How Online Patient–Physician Interaction Influences Patient Satisfaction

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Completed Research Paper

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Abstract

Online health interaction (OHI) is an effective and increasingly popular method for patients to access health information. Extant literature overlooks such service users' satisfaction derived from online interactions and the measurement of OHI processes. Based on the relational communication literature and the features of OHI, the present study proposes three dimensions to conceptualize the success of OHI processes (i.e., interaction depth, information intensity, and time breadth) and explores the association between these interaction processes and service satisfaction. Further, two characteristics of OHI, namely information richness and indirect interaction, are identified as contingent factors on those proposed linkages. The research model was tested on the objective data collected from an online healthcare platform. The study findings showed that (1) interaction depth, information intensity, and time breadth positively impact service satisfaction and (2) both information richness and indirect interaction negatively moderate the effects of interaction depth and information intensity and positively moderate the effect of time breadth. The present study contributes to the existing literature by conceptualizing online interaction process and identifying the role of the specific characteristics of online healthcare and also provides implications to practitioners.

Keywords: Online patient–physician interaction, interaction process, service satisfaction, information richness, indirect interaction

Introduction

In the healthcare industry, online communities and platforms are commonly used by patients who seek as well as share their vital health information (Yan and Tan 2014). Pew Internet & American Life Project reports that 80% of Internet users in the United States (i.e., estimated to be nearly 93 million) have searched for health information on the Internet (Demitz 2018). Various communities and platforms allow patients, physicians, and other stakeholders to exchange health and even medical information. Several earlier studies have confirmed that seeking and sharing online health information can benefit different stakeholders, such as patients (Yan and Tan 2014), physicians (Guo et al. 2017), and society (Cao and Wang 2018; Mein Goh et al. 2016).

Among the various types of online health information seeking and sharing behaviors, the online health interaction (OHI) between patients and physicians is a popular and powerful method for acquiring medical information. OHI replaces traditional face-to-face patient–physician interactions and provides several benefits. For instance, OHI saves patients' time and effort on offline appointments, improves efficiency for providers, allows physicians time for reflection, and increases patient participation in service encounters (Jucks and Bromme 2007). With such benefits, several OHI platforms, such as *practo.com* and *haodf.com*, have been developed by bringing together physicians from various offline hospitals to interact and respond to patients' online queries. However, one substantial drawback of the OHI approach is the difficulty in assessing the quality of text-based health information provided by the platforms (Jucks and Bromme 2007;

Kindig et al. 2004). Thus, best practices for designing and executing a successful OHI are underexplored for both practitioners and scholars. Therefore, this study elucidates the interaction process and its impact on an important indicator of OHI quality from the questioner perspective, that is, service satisfaction. Accordingly, this research investigates the following question: *How does OHI influence service satisfaction?*

Extant literature on online interaction in healthcare has yet to reach a consensus on the best method to assess the interaction process. Based on the earlier literature on communication (Hancock and Dunham 2001) and the unique features of OHI (Yang et al. 2015a; Zhang et al. 2019), the present study proposes three aspects to conceptualize the online patient–physician interaction, namely, interaction depth, information intensity, and time breadth. In particular, interaction depth refers to the number of conversations in one patient–physician interaction (Palmatier et al. 2006); information intensity indicates the strength of the information exchanged in one patient–physician interaction; and time breadth specifies the time interval of one patient–physician interaction. Based these three dimensions, the present study explores how OHI questioners derive service satisfaction from the interactions with online physicians.

In comparison to other online interactions (e.g., buyer–seller interaction), OHIs have a few unique characteristics, such as patients can present their medical records to physicians to better facilitate the online interactions (van der Eijk et al. 2013). Presenting past medical records affects the richness of information that can be exchanged with regard to a particular health issue being discussed on the OHI platform. Enhancing the richness of information can directly enhance the outcomes of the interaction process (Ramirez and Burgoon 2004).

In addition, the OHI platform also supports indirect interaction, which occurs when an advocate companion engages in the online interaction with a physician on behalf of a patient. A national survey in the United States indicates that about one-third of the online interactions are not with the patients themselves but with their relatives or friends (Bass et al. 2006). This is understandable in the context of healthcare because many patients are inhibited by low IT self-efficacy (i.e., too young or old) or constrained by poor health, rendering them unable to use the OHI platform. Such patients depend on their advocate companions (e.g., family members and friends) when consulting a physician on the online platforms (Ishikawa et al. 2005). Earlier studies have suggested that patient's interaction patterns can significantly shape the efficiency and quality of healthcare services (Kane and Alavi 2008). However, the existing literature has limited understanding of the influences of information richness and interaction patterns on service satisfaction. Therefore, the present study highlights the role played by information richness and indirect interaction in the linkage between interaction process and service satisfaction. Accordingly, the next research question arises: *How is satisfaction with the OHI affected by information richness and indirect interaction?*

To narrow the gaps in our understanding and address the research questions, a theoretical model based on the literature of OHI, relational communication, information richness, and indirect interaction is built. This model and the associated hypotheses are then tested using objective interaction data from a leading online healthcare platform in China. This study contributes substantially to the extant literature. First, in earlier studies on online interaction, relatively narrow and selective factors were chosen to conceptualize the interaction process. The present study adopts a significantly broader conceptual approach to measure the OHI process using interaction depth, information intensity, and time breadth. Second, while OHI has been a popular and important topic in the healthcare, there is lack of research on the specific characteristics of online interactions between patients and physicians and how such characteristics shape satisfaction development. By identifying the specific characteristics in OHI and testing their contingent roles, the present study explains the underlying mechanisms of OHI from a combined perspective of information richness and use pattern. Third, by an in-depth study of the interplays between interaction process factors and OHI characteristics, the study findings provide an improved understanding of the relative importance of the interaction factors in OHI. Finally, this study also reveals the indirect OHI and its contingency role. These contributions have implications for both future research and online health practitioners.

