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The status and challenges of online consultation service in internet hospitals operated by physical hospitals in China: a large-scale pooled analysis of multicenter data

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Abstract

Background While Internet hospitals have rapidly developed as China's dominant digital healthcare model, critical evidence gaps persist regarding operational status and challenges of their core online consultation services. This study aimed to evaluate the current status and challenges of online consultation in Internet hospitals services through large-scale multi-center business data analysis.

Methods Retrospective analysis of 594,695 online consultations (2020–2021) from 30 Internet hospitals across 11 Chinese provinces. Descriptive analyses were conducted on counselee demographics, consultant qualifications, and order informations. A novel five-category consultation classification was applied. Multivariate logistic regression identified the inflencing factors for order, while locally weighted regression (LOESS) modeled workload-response relationships.

Results There were 244,678 counselees (median age 29) and 5,781 providers (91.89% doctors) involved. Service are concentrated in pediatrics, obstetrics and gynecology (48.25%). Senior-title providers handled 43.79% consultations but showed reduced completion probability (OR = 0.77). The main types of consultations were re-visit (44.89%) and first visit (34.57%). Temporal patterns revealed peak consultation hours at 10:00 (8.11%) and 16:00 (7.29%), with provider response peaks at 12:00 (5.38%), 16:00 (6.61%), and 21:00 (6.63%), averaging 3.64-hour response delays. Provided medical history (OR = 2.13) could independently increase the response probability, whereas senior title (OR = 0.77) could reduce such probability. Workload-response efficiency transitioned from positive (< 78 orders) to negative correlation (> 1,700 orders), with 27.69% uncompleted orders attributed to consultant factors (75.87%).

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Conclusions Even with the increased momentum, the online consultation service still faces many challenges mainly including the relative absence of elderly patients with chronic diseases, personnel qualification issues, the imbalance of service supply and demand, the unfitness of order contents with official regulations, and the insufficient quality control of response rate and timeliness. Comprehensive measures should be carried out to promote the effectiveness of online consultation for better disease prevention and control.

Keywords Internet hospital, Online consultation, Online health care services, Digital health, China

Background

As a novel strategy for outpatient healthcare and supplementary means to offline visits, Internet hospital functions as a virtual platform that delivers medical services through the network [1]. Since the first Internet hospital was approved in China in 2014 [2], various parties including governments, hospitals and enterprises have actively explored its construction and operation mode [3]. In 2018, the Chinese government officially issued the "Administrative Measures for Internet Diagnosis and Treatment (Trial)" and other three documents [4], which became a key developmental milestone for Internet hospitals. It clearly specified that Internet hospitals must be founded on the basis of physical hospitals [5], making Internet hospital be the only statutory type of platforms to provide online diagnosis and treatment services. It also gave a clear definition for the scope of online diagnosis and treatment services as serving re-visit individuals with common and chronic diseases, providing family physician services and remote collaboration between medical institutions. With the supports of serial policies, the number of Internet hospitals increased from 92 to 315 [6] with users expanding from 28 million to 45 million during 2018 and 2019 [3]. During the epidemic of COVID-19, Internet hospitals became an important part of joint prevention and control system [7–10], which considerably alleviated the pressure on healthcare system [11]. The number of Internet hospitals had exceeded 1,700 by the end of 2021 in China [6].

The main function of Internet hospital provided is online consultation service, which can enhance the equity of medical resources. Compared with traditional offline health care services, online services break through the limitation of time and space, reduce medical costs, alleviate offline medical congestion, and thus provide a brand-new solution to diagnosis and treatment [2]. Easy access to doctors online without significant time or financial cost can boost patient's enthusiasm for the follow-up and post-diagnosis management [12, 13]. However, there are still potential challenges that the online consultation service may confront, including the low proportion of elderly counselees [14], poor service efficiency [15], imbalance consultation orders between departments [16], and so on.

The existing data-supported analyses on online consultation service were mostly based on enterprise-operated online consultation platforms, such as PingAn Good Doctor [17] and Haodf [18–22], which were fundamentally distinct from Internet hospitals. Existing single-center researches on physical hospital-operated platforms may have the problems of insufficient sample size and under-representation [23]. Despite of these existing evidence, several concerns have not been clearly addressed or answered so far, including:

1. Do the online consultation services properly serve the target audience as patients with chronic conditions?
2. Are the practice qualifications of consultants strictly ensured in online consultation services as well as in offline visits?
3. Whether the content of the online consultation conforms to the current policy?
4. Can the quality and efficiency of online consultation services be guaranteed for counselees?

