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Zhou, L., Sun, F., Yang, B., Zhang, X. (2025). The Effect of Physician Collaboration on Consultation Efficiency in Online Medical Teams. In: Tu, Y.P., Chi, M. (eds) E-Business. Generative Artificial Intelligence and Management Transformation. WHICEB 2025. Lecture Notes in Business Information Processing, vol 551. Springer, Cham.

The Effect of Physician Collaboration on Consultation Efficiency in Online Medical Teams

Abstract. Online Medical Teams (OMTs) are gaining widespread popularity as a new mode in Online Health Communities (OHCs), providing patients with comprehensive treatment and guidance. However, scant empirical literature examines the impact of multiple physician engagement on team efficiency in OHCs. In this paper, we fill this gap by exploring the impact of physician collaboration on consultation efficiency in OMTs. Specifically, we collect data from Haodf spanning 2017 to 2023 and employ a difference-in-differences approach. Our findings reveal that physician collaboration in OMTs reduces consultation efficiency. Based on the previous literature, we propose two underlying mechanisms, i.e., free-riding and cognitive-load effect, driving this effect. Our further analyses show that the cognitive-load effect significantly contributes to the decline in team efficiency, while there is no evidence to support the free-riding effect. In addition, patient gender and physician experience have heterogeneous effects on the main effect. To be specific, male patients and more experienced physicians mitigate the negative impact of physician collaboration on consultation efficiency. This study offers valuable theoretical insights for academic research and practical implications for the online healthcare industry.

Keywords: Online Health Community, Online Medical Team, Efficiency, Difference-In-Differences

1 Introduction

An online healthcare community (OHC) is a virtual platform where physicians deliver timely medical consultations and tailored healthcare information to patients [1]. According to a report, the number of Internet healthcare users in China had reached 394 million by December 2023 [2]. OHCs serve as an effective platform for remote interactions between physicians and patients, allowing patients to input their symptoms from home and receive timely diagnoses and appropriate treatments. Compared to traditional face-to-face interactions, these platforms transcend time and space restrictions, thereby reducing waiting times in outpatient settings and significantly enhancing the healthcare experience [3].

With the online healthcare community flourishing, a novel health services mode, online medical teams (OMTs), have emerged in the leading OHC platforms in China, such as Good Doctor, WeDoctor, and Haodf.com [4]. OHCs encourage registered physicians to form OMTs and provide a “many-to-one” service model for multiple physician-patient interactions. By integrating physicians from different hospitals and departments, OMTs provide patients with more comprehensive and personalized treatment, thus enhancing resource allocation and mitigating human resource shortages in healthcare services. According to the 2020 summit meeting of Haodf.com, the platform had 3,903 active teams with 13,608 members. The number of patients treated increased

from 88,190 in 2018 to 693,668 in 2019, nearly an eightfold rise [5]. Therefore, it is evident that OMTs are extensively used in OHCs and have become a significant channel for patients to seek health information and obtain valuable suggestions and advice.

Consultation efficiency is linked to the quality of online medical services and physicians' performance in OHCs [6]. In the context of OMTs, high efficiency is characterized by the quick and accurate response of medical consultations among multiple physician collaboration, which directly improves patient satisfaction [7]. Therefore, it is important to examine the factors of consultation efficiency in OMTs. In practice, Haodf.com has introduced OMTs to enhance consultation efficiency and optimize team operation management [8]. However, whether OMTs genuinely enhance overall efficiency remains an open question. Some studies argue that OMTs services may reduce team efficiency due to limited resources and energy (Liu et al., 2023a), while others emphasize the high efficiency achieved through medical team collaboration [9], [10]. Thus, academic research on consultation efficiency in OMTs has lacked robust empirical analysis, and the underlying mechanisms warrant further in-depth investigation.

Although a large body of OMTs literature has explored the antecedents of joining an OMTs (see, for example, [11], [12], [13]) and its effects and outcomes (see, for instance, [3], [4], [5], [9], [10], [14], [15]), to the best of our knowledge, none of these studies specifically focuses on team efficiency, particularly the effect of physician collaboration on consultation efficiency, therefore, the relationship between physician collaboration and consultation efficiency is vague theoretically. Thus, our paper aims to address these research gaps by investigating the following questions:

RQ1: Does physician collaboration affect consultation efficiency?

RQ2: What underlying mechanisms between physician collaboration and consultation efficiency?

To address our research questions, we examine the effect of physician collaboration on consultation efficiency using data from Haodf.com. The findings indicate that physician collaboration in OMTs reduces consultation efficiency. At the mechanistic level, the cognitive-load effect contributes to the decline in team efficiency, while the influence of the free-riding effect is not supported by the evidence. Regarding patient and physician heterogeneity, male patients and more experienced physicians tend to mitigate the negative impact of physician collaboration on consultation efficiency.

