outpatient appointments eliminate the constraints of fixed times and geographical distance. Through this system, patients can conveniently schedule their appointments and access real-time appointment information, as well as expand the reach of their medical services, enhance workflow efficiency, and reduce waiting times (Mey and Sankaranarayanan, 2013). Nevertheless, online outpatient appointment systems face challenges related to missed appointments.

2.2. Patients' missed appointments from online bookings

Previous studies have indicated that age and gender have varying effects on patients' missed-appointment behavior (Cronin et al., 2013; Fiorillo et al., 2018; Kheirkhah et al., 2016; Lehmann et al., 2007; Liu, 2016; Zhou et al., 2018). Furthermore, such factors as income, marital status, and race have also been found to affect patients' missed-appointment behavior (Daggy et al., 2010; Lee et al., 2005; Lehmann et al., 2007). Other significant influencing factors include appointment lead-time (Cronin et al., 2013; Peng et al., 2016), weather condition (DeFife et al., 2010; Peng et al., 2016), patient distance from hospital (Daggy et al., 2010; Dantas et al., 2019; Whiting et al., 2015), previous patient visit experience (Fiorillo et al., 2018; Jain and Chou, 2000), medical insurance (Peng et al., 2016; Whiting et al., 2015), appointment channels (Zhou et al., 2018) and appointment specialties (Jain and Chou, 2000; Rosenbaum et al., 2018). Collectively, these factors contribute to the complex dynamics of missed-appointments.

Compared to traditional offline clinic appointments, in the context of online clinic appointments, patients are more susceptible to the influence of physicians' online reputations. However, the existing research on patients' missed appointments has overlooked the influence of online physician reputations on this behavior. Additionally, to the best of our knowledge, this study represents a pioneering attempt to explore the impact of online physicians' reputations on patients' missed-appointments in the unique context of the Chinese online healthcare market. Our research innovatively integrates both online and offline data, considering them as determining factors for patients' missed-appointments. Furthermore, we emphasize the significant role played by patients' outpatient experiences in their tendency to miss appointments. Patient experience has become a fundamental component of healthcare (Godovykh and Pizam, 2023), as it influences patient satisfaction with healthcare services, perceived quality, loyalty to healthcare providers, and patient behavioral intentions (Kandampully et al., 2018; Majeed and Kim, 2023). Therefore, a comprehensive understanding of how patients' outpatient experiences interact with other factors in online appointment scheduling can contribute to a better understanding of patients' behavior regarding missing appointments.

Our study divided the factors influencing patients' missed-appointment behavior into two categories: individual factors, environmental and other objective factors. Individual factors mainly refer to those that cause patients to perceive their own will or ability to break the appointment. Environmental and other objective factors mainly refer to factors affecting the behavior of the patient brought about by the external

environment, which cannot be determined by the patient. The individual factors in this study mainly included appointment lead-time, weekday appointments, and appointment times. The environment and other objective factors mainly included online doctor rating, doctor's expertise, and patient's distance. Because of the scarcity and competitiveness of medical resources (Ye et al., 2019), patients engaging in online clinic appointments compete with other patients. This competitive behavior is influenced by patients' individual capacities, which consequently affects their choice of lead times for appointments, appointment dates, and appointment times. Additionally, the expertise of physicians signifies the scarcity of medical resources (Wu et al., 2020), whereas the distance between patients and hospitals denotes the accessibility of medical resources. These external factors are beyond patients' control and shape their behavior in the context of online outpatient appointments.

2.3. Attribution theory

Attribution theory mainly studies the explanations and inferences of individuals regarding their own or others' behaviors (Ostrom, 1981). Attribution was used to determine the cause of the results. This refers to the cognitive activity that confirms the cause of a result through the processes of perception, thinking, inference, and other internal information processing based on the result of a certain action or event. Therefore, attribution theory is considered a study of deconstructive causes. Attribution is the basic cognitive process of an individual, and there must be reasons behind individual behaviors. When exploring the reasons behind behaviors, individuals attribute it to personal or external environmental factors. Personal factors are called personal tendency attributions, and external environmental factors are also called situational attributions (Heider, 1958). Internal factors are those that the individual has, mainly including the individual's characteristics, needs, emotions, beliefs, attitudes, motivations, and efforts. External factors include the natural and social environment, expectations of others, rewards, orders, weather, work difficulty, luck, and other elements independent of the individual.