Literature Review

Related Work on Online Health Interaction (OHI)

OHI includes any online communication between or among patients and physicians to reveal or exchange health and medical information (Moore 1989). This study focuses on the online interactions between

patients and physicians, providing online health services. In the past few years, as the use of Information and Communication Technologies in healthcare has become ubiquitous, several online healthcare platforms and communities have emerged to facilitate the interactions among patients and between patients and physicians (Zhang et al. 2019). In addition to such communication, these online platforms also let patients to input and manage their own health information, gain access to remote monitoring services, obtain general information about diseases and wellness, and engage in communities with similar health interests or issues (Kamis et al. 2014). Among these online health activities, the OHI was found to be similar to face-to-face hospital visits in terms of time spent for health issues, ease of interaction, and other aspects of the interaction (Dixon and Stahl 2009). Therefore, OHI denotes an efficient approach for patients to easily access health information and consult online physicians.

Although OHIs are widely available, there is limited literature on this emerging and significant healthcare platform; of these, Lu et al. (2011) established that the use of an interactive communication tool improved the relationship between a physician and cancer patients. Similarly, based on online health communities, Nambisan (2011) found that effectiveness of information seeking, rather than social support, affects patients' level of perceived empathy. In addition, social support (including informational support, emotional support, and companionship) was identified as an important outcome of online patient–patient interaction, resulting in positive influences on the health conditions of patients with mental health issues (Yan and Tan 2014). In addition, Yang et al. (2015a) used response speed and interaction frequency to measure the interaction process and found that they significantly affected patient satisfaction. Based on physicians' online information on the website, Yang et al. (2015b) confirmed that online information on physicians can directly affect patients' choice of physicians on OHI platforms. As a model for OHI, online health communities were shown to overcome the weaknesses found in offline healthcare and provide informational and emotional support to patients (Atanasova et al. 2018). Zhang et al. (2019) used informational and interpersonal unfairness to conceptualize how online interaction processes impact patient–physician relationship development. Finally, several prior studies showed that OHI use can reduce urban–rural health inequality or disparities (Cao and Wang 2018; Mein Goh et al. 2016). From the above review, we can conclude that there is not a consensus about how to theoretically conceptualize and empirically measure the online health interaction.

Online Health Interaction: A Relational Communication Perspective

Although OHI has been studied and measured in several prior studies, there is no consensus on how to best measure the online interaction process. Hence, the present study draws on the literature on relational communication to conceptualize the OHI process. The key strength of leveraging relational communication theory lies is its recognition of both the informational and the relational benefits from the interaction, which is particularly relevant in a healthcare context. In addition, people communicate to obtain and deliver information as well as to modify a social relationship (Watzlawick et al. 2011). Similarly, seeking information through interactions is a means of achieving instrumental and social goals, or a combination thereof (Ramirez Jr et al. 2002). Therefore, based on the perspective of relational communication, patient–physician interaction serves two goals for patients, that is, to obtain health-related information and to develop the patient–physician relationship.

From the perspective of health-related information seeking (instrumental benefits), interaction depth and information intensity are the two key aspects of the online patient–physician interaction process. In particular, interaction depth is defined as the number of conversations in a patient–physician interaction. The main difference between online interactions and face-to-face interactions is the convenience of retrieving prior interaction records (Zhang et al. 2019). In face-to-face communication, for instance, it is difficult to accurately and completely recall previous interactions (Kaiya et al. 1995). Yet, in the context of an online interaction, OHI allows patients to freely check and review earlier text-based interactions (Zhang et al. 2019). As such, after a few rounds of online patient–physician interaction in an OHI, a deeper and more focused discussion on a particular topic can emerge. Because the information exchanged between the patient and physician is focused on the patient's particular medical issue or condition, rather than open to the issues and conditions of multiple patients in a general online community, the amount of information exchanged can be relatively high (Ren and Kraut 2014). Thus, depending on how an OHI is designed and utilized, the focus and depth of interaction can vary for different OHI processes, making it an important dimension to measure the interaction process.

Information intensity refers to the strength of the interaction process and is a key aspect when measuring both offline and online interaction processes (e.g., interpersonal knowledge exchange and interpersonal activity) (Hancock and Dunham 2001; Iorio et al. 2017). As the OHI is used to exchange information between physicians and patients, with additional information in the interaction process, the intensity of information exchanged in one OHI can be high. To better measure the service-based interaction process and following the past literature on communication (Setia et al. 2013), information intensity, which measures the amount of information exchanged during the interaction, is identified as a second dimension to conceptualize the interaction process.

Moreover, from the perspective of patient–physician relationship development (social benefit), time breadth, which is defined as the time interval in a patient–physician interaction, is a critical factor. Past literature shows that interaction breadth is an important aspect of the interaction process (Hancock and Dunham 2001). As OHI is an anon-synchronous interaction process, with time lags between patient's questions and physician's responses, this makes OHI interaction different from face-to-face or synchronous computer-mediated interaction (Jones et al. 2004). Earlier research on online healthcare has used the duration of patient–physician interaction as a proxy for relationship continuity that influences patients' evaluation of the interaction (Yang et al. 2015a; Zhang et al. 2019). Therefore, time breadth is used to measure the third dimension of the interaction process.

Therefore, based on the relational communication theory, interaction depth and information intensity indicate the health-related information seeking and time interval suggests the patient–physician relationship development. To further elucidate the underlying mechanism of how these three dimensions determine service satisfaction with OHI, the present study explores whether the linkages depend on information content (i.e., information richness) and interaction patterns (i.e., direct or indirect interaction).

Information Perspective: Information Richness

The theory of information richness was developed to show how individuals choose a medium for communication based on the information requirements (Daft and Lengel 1984; Daft and Lengel 1986). Other media research indicates that interaction performance, in addition to media choice, can be affected by the capabilities of an interaction medium (Wang et al. 2016). As online communities and platforms extend more broadly into society, their capabilities evolve to support different forms of interaction; accordingly, information richness has been used to explore digital or online interaction channels, including e-mail (Gattiker et al. 2007), electronic word of mouth (Gattiker et al. 2007), and online communities (Goh et al. 2013). In the online contexts, the studies extended the information richness by including an additional attribute: the richness of information exchanged through the online channels (Goh et al. 2013). Such information exchange allows individuals to reduce uncertainty and make more informed decisions (Schubert and Ginsburg 2000). Hence, the richness of information that can be exchanged in an online interaction plays a role in interaction performance and satisfaction.