Our study mainly makes three important contributions: (1) our study extends previous studies in OMTs, and it is the first to empirically examine the impact of physician collaboration on consultation efficiency within OMTs from the operational management of platforms perspective. (2) this study reveals the underlying mechanisms of the impact of physician collaboration on consultation efficiency. (3) this study provides relevant insight into the prominent role of patient gender and physician experience as boundary conditions in our analysis.

2 Literature review

2.1 Online team consultations

With the popularization of the Internet, OHCs are increasingly becoming an important platform for patients to access health information and share their treatment experiences [16]. The OMTs, as a prevalent online healthcare service mode in OHCs, is a virtual group of healthcare professionals that collaborate and volunteer to provide online team consultations (OTCs) to patients via the Internet [11]. To be specific, OMTs typically consist of physicians from different disciplinary backgrounds who interact with patients, addressing their disease-related issues and sharing their health experiences. Therefore, patients can easily access physicians' services through online platforms, especially for those who live in remote areas or have limited mobility and can receive treatment without having to go to the hospital in person, which reduces waiting time and improves patient experience. Through multidisciplinary collaboration, OTCs can provide patients with more comprehensive medical advice and treatment suggestions [17].

Given the continuous development of the OTCs and their significant potential value in OHCs, we review two streams of literature related to our work: (i). the formation mechanisms of OMTs, which explain the factors of physicians joining OMTs; (ii). the consequences mechanisms of OMTs, which sheds light on the effects of OMTs' physician participation. The details of the literature on OTCs are presented in Table 1 of Appendix 1.

The first stream of literature explores the factors that motivate physicians to engage in OMTs. For example, Liu et al. (2023b) proposed a three-level theoretical model based on the self-determination theory. They found that intrinsic motivation factors (i.e., positive patient feedback) and social interaction ties facilitate physician engagement. However, extrinsic factors (i.e., consultation fees accrued) are less significant. Meanwhile, Qiao et al. (2021) indicated that social interaction ties may be one of the prominent advantages for physicians to join and participate in OMTs. In addition, Deng et al. (2023) based on the social identity theory and brand resources to emphasize the significance of developing a sense of identity for physicians to join a professional team. Besides, Liu, Perera, and Wang (2023) explored the moderation effects of physician's team engagement on their team joining behavior.

The second stream of literature primarily examines the effect of OMTs in virtual communities from three main aspects: team, physician, and patient level. At the team level, the majority of scholars explored the factors of team performance in OMTs, particularly from the team members' characteristics. For instance, Yang et al. (2021) demonstrated that physicians' reputation and experience diversity positively influence OMT performance, although star physicians may weaken the positive effect of reputation diversity. Du et al. (2024) draw on the input-process-output framework, showing the negative indirect effect of team diversity (including gender diversity, hospital diversity, professional background diversity, and professional competence diversity) on online medical team service performance via shared leadership. Wang et al. (2023) indicated that physicians' status capital and decisional capital are positively related to

their performance, and the status capital and decisional capital are of an OMT enhance physicians' performance. Liu et al. (2020) found that status capital diversity and decision capital diversity negatively influence team performance, while diversity of online reputation and professional knowledge positively influence team performance. Additionally, some researchers examined the antecedents of team status (i.e., team disbandment). Li et al. (2021) investigated that variety diversity positively influences team disbandment, while disparity diversity negatively influences disbandment. Meanwhile, the separation of diversity related to team member attitudes has a negligible effect on dissolution.

At the physician level, prior studies investigated the effect of OMTs on physicians, mainly focusing on physician engagement and individual performance. For instance, Zhang et al. (2023) explored physicians' participation in doctor–medical institution collaboration (DMIC) services based on structural holes theory. They revealed that providing DMIC services improves physicians' online consultation performance but does not significantly affect physicians' knowledge-sharing behaviors on OHC platforms. Liu et al. (2023a) show that physicians' participation in OMTs positively impacts their online performance. However, for physicians treating low-risk diseases, this involvement weakens the positive relationship between their OMT participation and online performance. Deng et al. (2023) demonstrated that physicians can improve their performance by joining teams with leaders who have warmth, competence, and ethical images. Li et al. (2020) investigated that team strength and team similarity would significantly increase physician trust.

At the patient level, prior literature focuses on the impact of OMTs on patient outcomes, particularly including patient satisfaction. For example, Zhang et al. (2025) found that multiple physicians engaging in OTC increase patient satisfaction and examined the moderating effects of team composition and team replies. Wang and Zhang (2024) found that OMTs' engagement significantly influences informational and emotional support, which subsequently enhances patient satisfaction. Liu et al. (2023) examined the effect of team-level and individual-level linguistic styles on patients' emotional well-being based on linguistic style theory. They showed that the expression of positive emotions from the team and attention to patients' perceptions and biological conditions prompt patients' emotional well-being. Wu and Deng (2019), based on the transactive memory system (TMS) theory, divided the coordination of OMTs into three different collaborative modes, finding that a leader's capital increases patient satisfaction by improving collaborative modes.