The main concept of the attribution model is that individuals always try to infer and explain when they perceive people's behavior. Attribution refers to the causal explanations and inferences made by the observer regarding the behavior of others or themselves to predict and evaluate the behavior of the individual and control the environment and behavior (Kelley, 1967). Attribution will change an individual's expectations of the actor and bring about a series of emotional changes in the actor, and the result of this attribution will further affect the individual's subsequent behavioral motivation (Weiner, 1986). In this study, in the online outpatient appointment process, patients made a series of attributions to their own or others' behavior, and different attribution results affected the patients' online outpatient appointment activities.

3. Hypothesis development

3.1. The environment and other objective factors of patients' missed appointments

Online appointment services for outpatients in most of the top three hospitals in China provide two types of medical resources: expert-registered tickets and ordinary-registered tickets. The distinction between these two categories lies in the doctor's level of expertise. Expert doctors typically possess higher levels of professional competence than their general counterparts. Consequently, patients tend to prefer scheduling appointments with expert doctors to avail themselves of high-quality medical services. Consequently, patients who book appointments with expert doctors perceive a heightened level of medical service quality, which can influence the likelihood of missed-appointments.

Patient distance refers to the distance between the patient and the hospital, and serves as a critical gauge of medical resource accessibility.

Given China's uneven economic development, economically disadvantaged regions have encountered a scarcity of medical resources. Superior healthcare services are primarily concentrated in economically prosperous areas, making access to medical resources relatively difficult for patients residing in remote locations. Previous research has also demonstrated the significance of the patient-hospital distance as a crucial predictor of missed appointment behaviors. As the distance between the patient and hospital increases, the likelihood of patients engaging in missed-appointment behavior increases correspondingly (Daggy et al., 2010, 2019).

Reputation is a crucial aspect of healthcare service provision (Ram-saran-Fowdar, 2005), and is widely regarded as the most valuable attribute by physicians (Romano and Baum, 2014). With the growth of online healthcare, an increasing number of Chinese patients utilize online doctor reviews to assess healthcare providers and seek specific doctors to address their healthcare needs (Hao, 2015). Consequently, the reputation of outpatient doctors significantly influenced missed appointments. In this study, online doctor rating is employed as a metric to gauge the reputation of outpatient doctors. Higher online doctor ratings correspond to a higher perceived quality of medical services by patients. Given this reasoning, we hypothesize the following:

Hypothesis 1. A doctor's expertise has a significant negative impact on patients' missed-appointment behavior.

Hypothesis 2. Patient distance is positively associated with patients' missed-appointment behavior.

Hypothesis 3. Online doctor rating is negatively associated with patients' missed-appointment behavior.

3.2. Individual factors for patients' missed appointments

Appointments on weekdays are an important factor influencing patients' missed-appointment behavior. A previous study showed that weekday appointment plays a significant role in shaping patients' missed-appointment behavior (Cronin et al., 2013). Hospitals typically offer a greater number of appointments on weekdays than on weekends, resulting in an uneven distribution of outpatient appointments throughout the week, with variations corresponding to working and rest days. Because of these differences in appointment availability, the timing of patients' appointments can affect the likelihood of missed appointments.

The appointment time refers to the specific timeslot chosen by patients for their appointment, either in the morning or afternoon. Previous studies have demonstrated the significance of appointment time as a predictor of missed-appointment behavior (Dantas et al., 2018). This is because patients often experience waiting times in hospital outpatient clinics and must wait for treatment after obtaining their assigned numbers. Consequently, different appointment times can affect a patient's waiting duration, thereby influencing the likelihood of missed appointments.

Appointment lead-time is another influential factor in patients who miss appointments, as highlighted in existing research. Studies have indicated that longer appointment lead-time are associated with higher rates of missed appointments (Lee et al., 2005; Zhou et al., 2018). Additionally, research has found that patients scheduled for more than two weeks in advance are more prone to missed-appointments (Daggy et al., 2010). Extended lead times increase the risk of patients forgetting their appointments, and forgetfulness is a contributing factor to the likelihood of missed-appointment behaviors, particularly in the context of online appointments. Based on this discussion, we hypothesize the following.

Hypothesis 4. A weekday appointment is negatively associated with a patient's missed-appointment behavior.

Hypothesis 5. Appointment time is positively associated with a patient's missed-appointment behavior.

Hypothesis 6. Appointment lead-time is positively associated with a patient's missed-appointment behavior.