When patients interact with a physician in an OHI, information containing multiple cues, for example, text reports, numeric test results, charts, and pictures, can be provided (Gattiker et al. 2007). Among these, the medical records, including patients' diagnoses and investigation results data from hospitals (Wang et al. 2012), help physicians to understand the patients' health condition quantitatively and can be well informed about a patient's health. With providing medical records as a part of the OHI process or not, this difference in information richness will likely have a meaningful impact on the subsequent interaction process. However, even though exchanging personal health information from hospitals is common in online platforms (Frost et al. 2014), the extent to which such information is provided or not and how these differences influenced communication outcomes and satisfaction is underexplored in the current literature. To better understand the linkages between the interaction process and satisfaction, this study further explores whether the relationships are contingent on information richness of the interaction.

Interaction Patterns: Indirect versus Direct

The use of systems or services can be both direct and indirect (Tong et al. 2017). Direct use refers to the extent to which a user personally operates a system or engages with a service; indirect use is the extent to which the user interacts with a system or service through one or more intermediary users (Kane and Alavi 2008; Tong et al. 2017). Empirical works on direct and indirect use in healthcare contexts have primarily

focused on exploring physicians' system use behavior, such as the antecedents (Tong et al. 2017; Xu et al. 2018) and consequences (Kane and Alavi 2008) of indirect use. Even though indirect use has attracted researchers from the information systems (IS) field in recent years, the majority studies on system or service use still focused on direct use and disregarded the indirect use (Delone and McLean 2003).

Indirect interaction is common among patients when accessing Internet-based health services (Bass et al. 2006). Yet, the current literature is scant. Owing to the limited capability in using emerging technologies, disability due to diseases, or limited confidence in online health services, a few patients access OHI through indirect interaction, such as being helped by advocate companions (e.g., their friends or relatives). In the indirect OHI, the person (i.e., questioner) interacting with the physician is an advocate companion for the patient, and the advocate companion serves as a patient promoter who supports the patient's agenda, a patient extender who acts as the voice of the patient, and a mediator who bridges the gap between the patient and the physician (Ishikawa et al. 2005). Unlike direct interactions between patients and physicians, the indirect OHI incurs high interaction costs for the companion. In particular, the indirect interaction requires the advocate companions to enter, retrieve, and receive information from the OHI as well as deliver all diagnosing information to the patient (Bisaso et al. 2008). Thus, the indirect OHI can be more cumbersome and complicated than the direct interaction with the OHI (Xu et al. 2018). Moreover, Ishikawa et al. (2005) found that advocate companions spend relatively greater behavioral resources in conducting the patient–physician interactions owing to stress and discomfort when highly personal information about the patient is exchanged (Greenfield et al. 1985). Therefore, there is a significant interaction cost difference between direct and indirect interaction, and the interaction patterns of OHI may play an important role in determining the service satisfaction with the OHI.

While, in healthcare, the role of indirect interaction can be more significant. Advocate companions not only care about patients' health, they also pay more attention to developing long-term relationship with physicians for long-run health guidance for the patients (Ford et al. 2011). This may be due to that advocate companions care about patients' health but as they do not have a clear evaluation of patients' health issues, they concern more about the patients' health condition than patient themselves (Harrison et al. 1995). Then, they will pay more attention to developing long-term relationship with physicians for the patients. Thus, even though it costs more for advocate companions to exchange information in indirect interactions, they value the relationship with physicians more. Therefore, this study includes indirect interaction as a contingent factor when exploring OHI satisfaction.

Research Model

The theoretical research model is presented in Figure 1. In particular, the model illustrates the relationships between interaction process, that is, interaction depth, information intensity, and time breadth, and service satisfaction. The model also illustrates the moderating role of information richness and indirect interaction. The hypotheses are proposed subsequently.

Figure 1. Modified Research Model
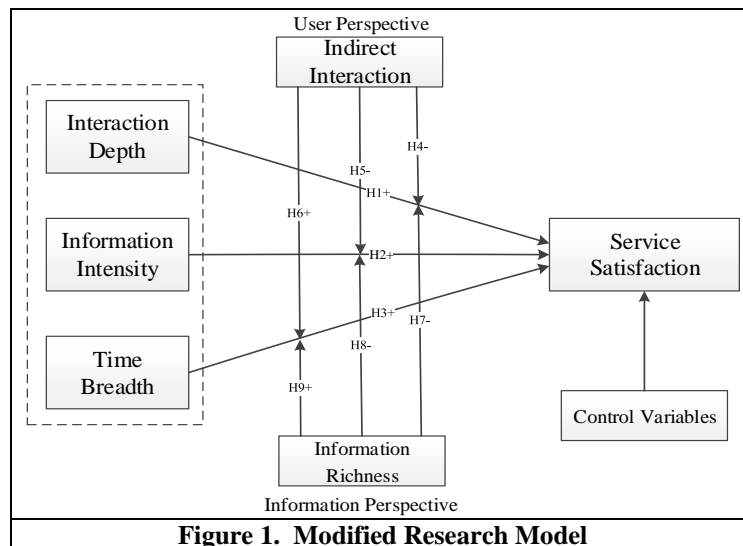
The Impact of Interaction Process on Service Satisfaction

Informational value is salient for patients to evaluate physicians and establish an approach toward the OHIs. The concepts of *interaction depth* and *information intensity* are proposed to explain the information value of a patient–physician interaction from the patients' perspective (Kim et al. 2010). On the one hand, interaction depth reveals the number of conversations between patient and physician in an interaction and involves information delivery that could assist patients in understanding their health conditions and treatment (Mauksch et al. 2008). Greater interaction depth (i.e., the more question–answer conversations) is more likely to result in the patient–physician interaction to be viewed as more helpful and effective.