In summary, prior research on OTCs mainly focuses on team performance and lacks the mechanism of consultation efficiency. Meanwhile, existing research on the impact of physician engagement in OMTs has focused on patient satisfaction and physician performance, and little has been paid attention to the effect of physician collaboration on consultation efficiency in OMTs.

3 Research hypothesis

Physician collaboration in a medical team consultation refers to the active cooperation of multiple physicians to assess, diagnose, and provide comprehensive recommendations for patient care [10]. Consultation efficiency is the response time of physicians when patients interact with them for their illness and health status. However, in the context of OMTs, this collaboration may reduce consultation efficiency due to two crucial effects: the free-riding effect among physicians and the cognitive-load effect on patients. The free-riding effect occurs when some physicians contribute less in a team setting, assuming that others will handle the workload, which reduces individual accountability and lowers overall efficiency. The cognitive-load effect refers to the increased complexity of the information patients must process when multiple physicians provide differing treatments and suggestions, leading to higher cognitive demands, more complex questions, and slower decision-making.

At the physician level, physician collaboration may lead to a free-riding effect, where individual physicians contribute less effort in collaborative settings, assuming that others will compensate. This can reduce accountability and proactive collaboration, complicating decision-making and lowering consultation efficiency. Previous studies have shown that the size of the OMT negatively impacts the team processes and performance [12]. As a result, smaller teams better utilize the full potential of their members, are less prone to the free-riding effect, and enhance accountability and collaboration through more effective intra-team communication [22].

Meanwhile, the participation of multiple physicians introduces diverse sources of information, which increases the complexity of the decision-making process for patients. According to Information Processing Theory [23], when patients are confronted with more information sources, they experience a higher cognitive load as they compare, integrate, and evaluate the opinions of different physicians. This increased cognitive effort can prolong the consultation time, thereby decreasing team efficiency, as physicians need to invest more time addressing these complexities. Consequently, physician collaboration may heighten patients' cognitive burden, lead to more complex questions, and require additional effort from physicians, ultimately reducing overall efficiency. Based on these, we propose the following hypotheses:

H1a: Physician collaboration in the online medical team decreases consultation efficiency.

On the other hand, it is possible that physician collaboration may enhance consultation efficiency through the coordination effect and complementary expertise [21]. In other words, the multiple physicians may facilitate real-time collaboration, where team members can collectively develop comprehensive diagnosis plans and treatment advice, this process could reduce the likelihood of errors and subsequently improve consultation efficiency rather than working independently [24]. Specifically, multiple physicians in an OTC may come from a different hospital or department, bringing a distinct academic background and expertise. This diversity allows multiple physicians to contribute specialized knowledge and skills from different perspectives, enriching the overall assessment of the patient's condition. By integrating expertise from multiple specialties, this coordination effect enhances the comprehensiveness and relevance of the

information provided, leading to more accurate diagnoses and tailored treatment plans. Such multidisciplinary coordination improves service quality in healthcare by offering a more holistic approach to patient care. This process optimizes consultation efficiency, as physicians can divide tasks and address complex cases more effectively [25]. Existing studies have posited that virtual teams in OHC settings considerably decrease consultation costs and enhance consultation efficiency [5]. Based on the above discussion, the effect between physician collaboration and consultation efficiency is not obvious. Therefore, we frame our hypothesis as an open empirical question and propose the following hypotheses:

H1b: Physician collaboration in the online medical team increases consultation efficiency.

4 Research methodology

4.1 Research setting and data collection

Our dataset originates from a prominent Chinese OHC platform, haodf.com. Using Python, we conducted a data scraping process in August 2023 to collect data spanning from 2017 to 2023. The dataset includes detailed information on each OMT, such as the composition of its physician members and individual physician profiles, as well as consultation records documenting the textual interactions between OMTs physicians and patients during each consultation.

To ensure the robustness of our analysis, we conducted a rigorous data-cleaning process to mitigate the influence of outliers. First, we consolidated the textual records of each consultation by concatenating consecutive messages sent by the same physician or patient into a single entry, thereby reducing the computational burden for subsequent analyses. Next, we filtered out consultations with an unusually low or high number of dialogue rounds. Specifically, consultations were excluded if the total number of physician-patient dialogue rounds after consolidation was fewer than five or greater than fifteen. Finally, given that our dependent variable is consultation efficiency, which is inherently linked to the response time of OMTs, we excluded consultations where the OMT took more than two days to respond to the patient, thereby minimizing variability in efficiency measurement.

The final dataset comprises 12,375 consultation records from 1,181 OMTs. These consultations involve responses from either one or multiple physicians. Approximately 31.9% of the consultations in our dataset include responses from multiple physicians, while 68.1% involve only a single physician.