3.3. Moderating effect of outpatient visit experience

Previous studies have provided evidence that previous outpatient visit experiences can play a moderating role in reducing the likelihood of missing appointments (Dantas et al., 2019; Fiorillo et al., 2018; Lee et al., 2018). Building upon these research findings, this study aims to further investigate the moderating effect of previous outpatient visit experiences on patients' missed-appointment behavior through empirical analysis. According to attribution theory, individuals' attributions of their own behavior can influence their cognitive and emotional reactions, which, in turn, can impact their future actions (Weiner, 2013). People tend to attribute their actions to external environmental conditions and, consequently, may restrict their subsequent behavior (Carroll and Payne, 1976; Jones and Nisbett, 1971; Sjoval and Talk, 2004). In the context of this study, the expertise of a patient's appointment doctor and distance from the healthcare facility are external environmental factors that may influence the patient's missed-appointment behavior. Previous outpatient visit experience in the context of online appointments can shape patients' attributions (Ye et al., 2019). The attribution of success or failure prior to a specific behavior (e.g., whether a patient missed an online outpatient appointment) can affect patients' expectations, emotions, and efforts, consequently influencing their likelihood of missed-appointment behavior. Therefore, studying the moderating effect of patients' previous outpatient visit experience on the relationship between the appointment doctor's expertise, patient distance, and patients' missed-appointment behavior is essential. By examining this relationship, this study aimed to provide insights into the interplay between patients' previous experience and their response to the appointment doctor's expertise and patient distance, shedding light on the factors that influence patients' missed-appointment behavior. Thus, we hypothesize as follows:

Hypothesis 7a. A patient's previous outpatient visit experience has a positive moderating effect on the doctor's expertise and the patient's missed-appointment behavior.

Hypothesis 7b. A patient's previous outpatient visit experience has a negative moderating effect on patient distance and the patient's missed-appointment behavior.

4. Data and methods

4.1. Research context and data

This study used data collected from a general hospital in Central China. The dataset consisted of outpatient appointment records extracted from electronic medical record (EMR) systems from May 2019 to August 2019. A total of 454,217 outpatient visit records were obtained. To focus on the online outpatient appointment context, the study sample was restricted to patients who used an online appointment system. To complement this study, outpatient doctor ratings were obtained from the Good Doctor website (www.haodf.com). This website is recognized as the largest and earliest online doctor review and healthcare community platform in China (Hao, 2015). These two datasets can be merged using the doctors' names. After removing invalid samples, the final sample sizes for the analysis were 382, 004.

4.2. Variables and research model

Dependent variables: Previous research has defined patients' missed-appointments as a patient's failure to attend a scheduled appointment or

canceling the appointment shortly before the appointment time (usually within one day), resulting in the inability to reassign the outpatient appointment to another patient (Ding et al., 2018; Huang and Hanauer, 2014; Lenzi et al., 2019). According to the outpatient appointment mechanism of the hospital, our study considered that patients missed-appointments if they did not show up for a scheduled appointment or canceled the outpatient appointment after six o'clock on the day of the scheduled appointment.

Independent variables: Appointment lead-time, appointment time, weekday appointments, online doctor rating (DOC RAT), appointment doctor's expertise (DOC EXP), distance, and previous outpatient visit experience (EXP). The appointment lead-time represents the number of days between the creation of the patient's outpatient appointment and the actual appointment date. The appointment time refers to the time of day when the appointment is scheduled, and is categorized into two levels: morning or afternoon. Weekday appointments signify the specific day of the week when the appointment is scheduled with six levels: Monday, Tuesday, Wednesday, Thursday, Friday, and Weekends. The doctor rating was derived from outpatient doctor ratings available online. The rating ranges from 0 to 5 and serves as a measure of the reputation of outpatient doctors. The appointment doctor's expertise represents the categorization of the doctor based on their expertise or ordinary status, classified into two levels: expert-registered ticket and ordinary-registered ticket. Distance is measured by the distance between the patient's location and the hospital, and is categorized into two levels, i.e., less than 300 km or more than 300 km.

Moderator variables: Previous outpatient visit experience was measured by whether the patient was visiting an outpatient clinic for the first time (two levels: first visit or not first visit).

Control variables: In eliminating the interference of other factors on the results, we further controlled for patients' age and gender.