On the other hand, information intensity represents the amount of information exchanged in OHIs and can indicate the physician's effort in treating the patient. Information intensity also helps in enriching a patient's understanding of his/her health condition. Overall, interaction depth and information intensity capture the value of the information a patient gains from the patient–physician interaction. Enabling patients to obtain an increasing amount of knowledge and information from physicians will result in positive perceptions about the interaction (Xiao et al. 2014). Earlier studies have shown that positive patient–physician communication increases service satisfaction with the physicians and their interaction (Stewart et al. 2000). Therefore, this research proposes that:

> H1: *Interaction depth of the patient–physician interaction has a positive influence on service satisfaction.*
> H2: *Information intensity of the patient–physician interaction has a positive influence on service satisfaction.*

Patient–physician interaction as a type of communication not only serves to satisfy a patient's informational needs in diagnosing diseases, but also simultaneously modifies the relationship between the patient and the physician (Zhang et al. 2019). Seeking disease-related information from a physician indicates a submissive relationship, patient's affection for the physician, as well as the intention to be affiliated with the physician in the future (Burgoon and Hale 1987). Time breadth reflects the time interval of a patient–physician interaction, indicating the physician's patience and concern for the patient. In the online patient–physician interaction, two-way dialogic interaction has mutual advantages between patient and physician (Burgoon et al. 2001). Hence, time breadth reveals the relational value of patient–physician interaction. Relational value is a key driver for an information seeker's preference for information content and source during seeker–provider interaction (Xu et al. 2010). Furthermore, earlier literature showed that interaction duration, as a proxy for continuity of relationship, is important in reducing hospitalization of older patients, thus increasing satisfaction with the physician's service (Stewart et al. 2000). Therefore, the following assumption:

> H3: *Time breadth of the patient–physician interaction has a positive influence on service satisfaction.*

The Moderating Effects of Indirect Interaction

In the indirect OHI, Ishikawa et al. (2005) showed that questioners notably spend more behavioral resources in conducting patient–physician interaction because they might find it uncomfortable in seeking highly personal health-related advise (Greenfield et al. 1985). Further, the advocate companions also need to deliver all diagnosing information advised by the physician to the patient. The indirect interaction requires the advocate companions (i.e., the friends or family of patients) to enter, retrieve, and receive information on behalf of the patients (Bisaso et al. 2008). Hence, the behavioral resources (i.e., efforts and time spent) in indirect interaction are much higher than that in direct OHI.

Consumer research showed that consumers place a higher value on the behavioral resources (e.g., amount of the time and effort) expended in the creation of a service when it is intended for another as opposed to oneself (Moreau et al. 2011). Thus, an advocate companion would have a higher costs/benefit ratio than a patient him/herself from a similar interaction process with physicians. In particular, with the advocate companion's behavioral efforts (i.e., providing more biomedical), he/she would expect a more effective interaction to satisfy his/her needs in disease diagnoses. Hence, given the same information value of the interaction for a disease, the advocate companions' higher level of efforts will lower the contingency of their efforts, leading them less satisfied with the interaction outcomes. Therefore, the following is proposed:

H4: *Compared with a direct patient–physician interaction, the positive influence of interaction depth on service satisfaction is much weaker in an indirect interaction.*

H5: *Comparing with a direct patient–physician interaction, the positive influence of information intensity on service satisfaction is much weaker in an indirect interaction.*

As mentioned earlier, behavioral resources (i.e., efforts and time spent) in indirect OHI are much higher than that in direct OHI, and an advocate companion places a higher value on the behavioral resources he/she spends with the physician (Moreau et al. 2011). Hence, he/she will appreciate the opportunity to interact with the physician on behalf of the patient to develop a quality relationship with the physician. In particular, an advocate companion's intention to communicate with the physician was higher, including follow-up interaction after the present visit, to obtain more information for the patients (Ishikawa et al. 2005). However, in a direct OHI, patients usually intend to psychologically resist "bad news" (i.e., diagnosing results) that is conveyed by a physician, and hence they intend to end any further interaction with a physician after this visit (Eggly et al. 2006). Time breadth indicates the relationship continuity between the questioner (patient or advocate companion) and the physician (Stewart et al. 2000), and this signal will be valued more by advocate companion in an indirect interaction than a patient in a direct interaction. Hence, given the same time interval of a patient–physician interaction, an advocate companion would experience a higher level of service satisfaction. Therefore, the following is assumed:

H6: Comparing with an indirect patient–physician interaction, the positive influence of time breadth on service satisfaction is much stronger in a direct interaction.

The Moderating Effects of Information Richness

In OHI, physicians need patient information to arrive at medical decisions (Zhang et al. 2019); hence, patients would help in physicians' diagnosing process by providing information through appropriate methods. It is commonly observed that patients not only deliver disease information to physicians via texting, but also provide pictorial healthcare data obtained from offline medical tests. The medical records, including patients' diagnoses and investigation results data from the hospital (Wang et al. 2012), help physicians to understand patients' health condition quantitatively, based on which they offer informed suggestions to the patients. Thus, information richness of the patient–physician interaction plays an important role in shaping the interaction outcomes.