Finally, we organized the data into a panel format to facilitate subsequent empirical analysis. At the individual level, each physician-patient consultation is unique, involving different OMTs, physicians, and patients. Consequently, each consultation record is treated as a distinct entity, with individual fixed-effects sequentially numbered starting from 1. In the time dimension, considering the unique nature of physician-patient consultation data, we designated the back-and-forth exchanges between physi-

cians and patients as the time component for panel analysis. For each consultation record, the time fixed-effects were sequentially numbered starting from 1, corresponding to the chronological order of the dialogue rounds.

4.2 Variable measurement

The dependent variable of our study, Efficiency, is measured using the reciprocal of the OMT’s response time. This metric reflects the time taken by OMT physicians to respond to each patient query during a consultation. Due to the granularity of the data, the response time for each reply is recorded in days, rather than hours or minutes. Given that we have already excluded consultations with response intervals exceeding two days, the possible values for this variable are 0, 1, and 2.

To address potential biases arising from this limitation, we conducted two validation methods. First, within this dataset, we compared the mean response time for consultations involving multiple physicians versus those involving only a single physician. Results presented in Table 2 show a significant difference in mean response time between the two groups (as indicated by a significant t-test), and both groups’ mean response times are substantially different from zero, which indicates that the measurement of the dependent variable is effective. Second, for robustness checks, we utilized data from the WeDoctor platform, which provides more granular time measurements, to validate the main results.

Table 1. The mean response time of the treatment and control groups.

	Treatment (More than one physician)	Control
Mean response time	0.148	0.140
T-stat.	-3.006	
Sig.	0.003	

A summary of all variables used in this study is provided in Table 2.

Table 2. Variables summary.

Type	Variable	Measurement	Min	Max	Mean	Stdev
Dependent Variable	Efficiency	The reciprocal of Physician’s response time	0.25	1	0.938	0.173
Independent Variable	Physician Collaboration	Whether a second physician has already participated in the team consultation.	0	1	0.280	0.449
Mechanisms variables	Team Size	Number of medical team members	2	10	4.255	1.930
	Patient Text Complexity	The complexity of patient’s response text a. Measuring the text length to indicate the complexity b. Using GPT-4o API to directly evaluate complexity (unfinished)	0	3,230	47.203	57.616

Control variables	Expert	Dummy variable, indicating whether the responding physician is the team leader	0	1	0.480	0.500
	Professional Title	Physician's professional title which was divided into 4 levels	1	4	2.721	1.024
Other variables	Physician's Experience	The number of patients that the physician has helped	0	2,760	361.414	571.742
	Patient's Gender	Dummy variable, indicating whether the responding physician's gender is male	0	1	0.429	0.495

4.3 Data analysis and results

Difference-in-differences model. To examine the causal impact of physician collaboration on consultation efficiency in OMTs, we utilized a difference-in-differences model. This approach evaluates changes in the medical team's efficiency by comparing outcomes before and after the second physician's collaboration [26]. Specifically, the model we used is as follows:

$$Efficiency_{it} = \alpha_i + \delta_t + \beta Time_t \times Collaboration_i + \gamma X_{it} + \varepsilon_{it}$$

Where $Efficiency_{it}$ represents the efficiency of the OMT in the t -th round of dialogue during the i -th consultation; α_i and δ_t are fixed effects for the consultation (individual) and round of dialogue (time) dimensions, respectively. $Time_t \times Collaboration_i$ indicates whether the second physician engaged the consultation during the t -th round of dialogue in the i -th consultation; X_{it} represents control variables, and ε_{it} denotes the error term of the model.

Hypothesis testing: Table 3 presents the main effects of the study. Model 1 tests the main effects by incorporating independent variables, control variables, and fixed effects.

Table 3. Main effect testing.

Type	Variable	Model 1
Independent Variable	Physician Collaboration	-0.023*** (0.003)
	Expert	-0.010*** (0.004)
Controls and fixed-effects	Professional Title	-3e-4 (0.002)
	Time	Yes
	Fixed-effects	Yes
	Individual	Yes
	Fixed-effects	Yes
F-stat.		93.66***

R ²	0.019
Observations	12373

Note: *p < .10; **p < .05; ***p < .01.

In Model 1 of Table 3, the coefficient of Physician Collaboration is -0.023 ($p < 0.01$), indicating that physician collaboration has a significant negative impact on the Team's efficiency. This result suggests that physician collaboration may introduce coordination costs or efficiency losses, leading to negative outcomes. Therefore, physician collaboration in the online medical team decreases consultation efficiency, and H1a is supported.

Mechanism exploring. Under the premise that hypothesis H1a holds, we further explore the potential mechanisms leading to the decline in OMT efficiency. Specifically, we define two variables to measure the free-riding effect among physicians and the cognitive-load effect on patients namely, team size and patient text complexity, respectively. Patient text complexity is measured by the length of the text in patients' replies to physicians. In the next version, we will supplement this analysis by using the GPT-4 API to directly measure text complexity, along with the corresponding steps and results.