Our analysis comprised three main steps. First, we estimated the research model using only control variables. Second, we introduced the main effects into the research model, which included appointment lead-time, appointment time, weekday appointments, online doctor rating, appointment doctor's expertise, and distance. Finally, we incorporated the interaction effect of previous outpatient visit experience into the research model. The comprehensive empirical model is described as follows:

$$\begin{aligned} \text{logit}(Y_i) = & \beta_0 + \beta_1(\text{Age}_i) + \beta_2(\text{Gender}_i) + \beta_3(\text{Leadtime}_i) + \beta_4(\text{AppointmentTime}_i) \\ & + \beta_5(\text{AppointmentWeekday}_i) + \beta_6(\text{DoctorRating}_i) \\ & + \beta_7(\text{DoctorExpertise}_i) + \beta_8(\text{Distance}_i) + \beta_9(\text{Experience}_i) \\ & + \beta_{10}(\text{DoctorType}_i \times \text{Experience}_i) + \beta_{11}(\text{Distance}_i \times \text{Experience}_i) + \varepsilon_i \end{aligned}$$

The R language tool glmnet package was used for logistic regression analysis (Friedman et al., 2010).

5. Results

5.1. Descriptive statistics

Table 1 presents an overview of the variables, using descriptive statistics. We provided the frequency and percentage for categorical variables and the mean and standard deviation for continuous variables. Regarding online outpatient appointments, the rate of missed-appointments was 11.1%. Furthermore, the average age of the outpatients was 36.6 years, with males accounting for 40.9% of the patients and females 59.1%. The correlations between the variables in this study are presented in Table 2. The findings revealed significant correlations between the dependent and independent variables, while demonstrating a low correlation between the study and control variables, indicating an acceptable level of multicollinearity. These results provide assurance regarding the accuracy of the model estimation.

To study the effect of weekday appointments and appointment times

Table 1
Descriptive statistics.

Variables	Mean	Standard deviation
Patients missed-appointments in outpatient online appointments	42,224 (11.1%)	-
Patients show up in outpatient online appointments	339,780 (88.9%)	-
Age	36.6	19.6
Gender		
Male	156,307 (40.9%)	-
Female	225,697 (59.1%)	-
Lead-time	4.9	4.7
Appointment time		
Morning	251,414 (65.8%)	-
Afternoon	130,590 (34.2%)	-
Appointment weekday		
Monday	85,837 (22.5%)	-
Tuesday	76,420 (20.0%)	-
Wednesday	70,257 (18.4%)	-
Thursday	68,786 (18.0%)	-
Friday	46,046 (12.0%)	-
Weekend	34,658 (9.1%)	-
Online doctor rating	3.9	0.2
Appointment doctor's expertise		
Expert appointment	317,788 (83.2%)	-
Ordinary appointment	64,216 (16.8%)	-
Distance		
Less than 300 km	327,191 (85.7%)	-
More than 300 km	54,813 (14.3%)	-
Experience		
First visit	256,506 (67.2%)	-
Not first visit	125,498 (32.9%)	-

on missed-appointment rates, missed-appointment rates were calculated for our study samples for six weekdays and two times. As shown in Fig. 1 (a), the missed-appointment rate on Monday was 10.9%, and slowly grew to weekends (11.2%), then dropped on weekends (10.3%), followed by a smooth increase until weekends. The missed-appointment rate on

weekends was the highest (13.1%). As shown in Fig. 1 (b), the missed-appointment rate in the afternoon (12.5%) was higher than that in the morning (10.3%).