The questioners' expectations on informational value (e.g., diagnosing information) would rise once textual and pictorial information on the diseases provided to the physician during the interaction. In particular, comparing with textual input only, the questioners' would expect more effective communication with the physicians, for example, few conversations and short question-and-answer, in the combined input of textual and pictorial information. Hence, given the same level of information value (i.e., interaction depth and interaction intensity) received, the questioners would perceive that they received unfair information if they provide both textual and pictorial information to assist physicians' diagnosing, compared with the situation when then provide only textual information (Zhang et al. 2019). They question the physician's ability in accurately diagnosing their diseases, even with their best information support, inducing them become less satisfied with the interaction with the physician. Therefore, the following is proposed:

H7: *The positive influence of interaction depth on service satisfaction will be weakened by information richness.*

H8: *The positive influence of information intensity on service satisfaction will be weakened by information richness.*

Patients' input of disease information in healthcare leads to the building of a relationship of trust and confidence with the physician (Arrow 1963). Hence, the methods of questioners' input would influence the role of relational value of service satisfaction. In particular, information richness is believed to assist physicians in making the final diagnosis decision and shortening the interaction breadth. However, comparing with textual input alone, the same degree of time breadth would empower the questioners' perception of being treated importantly and patiently by the physician in the condition of textual and pictorial information. Thus, the questioners' relational value from the interaction and the relationship with physician would be highly valued. Therefore, with providing textual and pictorial information, the effect of time breadth will be strengthened and they will be more satisfied with the interaction with the physician, leading to the following is proposed:

H9: *The positive influence of time breadth on service satisfaction will be strengthened by information richness.*

Research Methodology

Data collection and measurements

To test the research model and hypotheses, a leading online healthcare platform in China, namely, *Haodaifu Zaixian* (*www.haodf.com*, good physician online in English), was chosen as the research context. This platform gathers physicians from various hospitals in China to provide online health services to patients remotely. Since its development in 2006, it now has about 200,000 physicians and is serving about 300,000 patients daily.[1] This platform encourages each physician to have a homepage and a community section. The homepage presents the physician's basic information, such as professional title, area of expertise, and offline hospital affiliation as well as online information including the number of online patients, contribution experience, and platform tenure. On the basis of this information, patients can choose which physician to consult. The community section is the place where the online interactions occur between patients and physicians.

In the community section, the patients can interact with physicians to obtain health information. After the patients chose a physician, they can post enquires at his/her community. The community section is like a Q&A section that enabling non-instant health interactions. Figure 2 shows an example of the interaction.

Figure 2. An Example of Online Health Interaction

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[1] https://www.haodf.com/info/aboutus.php

The online interaction data and homepages of 620 physicians from two areas of expertise, namely, diabetes and lung cancer, to control the medical contexts was collected. In addition, these two diseases are chronic and may require multiple rounds of interactions between patients and physicians (Yang et al. 2019). Furthermore, diabetes and lung cancer are common diseases and have a large patient base. Thus, both medical contexts have conceptual and practical significance. With regard to these physicians, they interacted with 79,591 patients between 2014 and 2015.[2] Detailed information of these 79,591 interactions and the physicians' basic information were incorporated in the dataset for testing the hypotheses.

As it is impossible to directly measure *service satisfaction* from the objective interaction data, conclusions were drawn on the questioner's last post in a given interaction to indicate whether he/she was satisfied. As the service satisfaction we study is derived from the interaction process, we measure the satisfaction from real questioners, i.e., patients or their relatives. It is intuitive that if the questioner is satisfied with the physician's interaction, it is more likely for him/her to post a "thank you" note to end the interaction. Further, the "thank you" note also costs a question quota and needs payment, and sending such a note means the questioner would like to pay more for the interaction. As only the satisfied customers have a higher price tolerance, sending a "thank you" note after the service can indicates they are more satisfied. Thus, a "thank you" conclusion is used to imply that the questioner has recognized the quality of the physician's replies and expressed appreciation (Yang et al. 2015a) and, thus it was used as a proxy of service satisfaction.

Interaction depth was measured by a series of question and answers sessions, in which one round includes one inquiry of the patient and a corresponding response from the physician (a patient posting two inquiries sequentially or the physician replying to one inquiry several times were treated as one round). *Information intensity* was measured by the average number of words across all conversations in one OHI because it is logical that more words in a conversation would correlate with more information exchanged between patient and physician (Baek et al. 2012). *Time breadth* was measured by the time interval between the first and last posts in one interaction. This time interval can infer how long the interaction sustains. *Information richness* was measured by whether the questioners provides medical records from hospitals to the physician during the interaction. We further completed a text analysis of questioners' inquiries to identify those patients directly using the platform. In particular, keywords such as "my father," "my mother," "my wife," "my husband," "my child," and "my friend" were detected to identify those with direct versus *indirect interaction*. As interacting with physicians require the questioners to login their own accounts, it is inconvenient to change the questioner role between the patients and their relatives. Thus, we argue that one interaction is conducted solely by either the patients or their relatives.

Table 1. Variables and Measures

Variable	Measure	Mean	S.D.	Min	Max
Service Satisfaction	Whether the interaction is ended by a patient's "thank-you" note	.216	.412	0	1
Interaction Depth	The round of Q&A in the interaction	1.62	1.10	1	36
Information Intensity	The average number of words in all rounds of the interaction	318	242	0	6528
Time Breadth	The time interval of the interaction (day)	7.45	30.1	3.70e-4	492
Indirect interaction	Whether the interaction is conducted by the patients' relatives or friends	.240	.427	0	1
Information Richness	Whether the patient uploaded medical records in the interaction.	.444	.497	0	1
Title[3]	The professional title of the physician in hospital (ranked from 1 to 4).	3.47	.674	1	4
Hospital Ranking	Whether the hospital of the physician is 3A (the highest rank) hospital.	.932	.252	0	1
Disease Severity	The severity level of the patient's disease (1 for lung cancer and 0 for diabetes)	.618	.486	0	1
Num_Paper	The number of papers published by the physician on the platform.	66.4	141	0	936
Num_Gift	The number of virtual gifts received by the physician on the platform.	124	179	0	960
Note: There are 620 physicians with 79,591 interactions.					

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[2] The platform enforced a new interaction mechanism in early 2016, which can be a confounding effect that shapes the interaction between patients and physicians.

[3] Coding schema for Title: 1: resident physician, 2: attending physician, 3: associate chief physician, and 4: chief physician.

Physicians' basic information from their homepages, including their offline attributes (hospital level, professional title, and disease severity of their patients) and online information (the number of papers published and the number of virtual gifts received), were used as control variables. Table 1 presents a summary of all the variables and measures.

Model Estimation

The research model was analyzed using hierarchical regressions. For the first step, only the independent and control variables were included into the model estimation to test the direct effects of the interaction process variables. Next, the interaction terms were added to test the moderating effects. The regression models were tested using ordinary least squares (OLS) models. Table 2 reports the findings of the main result with models (1)–(3) indicating the OLS model results.