Model 2-1 of Table 4 examines the moderating role of Team Size, with the interaction term (Team Size $\times$ Physician Collaboration) showing a coefficient of 0.001 ($p > 0.1$). This indicates the role of team sizes cannot be validated.

Model 2-2 incorporates Patient Text Length and its interaction with Physician Collaboration. The result shows a negative and significant coefficient ($-2e-4$, $p < 0.01$). This suggests that patient text complexity significantly and negatively moderated the relationship between Physician Collaboration and Efficiency.

Table 4. Mechanisms testing.

Type	Variable	Model1	Model 2-1	Model 2-2
Independent Variable	Physician Collaboration	-0.023*** (0.003)	-0.029*** (0.006)	-0.012*** (0.003)
Moderating effects	Team Size $\times$ Physician Collaboration		0.001 (0.001)	
	Patient text length $\times$ Physician Collaboration			-2e-4*** (2e-5)
	Expert	-0.010*** (0.004)	-0.010*** (0.004)	-0.008** (0.004)
Controls and fixed-effects	Professional Title	-3e-4 (0.002)	-3e-4 (0.002)	-0.001 (0.002)
	Time			
	Fixed-effects	Yes	Yes	Yes
	Individual			
	Fixed-effects	Yes	Yes	Yes

F-stat.	93.66***	88.53***	96.94***
R ²			
Observations	0.019	0.019	0.021
	12373	12373	12373

Note: *p < .10; **p < .05; ***p < .01.

The results in Table 5 further show the mediating mechanism of patient text length. Physician Collaboration significantly increases patient text length (coefficient = 8.450, p < 0.01), demonstrating that higher Physician Collaboration is associated with greater complexity in patient text. In turn, patient text length negatively impacts efficiency (coefficient = -0.000, p < 0.01), suggesting that increased complexity in patient text may reduce efficiency.

Table 5. Mechanisms (Patient text length).

Type	Variable	Mechanisms	
		DV: Patient Text Length	DV: Efficiency
Independent Variable	Physician Collaboration	8.450*** (0.836)	-0.021*** (0.003)
Mediating Variable	Patient Text Length		-3e-4*** (1e-5)
Controls and fixed-effects	Expert	6.406*** (1.148)	-0.008** (0.004)
	Professional Title	-1.400** (0.638)	-7e-4 (0.002)
	Time Fixed-effects	Yes	Yes
	Individual Fixed-effects	Yes	Yes
	F-stat.	87.14	120.88***
	R ²	0.018	0.026
	Observations	12373	12373

Note: *p < .10; **p < .05; ***p < .01.

Heterogeneity analysis. Our main findings suggest that physician collaboration in the online medical team may reduce consultation efficiency. For OHC managers, a critical follow-up question is how to mitigate the negative impact of physician collaboration on consultation efficiency. Identifying these conditions can help optimize the service efficiency of medical teams and enhance patients' consultation experiences. To address this, we conducted a heterogeneity analysis from two perspectives: physicians and patients. From the physician perspective, we analyzed the role of online consultation experience [27], while from the patient perspective, we examined the influence of patient gender [28]. Additional results of the heterogeneity analysis will be provided in the next version. The current findings are presented in Table 6.

Table 6. Heterogeneity analysis.

Type	Variable	Model 3-1	Model 3-2
Independent Variable	Physician Collaboration	-0.027*** (0.003)	-0.023*** (0.003)
Heterogeneity	Physician's Experience	1e-5** (4e-6)	
	Patient's Gender		-0.001 (0.004)
	Expert	-0.009*** (0.004)	-0.010*** (0.007)
Controls and fixed-effects	Professional Title	-5e-4 (0.002)	-3e-4 (0.002)
	Time Fixed-effects	Yes	Yes
	Individual Fixed-effects	Yes	Yes
	F-stat.	88.82***	88.46***
	R ²	0.019	0.019
	Observations	12373	12373

Note: *p < .10; **p < .05; ***p < .01.

Model 3-1 in Tab 6 indicates that the Physician's Experience positively moderates the negative impact of Physician Collaboration on efficiency. This suggests that the higher the experience level of the responding physician, the less detrimental the effect of physician collaboration on the overall consultation efficiency. Experienced physicians are likely better equipped to manage coordination challenges, streamline communication, and provide timely and effective responses, thereby mitigating the potential inefficiencies associated with physician collaboration. However, the heterogeneity effect of the Patient's Gender was not supported.

We further conducted a multi-group analysis based on patient gender to explore the impact of physician collaboration on efficiency across different gender groups. The results, presented in Table 7, show that the absolute value of the coefficient for male patients (-0.022) is smaller than that for female patients (-0.025). This indicates that when female patients participate in consultations, efficiency tends to decrease more significantly compared to male patients, possibly due to differences in communication patterns or interaction dynamics.

Table 7. Multi-group analysis.