5.2. Empirical results

The logistic regression results are presented in Table 3. Model 1 included only the control variables. From the logistic regression results of Model 1, all control variables were significantly related to missed-appointments. Notably, age has a significant negative impact on patients' missed-appointments ($\beta = -0.011, p < 0.01$). This finding indicated that older patients were less likely to miss appointments. Compared with male patients, female patients are less susceptible to missed-appointments in the outpatient appointment ($\beta = -0.033, p < 0.01$). Model 2 includes the main effects in addition to the control variables. The coefficient of appointment doctor's expertise is negative ($\beta = -0.687, p < 0.01$), which means that patients who have an appointment with expert are less probability to missed-appointments in outpatient appointment compared with the ordinary appointment. Thus, H1 is supported. Distance has a significant positive effect ($\beta = 0.111, p < 0.01$), that is, if a patient lives farther from hospital, they are more likely to miss appointments in outpatient appointment. Therefore, H2 is supported. The higher the online doctor rating, the lower the probability of outpatients' missed-appointments ($\beta = -0.35, p < 0.01$). This finding confirms the role of patient-perceived quality and support H3. As for weekday appointments, compared with weekend, outpatients who make appointments on Wednesday ($\beta = -0.04, p < 0.1$) or Thursday ($\beta = -0.045, p < 0.05$) are less likely to missed-appointments, but outpatients who make appointments on Friday ($\beta = 0.064, p < 0.01$) are more likely to miss appointments, and H4 are partially supported. Appointment time also has a significant positive impact on patients' missed-appointment behavior, indicating that the outpatients who had an appointment time in the afternoon were more likely to missed appointments than those who had an appointment time in the morning ($\beta = 0.282, p < 0.01$). Thus, H5 is supported. Appointment lead-time has a significant positive impact, that is, the longer the lead-time is, the more likely for outpatients to miss appointments in the outpatient appointment ($\beta = 0.03, p < 0.01$), H6 was supported.

Model 3 incorporates interaction effects alongside the main effects and control variables. Similar to Model 2, all main effect coefficients in Model 3 remain statistically significant. Notably, previous outpatient visit experience demonstrates a significant negative coefficient ($\beta = -0.227, p < 0.01$). This finding suggests that, compared to first-time outpatients, those with prior visit experience are less likely to miss appointments. Additionally, the previous outpatient visit experience serves to mitigate the impact of doctor's expertise on patients' missed-appointment behavior ($\beta = 0.515, p < 0.01$). This result also reveals the important role of patient experience in reducing patients' missed-

Table 2
Correlation matrix (N = 382,004).

Variable number	Descriptive statistics construct	Mean (SD)	Variable number								
			1	2	3	4	5	6	7	8	9
1	Age	36.6 (19.6)	1.000 ^a	- ^b	-	-	-	-	-	-	-
2	Gender	0.59 (0.49)	0.069 ^c	1.000 ^a	-	-	-	-	-	-	-
3	Lead-time	4.92 (4.66)	0.050 ^c	0.035 ^c	1.000 ^a	-	-	-	-	-	-
4	Appointment time	0.34 (0.47)	-0.011 ^c	-0.007 ^c	0.037 ^c	1.000 ^a	-	-	-	-	-
5	Appointment weekday	2.50 (1.53)	0.035 ^c	0.011 ^c	0.042 ^c	-0.008 ^c	1.000 ^a	-	-	-	-
6	Doctor rating	3.91 (0.20)	0.085 ^c	0.019 ^c	0.139 ^c	0.041 ^c	0.008 ^c	1.000 ^a	-	-	-
7	Doctor's expertise	0.83 (0.37)	0.183 ^c	-0.017 ^c	0.339 ^c	0.114 ^c	0.111 ^c	0.249 ^c	1.000 ^a	-	-
8	Distance	0.14 (0.35)	0.008 ^c	-0.027 ^c	-0.005 ^c	0.022 ^c	-0.005 ^c	0.024 ^c	0.014 ^c	1.000 ^a	-
9	Experience	0.33 (0.47)	-0.026 ^c	0.013 ^c	0.009 ^c	0.014 ^c	0.021 ^c	0.001 ^c	-0.035 ^c	-0.006 ^c	1.000 ^a
10	Patients missed appointments	0.11 (0.31)	-0.066 ^c	-0.011 ^c	0.007 ^c	0.033 ^c	-0.010 ^c	-0.038 ^c	-0.085 ^c	0.11 ^c	0.030 ^c

^a Correlations between two variables are calculated using Pearson correlation analysis.

^b Not applicable.

^c $p < 0.01$.

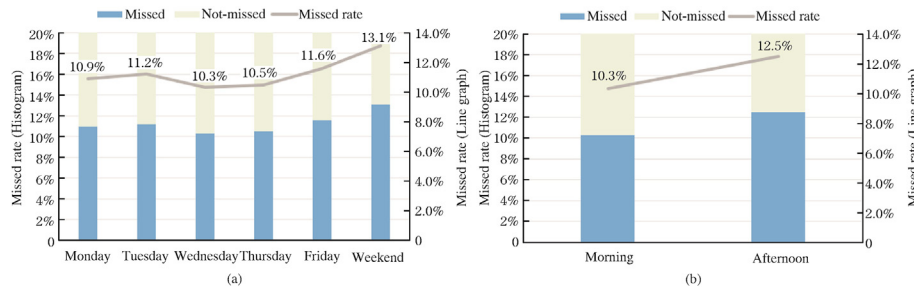


Fig. 1. Missed-appointment rate. (a) Missed-appointment rate in each day and (b) missed-appointment rate of morning and afternoon.