Table 2. Model Estimation Results[4]

DV: Service Satisfaction	Model (1)	Model (2)	Model (3)	Model (4)
Interaction Depth	.118**	.130**	.140**	.142**
Information Intensity	2.1e-04**	2.5e-04**	2.4e-04**	2.7e-04**
Time Breadth	3.6e-04**	2.1e-04**	1.7e-04**	6.6e-05
Indirect interaction Interaction Depth*		-.058**		-.057**
Indirect interaction Information Intensity*		-7.6e-05**		7.3e-05**
Indirect interaction Time Breadth*		5.5e-04**		5.3e-4**
*Information Richness*Interaction Depth*			-.006*	-.005†
*Information Richness*Information Intensity*			-7.4e-05**	-7.0e-05**
*Information Richness*Time Breadth*			2.9e-04**	2.7e-04**
Indirect interaction	.071**	.071**	.185**	.183**
Information Richness	.054**	.077**	.053**	.074**
Title	-.004*	-.045*	-.043*	-.004*
Hospital Ranking	.020**	.020**	.021**	.021**
Disease Severity	-.028**	-.028**	-.027**	-.026**
Num_Paper	-4.4e-05**	-4.4e-05**	-4.4e-05**	.000**
Num_Gift	-3.5e-05**	-3.5e-05**	-3.5e-05**	-.000**
Constant	-.051**	-.062**	-.095**	-.102**
R-Squared	12.2%	12.2%	12.7%	12.7%

Note: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.
There are 79,591 observations among 620 physicians.

Model (1) observes that there is a significant impact on service satisfaction by interaction depth (β = 0.118, t = 86.4, $p < 0.01$), information intensity (β = 2.1e-04, t = 21.2, $p < 0.01$), and time breadth (β = 3.6e-04, t = 7.54, $p < 0.01$). Thus, the three aspects of the interaction process all positively induce service satisfaction, supporting H1, H2, and H3.

Model (2) tests the moderating role of indirect interaction. The results show that indirect interaction negatively moderates the relationship between interaction depth and service satisfaction (β = −0.006, t = −2.15, $p < 0.05$) and the relationship between information intensity and service satisfaction (β = −7.4e-05, t = −3.75, $p < 0.01$), supporting H4 and H5. In addition, indirect interaction negatively moderates the relationship between time depth and service satisfaction (β = 2.9e−04, t = 3.02, $p < 0.01$), indicating H6 was also supported.

The moderating role of information richness was tested in model (3). The results show that information richness weakens the positive effects of interaction depth (β = −0.006, t = −2.15, $p < 0.05$) and information intensity (β = −7.4e-05, t = −3.75, $p < 0.01$) on service satisfaction, supporting H7 and H8. Alternatively, information richness strengthens the positive effect of time breadth on service satisfaction (β = 2.9e-04, t = 3.02, $p < 0.01$), indicating that H9 was supported. Model (4) shows consistent results.

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4 We also tested a model (4) with all the interaction terms and the results were consistent.

Robustness Checks

To test the robustness of the research findings, fixed effects (FE) models were used to eliminate the influences of the physician-level factors. The FE estimations assume the differences across analysis units can be captured using an intercept term of each unit (Littel et al. 1996). Organized dataset at the interaction level allows the physicians to differ in their general interactions with the patients. Thus, the unobserved physician-specific heterogeneities were controlled at the interaction level; models (1)–(3) in Table 3 present the FE model results. The results indicate that, with the exception of the effect of *Information Richness*Interaction Depth* on service satisfaction being negative but not significant, all other effects are significant and quantitatively consistent with the findings reported in Table 2. Thus, most of the results are robust when the physician-specific heterogeneities are controlled.

As service satisfaction was measured as a binary variable, logistic regressions were further used to test the models as a second robustness check and report these results in Table 4. Here, it can be concluded that all the effects found are consistent with the main findings in Table 2. Thus, the results are robust when different regression methods are applied.

Table 3. Robustness Check I Using FE Models			
DV: Service satisfaction	Model (1)	Model (2)	Model (3)
Interaction Depth	.120**	.142**	.121**
Information Intensity	1.7e-04**	1.9e-04**	2.0e-04**
Time Breadth	4.2e-04**	3.6e-04**	4.0e-04**
Indirect interaction* Interaction Depth		-.057**	
Indirect interaction* Information Intensity		-7.6e-05**	
Indirect interaction* Time Breadth		3.6e-04**	
Information Richness*Interaction Depth			-.003
Information Richness*Information Intensity			-5.6e-05**
Information Richness*Time Breadth			1.8e-04†
Indirect interaction	.065**	.179*	.065**
Information Richness	.047**	.056**	.063**
Title	YES	YES	YES
Hospital Ranking	YES	YES	YES
Disease Severity	YES	YES	YES
Num_Paper	YES	YES	YES
Num_Gift	YES	YES	YES
Constant	-.054***	-.093***	-.062***
R-Squared	11.9%	12.4%	11.9%
Note: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$. There are 79,591 observations among 620 physicians.			

Table 4. Robustness Check II Using Logistic Regressions			
DV: Service satisfaction	Model (1)	Model (2)	Model (3)
Interaction Depth	.829*	.962**	.921**
Information Intensity	.001*	.002**	.002**
Time Breadth	.003*	.002**	.002**
Indirect interaction* Interaction Depth		-.399**	
Indirect interaction* Information Intensity		-8.0e-04***	
Indirect interaction* Time Breadth		8.7e-04*	
Information Richness*Interaction Depth			-.182**
Information Richness*Information Intensity			-7.8e-04**
Information Richness*Time Breadth			9.8e-04†
Indirect interaction	.365**	1.30**	.366**
Information Richness	.310**	.309**	.807**
Title	-.020	-.021	-.019
Hospital Ranking	.195*	.197*	.194*
Disease Severity	-.2006**	-.190**	-.199**
Num_Paper	-5.0e-04†	-4.9e-04*	-4.9e-04
Num_Gift	-5.3e-05	-5.5e-05	-6.0e-05
Constant	-3.27**	-3.56**	-3.52**
Note: † p < 0.10, * p < 0.05, ** p < 0.01. There are 79,591 interactions among 620 physicians.			