Type	Variable	Physician Gender	
		Male	Female
Independent Variable	Physician Collaboration	-0.022*** (0.004)	-0.025*** (0.003)
Controls and fixed-effects	Expert	-0.013** (0.005)	-0.006 (0.005)
	Professional Title	0.001 (0.003)	-0.002 (0.003)
	Time		
	fixed-effects	Yes	Yes
	Individual Fixed-effects	Yes	Yes
	F-stat.	45.85***	48.55***
	R ²	0.022	0.017
	Observations	12373	12373

Note: *p < .10; **p < .05; ***p < .01.

Robustness test. We used data from the WeDoctor platform to test the robustness of the main effects. Like the Haodf platform, WeDoctor provides both one-on-one and multi-physician consultation services (medical team consultations). In this dataset, we collected cases from 371 team consultations conducted between 2015 and 2019, all of which involved multiple physicians participating in responses. Unlike the data collected from Haodf.com, this dataset includes timestamps accurate to the second, allowing for a more precise measurement of efficiency. The results derived from this dataset are presented in Table 8. The findings for the main effects are consistent with our original results, confirming the robustness of the main effects identified in our study. Additional robustness test results will be presented in the next version.

Table 8. Robustness test.

Alternative dataset from WeDoctor		
Type	Variable	Coefficient
Independent Variable	Physician Collaboration	-0.030*** (0.003)
Fixed-effects	Time	Yes

	fixed-effects	
	Individual	
	Fixed-effects	Yes
F-stat.		25.94***
R ²		0.066
Observations		371

Note: *p < .10; **p < .05; ***p < .01.

5 Discussion

5.1 Main findings

This study investigates the effect of physician collaboration on consultation efficiency from the perspective of operations management. Additionally, we explore the underlying mechanisms of free-riding and cognitive-load effects in OMT settings and examine the heterogeneity of patient gender and physician experience. Specifically, our research shows the following findings:

First, we find that physician collaboration significantly decreases consultation efficiency. Although no prior literature has examined the effect of physician collaboration on consultation efficiency within a medical team context, our findings align with research on efficiency in other teamwork or organizational settings [22], [29]. These studies suggest that smaller teams, with fewer members, tend to have more streamlined processes, thus improving team efficiency.

Second, we explore the mechanisms behind the free-riding and the cognitive-load effects. Our results show that patient text complexity is a crucial factor in the effect of physician collaboration on team efficiency. Specifically, physician collaboration introduces diverse sources of information, which increases the complexity of the decision-making process for patients, thereby reducing overall team efficiency. Regarding the free-riding effect, we find that the size of the OMT does not significantly impact the effect of physician collaboration on consultation efficiency. This finding suggests that the size of the team is not a key mechanism contributing to low efficiency.

Third, the effects of patient gender and physician experience on the relationship between physician collaboration and consultation efficiency exhibit heterogeneity. Specifically, male patients and more experienced physicians tend to weaken the impact of physician collaboration on consultation efficiency. While previous studies have mainly focused on the moderating role of patient gender and physician experience, few have explored the heterogeneity of the effect of physician collaboration on consultation efficiency in OMT settings.

5.2 Theoretical implications

This study offers several important theoretical contributions. First, our study extends previous studies in OMTs, and it is the first to empirically examine the impact of

physician collaboration on consultation efficiency within OMTs from the operational management of platforms perspective. Prior research on OMTs has predominantly focused on the effect of the physicians joining [13], [19], [19] and the factors of the team performance [4], [9], [14], [24], but few studies have explored the factors of consultation efficiency, especially in OHC settings. Additionally, while existing literature has predominantly examined the effect of physician collaboration on patient satisfaction [10], [15], the impact of such collaboration on consultation efficiency remains under-explored—particularly using panel data. Therefore, our study contributes to the literature on OMTs in healthcare by empirically extending the concept of efficiency to the OMT context.

Second, this study reveals the underlying mechanisms of the impact of physician collaboration on consultation efficiency. Compared with previous studies, which have largely overlooked the mechanisms of the factors on consultation efficiency in OMTs, our research empirically shows that physician collaboration significantly reduces team efficiency and identifies two key mechanisms at both the physician and patient levels. According to Information Processing Theory, our findings indicate that text complexity is the primary mechanism driving this effect, while OMT size does not significantly influence efficiency. Thus, our study not only sheds light on the factors affecting consultation efficiency but also highlights the important role of patients' cognitive-load effect as a critical mechanism, which enhances our theoretical understanding of the impact of physician collaboration.

Third, this study provides relevant insight into the prominent role of patient gender and physician experience as boundary conditions in our analysis. Our findings empirically suggest that the impact of physician collaboration on consultation efficiency is stronger for female patients compared to male patients. Additionally, the impact of physician collaboration is weaker when consulting more experienced physicians, who tend to be more efficient. With OHC platforms increasingly adopting the OMT model, it is crucial to understand the conditions under which consultation efficiency is reduced and how to enhance team efficiency. Therefore, our findings highlight the importance of considering these boundary conditions to optimize team structures and collaboration strategies.