Table 3

Logistic regression results.

Variables	Model 1	Model 2	Model 3
Age	−0.011(0.0003)***	−0.008(0.0003)***	−0.008(0.0003)***
Gender	−0.033(0.011)***	−0.055(0.011)***	−0.057(0.011)***
Lead-time	-	0.030(0.001)***	0.030(0.001)***
Appointment time	-	0.282(0.011)***	0.278(0.011)***
Appointment weekday			
Monday	-	0.008(0.021)	0.010(0.021)
Tuesday	-	0.018(0.021)	0.018(0.021)
Wednesday	-	−0.040(0.021)*	−0.042(0.021)**
Thursday	-	−0.045(0.021)**	−0.047(0.021)**
Friday	-	0.064(0.022)***	0.063(0.022)***
Doctor rating (DOC RAT)	-	−0.350(0.03)***	−0.357(0.03)***
Doctor's expertise (DOC EXP)	-	−0.687(0.014)***	−0.864(0.017)***
Distance	-	0.111(0.014)***	0.102(0.018)***
EXP	-	-	−0.227(0.023)***
DOC EXP × EXP	-	-	0.515(0.026)***
Distance × EXP	-	-	0.034(0.03)
Observations	382,004	382,004	382,004
Log-likelihood	−131972.7	−130294.5	−129967.7
Akaike Inf. Crit.	263951.4	260614.9	259967.5
Cox and Snell R ²	0.004	0.013	0.015
Nagelkerke R ²	0.009	0.026	0.029

Note: (a) Standardize coefficients are reported; standard errors in parentheses. (b) Significance level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

appointment behavior. These results support hypothesis H7a. However, for patients who missed appointments because of distance, the interaction effect of previous outpatient visit was not significant. In the following section, we test the robustness of our empirical model.

5.3. Robustness check

To check the robustness of the research model, we combined the doctor rating from the Weiyi website (www.guahao.com), a mobile Internet medical health service platform in China. The Weiyi website provides online appointment services to patients worldwide. It was authorized by China Health and Family Planning Committee in March 2010 and is the largest health appointment website in China with over 23,000,000 real-name registered users and 100,000 experts (Lu and Wu, 2016). To examine the stability of the models, a robustness test was conducted, in which the new online doctor rating was incorporated. The results of this robustness test are presented in Model 4 and listed in Table 4. Notably, all findings remained consistent and robust, indicating

the stability of our results. It is important to note that different diseases can also impact the missed-appointment behavior of outpatients (Whiting et al., 2015). The diseases differ depending on the specialty. Therefore, it is necessary to consider the impact of specialty on the results. In the robustness test, we added 71 specialties as control variables to Model 3. Model 5 presents the estimation results in Table 4; the estimated results for the specialty variables are not reported in detail. These results are consistent with those of Model 3.

6. Discussion and conclusion

6.1. Principal findings

This study aimed to explore the factors influencing patients' missed-appointment behavior in outpatient online appointments, as well as the moderating effect of previous outpatient visit experience. First, the impact of demographic characteristics, such as gender and age, on patients' missed-appointment behavior from online outpatient bookings was examined. Subsequently, the study investigated the effects of appointment lead-time, appointment time, weekday appointments, doctor rating, appointment doctor's expertise, and patient distance on patients' missed-appointment behavior from online outpatient bookings. Finally, this study explored the moderating effect of previous outpatient visit experience. The empirical results, as well as the robustness test results, revealed the significance of most of the findings in this study.

The statistical analysis conducted in this study provides compelling evidence that gender and age are significant factors influencing patients'

Table 4

Robustness test results.