In the main analyses, the service satisfaction measure was recorded by determining whether the OHI interaction was concluded by a patient's ending thank-you note. To further examine the robustness of the results, the study identified whether the patient sent virtual gifts to the physician (patients need to pay for the virtual gifts) or purchased for paid interaction quotas as an alternative service satisfaction measure. This is because the decision to pay for the OHI indicates the patient was satisfied with the previous interactions with the physician and would maintain an enduring relationship with the physician (Zhang et al. 2019). The third robustness check was whether the patient made payment in an OHI (for gifts or quotas) as another proxy of service satisfaction with logistic regression models. Table 5 presents the results. These results conclude that all the effects found are consistent with the main results reported in Table 2. Thus, a new measure of the dependent variable is adopted for robust results.

Table 5. Robustness Check III with a New Measure			
DV: Patient Payment	Model (1)	Model (2)	Model (3)
Interaction Depth	.719*	.825**	.681**
Information Intensity	.001*	.002**	.001**
Time Breadth	.007*	.006**	.007**
Indirect interaction Interaction Depth*		-.231**	
Indirect interaction Information Intensity*		-.001*	
Indirect interaction Time Breadth*		.002*	
*Information Richness*Interaction Depth*			-1.6e-04*
*Information Richness*Information Intensity*			-6.0e-04*
*Information Richness*Time Breadth*			.069†
Indirect interaction	.284**	1.19**	.286*
Information Richness	.456**	.446**	.306
Title	.128	.122	.124
Hospital Ranking	.432	.465	.423
Disease Severity	.224	.243	.221
Num_Paper	-2.0e-04†	-1.8e-04	-2.0e-04
Num_Gift	4.2e-05	-6.0e-05	3.9e-05
Constant	-8.38**	-8.78**	-8.38**
Note: † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$. There are 79,591 observations among 620 physicians.			

The above-mentioned analyses conclude that the main findings of this study are consistent irrespective of whether physician-specific heterogeneities were controlled, different regression methods were adopted, and how the dependent variable was measured. Therefore, the research assures valid and reliable results.

Discussion

Key Findings

This study presents four significant findings. First, the three dimensions used to conceptualize the patient–physician interaction process—interaction depth, information intensity, and time breadth—all positively contribute to service satisfaction. These relationships show that a large number of conversations, a high intensity of information exchanging process, and long interaction duration contribute to patients' satisfaction with the online interactions with physicians. The positive effects of the intensity and breadth dimensions are consistent with the previous communication research that such factors can benefit interaction outcomes (Hancock and Dunham 2001) and knowledge transfer (Iorio et al. 2017). It was verified that these effects remain vital determinants of service satisfaction with an OHI. Further, interaction depth was considered as an important feature of the one-to-one patient and physician interaction, arguing that when a high depth of information (manifested as more rounds of conversations on the same topic) is exchanged, patients will be more satisfied with the interaction.

Second, indirect interaction weakens the positive effects of interaction depth and information intensity on service satisfaction. The results show that when advocate companions conducted the OHIs for other patients, their depth and intensity of interaction with the physician contribute less to their satisfaction. These effects stem from the different information exchange processes. As the intermediary information processing in indirect OHI, it takes extra time and efforts for the advocate companions to exchange the health information between patients and physicians. As the depth and intensity of interaction increases, the extra time and efforts will become greater, and this, in turn, weakens the development of service

satisfaction. Thus, the positive effects of interaction depth and information intensity on service satisfaction are weaker when the OHI is conducted by the advocate companions of the patients.

Third, information richness also weakens the effects of interaction depth and information intensity on service satisfaction. Research finding suggests that when patients provide medical records to the OHI physicians, their depth and intensity of interaction with the physician gain less for their satisfaction as compared with those patients who do not provide medical records. These findings are understandable because patients who provided medical records have different expectations of the OHI when compared with those who did not. Providing medical records suggests that the patients have higher expectations about the interactions to meet their informational needs. Thus, the positive effects of interaction depth and information intensity are weaker among such OHIs.

Finally, both indirect interaction and information richness positively moderate the effect of time breadth on service satisfaction. As time breadth indicates the relationship continuity between the patient and physician in OHI, the larger time breadth is highly appreciated by advocate companions in an indirect interaction than by patients themselves. The larger time breadth can also lead patients to perceive being treated as being more important and with more patience by the physician when the medical records were provided than for those who did not. Therefore, the effect of time breadth on service satisfaction is stronger among indirect interaction and OHIs with medical records.

Theoretical Implications

This study investigates the effects of the interaction process, information richness, and use pattern on service satisfaction in OHI. Building on the previous literature that had no consensus on how to conceptualize the online interaction process (Yang et al. 2015a; Zhang et al. 2019), this work contributes to the body of literature on online interaction and health communication in several aspects.

First, the research findings provide insight to the extant literature on how to measure the online interaction process in healthcare. Although the online interaction has been extensively explored in the communication and IS fields (Demitz 2018; Hancock and Dunham 2001; Moore 1989; Zhang et al. 2019), many previous studies conveniently drew on sometimes ill-fitting factors when conceptualizing the interaction processes. Hence, a comprehensive approach to conceptualize the online interaction process is absent. Based on the relational communication theory and the characteristics of online health interactions between patients and physicians, this study proposes that in OHI, patients are supposed to obtain health-related information and to develop the patient–physician relationship, and therefore utilize three distinct dimensions to measure aspects of the OHI process, that is, interaction depth, information intensity, and time breadth. The model estimation further verifies that these factors can significantly impact service satisfaction with the OHI. Thus, this study provides a novel and comprehensive approach for conceptualizing the OHI process.