5.3 Practical implications

Our study shed light on several managerial implications for OHC managers, physicians, and patients. First, our findings offer valuable insights for OHC platform designers and managers. Specifically, this study found that physician collaboration can reduce consultation efficiency with text complexity as the primary mechanism. To address this issue, platform managers should focus on integrating AI tools that reduce cognitive load. These tools can assess and identify redundancy or similarity between responses from different physicians while also providing tailored summaries. This process streamlines information delivery and enhances decision-making, thereby reducing the cognitive burden on patients. OHC managers can enhance platform efficiency and improve patient care outcomes by optimizing communication and resource utilization.

Second, our study highlights the need for efficient collaboration within online medical teams for physicians. Physicians should be mindful of the potential for cognitive overload when engaging in joint consultations and focus on providing complementary rather than redundant information. Additionally, understanding the impact of the cognitive-load effect on consultation efficiency may encourage physicians to adopt technological tools, such as AI-driven platforms, to improve communication. These tools can help streamline information sharing by reducing redundancy and ensuring that each physician’s input is clear and relevant. By optimizing the number of physicians involved and enhancing the clarity of communication, both patient outcomes and team efficiency can be significantly improved.

Third, our findings provide valuable implications for patients. Our findings suggest that the complexity of questions can negatively impact consultation efficiency. When multiple physicians collaborate, patients may inadvertently ask more detailed or complicated questions, increasing cognitive load and reducing overall efficiency. Therefore, patients should be mindful of structuring their questions clearly and concisely. Focusing on the key issues and avoiding overly complex queries can help streamline the consultation process, reduce cognitive burden, and lead to more efficient and effective communication with physicians.

5.4 Limitations and Future Research

While our findings offer valuable insights, several limitations should be acknowledged, which also point to potential directions for future research. First, although our data primarily derives from haodf.com, and we have tested the robustness of our main findings using data from WeDoctor in China, this limits the generalizability of our results to other countries with different cultural contexts. Future studies could enhance the applicability of our conclusions by incorporating cross-culture datasets. Second, we measured the dependent variable—consultation efficiency—solely based on response time between physicians and patients. Future research could employ additional methods, such as analyzing consultation duration, patient satisfaction, or diagnostic accuracy, to provide a more comprehensive evaluation of consultation efficiency. Finally, while our analysis has predominantly focused on the free-riding and the cognitive-load effects, we recognize that other physician- and patient-level factors may also contribute to the impact of physician collaboration. Future studies should investigate these additional factors and explore their complex interactions to deepen our understanding of the underlying mechanisms.

6 Conclusion

The emerging OMT is rapidly gaining popularity and becoming a leading mode in OHCs. This study explores the impact of physician collaboration on consultation efficiency. Using the difference-in-differences method, we find that physician collaboration in OMTs decreases consultation efficiency. We further investigate the two underlying mechanisms of this effect. The empirical results suggest that the cognitive-

load effect is a crucial factor in the reduction in team efficiency, while the free-riding effect does not significantly impact the findings. Additionally, the effects of patient gender and physician experience on the relationship between physician collaboration and consultation efficiency exhibit heterogeneity. Our study could provide several theoretical implications for literature and practical implications for different practitioners.

Appendix

Table 1. Literature Review of OTCs.

Authors	Perspec- tive	Data	Theory	Methodology	Main factors	Dependent variables	Conclusion
Wu and Deng (2019)[21]	Team	Haodf	Transactive memory (TM) theory	Regression, OLS, GLM	Specification (Departments), Credibility (Ratio of high-capital physicians), Collaborative modes (moderate)	Order quantity/ pa- tient satisfaction, ser- vice quality	-Leader's capital was a critical factor promoting the effective TMS develop- ment and further affect both team's process and outcome performance. -Positive moderating effects of coordination on the relationship between credibility and performance are found.
Yang et al. (2021)[9]	Team	Haodf	Signaling theory	Regression, fixed-effect model	Reputation diversity, experience diversity, existence of star physi- cian(moderate)	Team performance	-Reputation diversity and experience diversity of physicians in OHC teams exert positive influences on team performance. -Star physicians will increase the positive influences of experience diversity, but weaken the positive effect of reputation diversity on team performance.
Liu et al. (2023a)[4]	Team	Good Doctor	Trust-trans- fer theory	PSM-DID	Physicians' team joining behav- ior, physicians' team engagement (moderate)	Physicians' online performance	-Physicians' OMT joining behavior positively influences their online perfor- mance. -For the physicians who deal with low-risk diseases, their OMT engagement weakens the positive relationship between their OMT joining behavior and online performance
Liu et al. (2023)[20]	Individual	Haodf	Linguistic style theory	Regression	vocabulary richness, use of health-related terms, emotional expression, vocabulary rich- ness、 use of health-related terms, emotional expression)	Patients' emotional well-being	-Expression of positive emotions by the team and attention to patients' per- ceptions and biological conditions benefit patients' emotional well-being
Du et al. (2024)[5]	Team	Haodf	Input-Pro- cess-Output theory	Two-level HLM	Gender diversity, hospital diver- sity, professional background di-	Team service Perfor- mance	-Gender diversity and professional competence diversity negatively influ- ence shared leadership in online medical team service