Variables	Model 4	Model 5
Age	−0.008(0.0003)***	−0.009(0.0003)***
Gender	−0.060(0.011)***	−0.052(0.011)***
Lead-time	0.029(0.001)***	0.028(0.001)***
Appointment time	0.278(0.011)***	0.284(0.012)***
Appointment weekday		
Monday	0.001(0.021)	−0.008(0.022)
Tuesday	0.012(0.021)	0.031(0.022)
Wednesday	−0.047(0.021)**	−0.053(0.023)**
Thursday	−0.050(0.021)**	−0.050(0.023)**
Friday	0.064(0.022)***	0.065(0.024)***
Doctor rating (DOC RAT)	-	−0.384(0.032)***
NEW DOC RAT	−0.098(0.016)***	-
Doctor's expertise (DOC EXP)	−0.864(0.018)***	−0.873(0.018)***
Specialty	-	Partial significant
Distance	0.099(0.018)***	0.094(0.020)***
EXP	−0.227(0.023)***	−0.204(0.025)***
DOC EXP × EXP	0.512(0.026)***	0.478(0.028)***
Distance × EXP	0.033(0.030)	0.029(0.033)
Observations	382004	328356
Log-likelihood	−130022.7	−111738
Akaike Inf. Crit.	223520	223520

Note: (a) Standardize coefficients are reported; standard errors in parentheses. (b) Significance level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

missed-appointment behavior from online outpatient bookings. Specifically, our findings demonstrated that age had a significant negative impact on patients' missed-appointment behavior. Older patients were less likely to miss appointments than younger individuals, which aligns with previous studies (Lehmann et al., 2007). Moreover, existing studies have indicated that gender plays a significant role in patients' missed-appointment behavior (Kheirkhah et al., 2016; Liu et al., 2017). Consistent with these findings, our study revealed that women are less likely to miss appointments from online outpatient bookings than men.

Several key findings emerged from the main effect analysis conducted in this study. First, appointment lead-time was found to have a positive and significant effect on patients' missed-appointment behavior from online outpatient bookings, with longer lead times being associated with a greater likelihood of missing appointments. This finding is consistent with those of previous research studies (Daggy et al., 2010; Dantas et al., 2019; Liu et al., 2017), and suggests that longer lead times may increase the risk of forgetting, making it more likely for patients to miss their appointments in online settings. Additionally, patients with afternoon appointments were found to have a higher risk of missed-appointments than those with morning appointments (Peng et al., 2016). Furthermore, patients who had appointments on weekends and Thursdays were less likely to miss their appointments than those on weekends, whereas patients with Friday appointments had a higher risk of missed-appointments than those on weekends.

The online doctor rating was found to have a significantly negative effect on missed-appointment behavior. Higher online doctor rating was associated with a lower probability of missing appointments. This can be attributed to the perception of higher quality care associated with doctors who receive higher ratings (Deng et al., 2019; Romano and Baum, 2014), which, in turn, reduces the likelihood of missing appointments. Moreover, the type of appointment doctor had a negative and significant impact on patients' missed-appointment behavior from online outpatient bookings. Patients who made appointments with expert doctors were less likely to miss appointments than those who made appointments with ordinary doctors. This is likely due to the perception that expert appointments offer higher-quality medical care services. Finally, patient distance was found to have a positive and significant effect on missed-appointment behavior from online outpatient bookings. While online appointments overcome geographical limitations, patients who were farther away from the hospital had a higher risk of missing appointments owing to transportation limitations and other challenges associated with distance (Daggy et al., 2010; Dantas et al., 2019).

The results of the empirical analysis indicate that patients with previous outpatient visit experience had a lower risk of missed-appointments from online outpatient bookings than patients who visited the outpatient clinic for the first time. This finding aligns with previous research and emphasizes the importance of previous outpatient visit experiences in reducing the likelihood of missing appointments (DeFife et al., 2010; Fiorillo et al., 2018; Jain and Chou, 2000). Furthermore, our study revealed a significant positive moderating effect of previous outpatient visit experience on the relationship between the appointment doctor's expertise and patients' missed-appointment behavior. This suggests that previous outpatient visit experience can mitigate the occurrence of missed-appointments associated with the expertise of a different appointment doctor. In other words, patients with previous experience are less likely to miss appointment, regardless of whether they have an appointment with an expert or ordinary doctor. However, unlike other studies (Ye and Wu, 2022), the moderating effect of previous outpatient visit experience on the relationship between patient distance and patients' missed-appointment behavior was not found to be significant. This implies that previous outpatient visit experience did not significantly influence the relationship between patient distance and the likelihood of missed-appointment behavior from online outpatient bookings. The underlying reason for this phenomenon could be attributed to the existence of other factors beyond previous outpatient visit experiences, such as

weather conditions and unforeseen events, which also influenced the relationship between patient distance and missed-appointment behavior. In other words, there may be a complex interplay of multiple interaction effects in the association between patient distance and missing appointments, thereby resulting in a non-significant outcome. These findings highlight the role of previous outpatient visit experience as a mitigating factor in the behavior of patients who missed appointments, particularly in relation to the appointment doctor's expertise. Understanding the influence of previous experience can assist healthcare providers in designing targeted interventions to reduce missed-appointment rates and improve the effectiveness of online outpatient appointment systems.