Second, the findings also contribute to the health interaction literature. In recent years, online health information seeking is becoming an effective and useful approach for patients to access health information, making OHI a popular topic in health research and practice. While several prior studies have investigated how OHI operates or provides benefits for different stakeholders (Guo et al. 2017; Lu et al. 2011; Yan and Tan 2014), few have investigated the specific characteristics of online interactions between patients and physicians and how such characteristics shape the outcome development process. Drawing on the specific characteristics in OHIs to identify indirect interaction and information richness and further exploring their contingent roles on the links between interaction process and satisfaction, this research examines the underlying mechanisms of OHI from a combined perspective of information richness and usage patterns. Therefore, this study verifies that satisfaction development in OHI is a complicated process due to the healthcare context and needs further investigation.

Third, this study also provides insight regarding the linkage between interaction processes and satisfaction. By explicitly exploring the interplays between interaction process factors and OHI characteristics on service satisfaction, we found that three separate factors have different effects when patients provide medical records (i.e., information richness) or when directly or indirectly access the OHI. This study confirms that the linkage between the interaction process and satisfaction is contingent on factors related to the interaction context. Future research should consider these and also other contextual factors.

Finally, this study uncovers the indirect interaction phenomenon in online healthcare and its role in satisfaction development. Indirect interaction is common in healthcare because many patients are

physically unable to directly access the OHI. Even though indirect interaction has been explored in prior IS studies (Kane and Alavi 2008; Tong et al. 2017), and has been noted in the healthcare field (Bass et al. 2006; Ishikawa et al. 2005), little research has explored this important factor. Drawing on the OHI, it is found that 24% of online interactions (from Table 1) are conducted by indirect interaction in the research sample. Further, the study proves that indirect interaction plays a significant role in satisfaction development by exploring different moderating effects on the interaction process factors and service satisfaction. This finding not only builds on prior related research, but it also enhances the current knowledge on OHI deployment that interaction patterns matters.

Practical Implications

The present study also provides some practical implications for the different OHI stakeholders. First, the OHI providers or physicians who provide OHI services should be aware of the three important aspects of service satisfaction, namely, interaction depth, information intensity, and time breadth. Thus, to enhance service satisfaction, physicians should conduct depth interaction with patients (e.g. obtaining more specific information about patients' health condition), provide more information to the patients (e.g. providing more suggestions for patients' health issues), and keep long-term interaction records with the patients (e.g. tracking patients' later condition). OHI providers, such as platform managers, can also remind physicians to adopt such measures by designing interaction mechanisms for the platform or sending reminders to physicians.

With regard to the roles of information richness and interaction pattern, OHI providers or physicians should have various strategies for different OHIs. When patients have minor health issues, OHI providers or physicians should discourage them from providing medical records as such steps weaken the effects of interaction depth and information intensity on satisfaction. However, for patients with chronic and serious diseases, OHI providers or physicians should encourage them to upload their medical records because such information richness can strengthen the effect of time breadth on satisfaction. In case of indirect interaction, that is, for those interacting with the OHI on behalf of others, OHI providers or physicians can focus more on the time interval of interaction rather than interaction depth and information intensity. This is suggested because the indirect questioners (i.e., advocate companions) care less about the health-related information obtained from the OHI but emphasize the patient–physician relationship development.

Second, patients who use OHI themselves should also recognize how to conduct satisfying online interactions with physicians. To develop satisfaction, patients should know how to obtain required information from the online physicians, that is, increasing the depth of interaction and information intensity, and develop a stable patient–physician relationship by having long-term interactions with physicians. If providing medical records in the OHI, patients should know that such records can increase their expectations on the OHIs and possibly their satisfaction. By understanding the implications of their interaction behaviors, patients can make informed decisions about their OHI use.

Third, for the indirect questioners of OHI—that is, patients' relatives or friends—they should acknowledge that indirect interaction can bias their satisfaction development. As the special role of the indirect questioners, they highly value relationship development in OHI but have little value for the information exchange process. Thus, indirect questioners should be aware of the special evaluation process due to the interaction pattern and try to shape their usage patterns to maximize their satisfaction.

Limitations and Future Directions

The work has its own limitations. First, to better measure the online interaction process and avoid bias from self-reported data the second-hand interaction data is used. Even though the variables are meticulously quantified based on the existing literature, the gap between the theoretical variables and the objective measures is still a matter of concern. Future research can enhance the consistency between the interaction process variables and measures by adopting other objective measures. Second, we measure indirect interaction by analyzing how the questioners mention the patients using a text mining approach. It is possible that the patients themselves also involve the interaction process. At this stage, we cannot address this issue due to the data limits, appealing for future research to use more technical approach to test whether the questioner is changed in one interaction. Third, in data analyses, we considered the physician-level factors, while patient-level unobserved features were not controlled. This is because we cannot access the

detailed patient data from the platform due to privacy issues. Finally, the research context and dataset are from a Chinese online healthcare platform, which may not generalize to other contexts. Future research is essential to test the relationships in different cultures or conceptualize the interaction process from a new perspective.

Conclusion

The past decade has witnessed a rapid growth in online healthcare communities and platforms. Among the different online health information exchanging approaches, OHI has become popular for patients to obtain health information from online physicians. However, the current literature on OHI has yet to reach a consensus on how to measure the online interactions between patients and physicians. Based on the relational communication theory, the research proposes three aspects to measure the online interaction process (interaction depth, information intensity, and time breadth) and further explores their effects on service satisfaction. To further understand the underlying mechanism of satisfaction development in the OHI, this research also proposes two characteristics of online health interaction, that is, information richness and indirect interaction, as contingent factors that shape the linkages between interaction process and satisfaction. Objective data were collected to test the hypothesized direct and moderating effects. This study contributes to the extant literature by conceptualizing the online interaction process and extends the current understanding of online patient–physician interaction and various interaction patterns. The findings also provide implications for the OHI practitioners, physicians, patients, and their relatives or friends. To conclude, the research findings help in understanding online health behavior and motivate additional research on the complicated patient–physician interactions in the online context.

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