					versity, and professional competence diversity, shared leadership in team service(mediate), team size(moderate)		- Shared leadership mediates and mitigates the negative effects of gender diversity and professional competence diversity on service performance - Negative indirect effect of team diversity on online medical team service performance via shared leadership is mitigated by team size.
Wang et al. (2023)[14]	Individual level (Physicians)	Haodf	Social exchange theory	Hierarchical linear model (HLM)	OMT's status capital, OMT's decisional capital, Physicians' status capital, Physicians' decisional capital	Physicians' performance	- Physicians' status capital (SC) and decisional capital (DC) are positively related to their performance. - The SC and DC of an OMT not only increase physicians' performance but also indirectly strengthen the positive effect of physicians' SC on their performance.
Li et al. (2019)[25]	Team	Haodf	Upper Echelons Theory and Social Exchange Theory	Linear regression and hierarchical multiple regressions	Leader professional capital(S)	Team-based service demands	- MT's characteristics have a significant impact on TSD - Team heterogeneity influenced TSD in two ways: (1) provided a direct negative impact and (2) positively moderated the relationship between professional capital and TSD
Li et al. (2021)[18]	Team	Good Doctor	/	Logistic regression and maximum likelihood estimation (MLE)	Separation Diversity, Variety Diversity, Disparity Diversity, Leader Type(moderate)	Status of Medical Team (Disbanding or Not)	-Variety diversity positively affects TD -Disparity diversity negatively affects TD -Separation diversity exerts a negligible influence on disbandment
Wang and Zhang (2024)[15]	Patient	Haodf	/	Linear model, OLS	OMT engagement, language concreteness, emotional intensity, multiple specializations(moderate)	Patient satisfaction	-OMTs' engagement significantly enhances patient satisfaction. -Multiple specializations strengthen the impact of OMT engagement on both language concreteness and emotional intensity.
Zhang et al. (2023)[16]	Doctor	/	Structural holes theory	DID	Participation in DMIC services, professional title (moderate)	-Doctors' online consultation performance -Knowledge-sharing behaviors	-DMIC services improves doctors' online consultation performance and patients' evaluations of them but has no significant effect. - Doctors' knowledge-sharing performance and consultation performance mediate the relationship - Doctors participation's impact on doctors' consultation performance and patients' evaluation of them is weaker for doctors with higher professional titles than for doctors with lower professional titles.

Deng et al. (2023)[11]	Doctor	Haodf	Social identity theory	OLS, regression	Leader' warmth image/ competence image/ ethics image, member's warmth image/ competence image/ ethics image	Member's process performance, member's outcome performance	- Team capital positively affects members' performance through warmth and ethics images - Team capital is negatively related to warmth image but positively related to ethics image.
Wang (2024)[24]	OMT	Haodf	/	Ordinary least squares regression	Knowledge collaborates, leader participation, passive participation, chief doctor participation, multidisciplinary participation	OMT performance	-A positive influence of knowledge collaboration on OMT performance. -Leader participation weakens the relationship between knowledge collaboration and team performance.
Li (2020)[30]	Doctor	Haodf	Identity theory	Ordinary least squares (OLS)	Doctor efforts (Central efforts, peripheral efforts), identities in online medical team (moderate)	Individual service quality	Central and peripheral effort, and leader and MTM identity – all had significant and positive impacts on the service quantity (SQ) of both written and telephone consultations.
Liu et al. (2023b)[12]	Physician	Good Doctor	Self-determination theory	Panel ordinary least squares (OLS) and hierarchical linear model (HLM)	Time, extrinsic motivation, intrinsic motivation, social interaction ties, OMT's scale(m), professional expertise(m)	Physician engagement	- Intrinsic motivational factors (e.g., positive patient reviews) and social interaction ties promoted engagement. - Professional expertise and the scale of OMTs were also found to modulate physician engagement.
Liu et al. (2023) [20]	Patient	Haodf	Linguistic analysis theory	Regression	Team leader level/ Individual level/ Team individual level (Vocabulary richness, use of perceptual words, use of biological words, emotional expression)	Patients' emotional well-being	The expression of positive emotions by the team and attention to patients' perceptions and biological conditions benefit patients' emotional well-being
Liu et al. (2020) [3]	Physician	Good Doctor	/	Multiple linear regression	Status capital diversity, decision capital diversity, online reputation diversity, professional knowledge diversity, leader reputation(moderate)	Team performance	-Status capital diversity and decision capital diversity negatively affect team performance -Diversity in terms of online reputation and professional knowledge positively affect team performance -Leader reputation moderates the impact of status capital diversity and online reputation on team performance.

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