6.2. Contributions

The findings of this study make several valuable contributions to the existing literature. First, it addresses the research gap by focusing on the unique context of online outpatient appointments in China, which has been relatively understudied. Drawing on attribution theory, this study empirically investigates the factors influencing patients' missed-appointment behavior from online outpatient bookings, thereby expanding the application of attribution theory. Second, the study identified multiple factors that significantly impacted patients' missed-appointment behavior from online outpatient bookings, including gender, age, appointment lead-time, appointment time, weekday appointments, appointment doctor's expertise, online doctor rating, patient distance, and previous outpatient visit experience. Moreover, the study recognizes the significance of online doctor rating as a crucial determinant of perceived quality for patients (Lu and Wu, 2016), which further influences patients' missed-appointment behavior from online outpatient bookings. Finally, this study confirms the negative impact of previous outpatient visit experience on patients' missed-appointment behavior and reveals the moderating effect of previous outpatient visit experience on the relationship between the appointment doctor's expertise and patients' missed-appointment behavior. This finding not only contributes to filling the gaps in previous research but also sheds light on the nuanced interplay between appointment-related factors and patients' previous experiences.

This study offers valuable contributions to the practical implementation and policy development of online outpatient appointments, providing a solid theoretical foundation for medical institutions to devise effective strategies to reduce the occurrence and negative impact of patients' missed-appointment behavior. To mitigate patients' missed-appointment behavior, medical institutions can implement proactive measures to address the potential issue of forgetfulness. For instance, hospitals can set reasonable lead times for online appointments and adopt efficient reminder systems, such as SMS and phone notifications, to minimize the likelihood of patients' missed-appointments (Kheirkhah et al., 2016; Rosenbaum et al., 2018). Furthermore, because of the impact of appointment time and weekdays on missed-appointments, hospitals can offer different appointment numbers depending on the time of day (e.g., offering more appointments in the afternoon), and can also implement a flexible booking policy for different dates. At the same time, the utility of patients' prior experiences confirms the need for hospitals to focus on improving patients' experiences and satisfaction with their visits. Hospitals can implement policies, such as time-division appointments, to improve workflow, reduce in-hospital waiting times, and enhance patient experience. Finally, this study confirms the impact of doctors' online reputations on patients' missed-appointments, which reminds doctors to focus on maintaining their online reputations while providing consultation services to improve patient satisfaction across different channels. Hospitals can regularly organize relevant activities to enhance physicians' awareness of maintaining their online reputations. Hospitals can intensify publicity efforts for physicians through various platforms to increase their visibility.

6.3. Limitations

This study has several limitations. First, because the data used in this study were obtained from a specific hospital, the generalizability of our findings may be limited by the unique characteristics of that particular institution. Consequently, caution should be exercised when applying our research results to healthcare settings in other countries. Second, our control variables encompass only age and gender, potentially excluding other relevant patient attributes, such as educational level, marital status, and income level. The absence of these variables might have affected the robustness of the results. Third, weather conditions on the day of patient appointments and other unforeseen events may also influence the likelihood of missing their appointment. Unfortunately, owing to the limitations of the dataset, we were unable to consider the influence of such factors as weather conditions. Future research could employ surveys and interview methods to delve more comprehensively into the authentic reasons for missed appointments.

6.4. Conclusions

To summarize, the findings of this study support the relationship between gender, age, appointment lead-time, appointment time, week-day appointments, online doctor rating, appointment doctor's expertise, patient distance, and previous outpatient visit experience with patients' missed-appointment behavior from online outpatient bookings. These results are consistent with previous studies in this field. Moreover, the moderating effect of previous outpatient visit experience on the relationship between appointment doctor's expertise and patients' missed-appointment behavior from online outpatient bookings was confirmed. Further research is needed to expand our knowledge of patients' missed-appointment behavior in the context of online outpatient bookings.

Declaration of competing interest

The authors declare that there are no competing interests.

Acknowledgments

The authors thank the cooperative medical institutions for providing the anonymized data.

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