To answer the above questions, the comprehensive analysis using real-world multicenter data is urgently needed to objectively assess the current status and explore the main challenges of online consultation service.

This study performed an integrative analysis on business data generated from 30 Internet hospitals nationwide in China during 2020 and 2021. The current status and main challenges of online consultation service were evaluated from counselee, consultant, and order aspects, with a view to provide empirical evidences for improving service quality and effectiveness.

Methods

Data sources

A total of 594,821 online consultation records were collected from 30 Internet hospitals distributed across 11 provinces in China. Following standardized data cleaning procedures, 126 fully identical records were removed, while duplicate consultation records and those containing null values were retained as part of this study. Ultimately, this study retained 594,695 de-identified online consultation service data from 30 Internet hospitals distributing in 11 provinces in China from January 1, 2020 to December 31, 2021. All Internet hospitals included in this study are operated by non-profit tertiary hospital, including 10 in Fujian, 5 in Anhui, 3 in Xinjiang, 2 each in

Guangxi, Guangdong, Henan and Tianjin, 1 each in Inner Mongolia, Ningxia, Shanghai, and Liaoning. Among them, 28 hospitals are public and the other 2 are private. In terms of hospital types, there are 22 general hospitals, 5 traditional Chinese medical hospitals, 2 mental hospitals, and 1 women's and children's hospital. Appendix Table 1 displays the province, ownership and types of the physical hospitals that the Internet hospitals operated.

All data were securely stored at Zoenet Health Technology Co., Ltd, which cooperates with hospitals to run the online consultation services. The company de-identified these data and constructed an Internet environment for secure analysis, obtaining data according to the principle of minimum availability. After conducting an analysis of the data in the intranet security environment, the analysts exported the analytical results rather than the underlying data itself.

Study definitions

Information of counselees

The information of counselees contains their gender, age, present diagnosis and medical history. Present diagnosis refers to the initial diagnosis of the current disease related to the counselee's consultation. The counselee's past diseases, operations, injuries, and treatments experiences comprise the overall medical history. The present diagnosis and medical history are offered by the counselees at the time of order submission and are not mandatory, in case that counselees may be in good health conditions or unclear of current diagnosis.

Information of consultants

The information of consultants includes their occupational category, professional title and department. The occupational categories of consultants include doctors, nurses, technicians, therapists and pharmacists. While doctor can offer all kinds of online consultation services including diagnosis and treatment, the remainder types of consultants can only provide medical consultation services. The professional titles are classified into junior, intermediate, sub-senior and senior in ascending order, according to the grades of Chinese medical worker's professional titles [24]. It should be noted that the qualification for online practicing medicine is the same as the offline. Only doctors can prescribe and provide diagnosis and treatment services to patients. Other types of consultants, such as nurses and therapists, may also engage in online medical consultation services, but they are not authorized to prescribe or provide online diagnosis and treatment services.

Information of consultation orders

The information of consultation orders consists of consultation department, consultation type, order completion status and time-related information. A total of 44 departments were identified. The online consultation services provided by the Internet hospital include online medical consultation (virtual consultation) services and online diagnosis and treatment (virtual visit or virtual re-visit) services. Specifically, online consultation services refer to all kinds of consultations that occur on the Internet hospitals. Among them, online medical consultation services refer to general consultation that does not involve diagnosis and treatment, while online diagnosis and treatment services refers consultations seeking for diagnosis and treatment on the Internet hospitals, including first visits and re-visits. As Internet hospitals in China are still in the developmental stage, there is currently no specific recognized or official classification method for online consultation services. In order to further explore the order types and distribution of online consultation, we innovatively put forward the classification criteria shown in Table 1 and Fig. 1. All online consultation services can be classified into 5 types as first visit, re-visit, health consultation, process consultation and irrelevant content. Among them, first visit and re-visit consultations belong to online diagnosis and treatment services, and the other three

Table 1 Categories, definitions and examples of online consultations

Categories	Definitions	Examples
First visit	The purpose of the counselee is to seek diagnosis or (and) treatment but without any medical records, diagnosis results or accessory examination reports, etc.	"I've got dizziness, fatigue and runny nose. What king of illness do I have?" "What should I do if I have insomnia regularly in the evening?"
Re-visit	The purpose of the counselee is to seek diagnosis or (and) treatment with any of medical records, diagnosis results or accessory examination reports, etc.	"After the consultation last time, I still feel dizzy and tired." "Could you please check my most recent physical examination report to see if everything is ok?"
Health consultation	The counselee wants to simply obtain knowledge about health and medical issues.	"Can I take cold medicine after drinking alcohol?" "When can I have a bath or shower after hysterectomy?"
Process consultation	The counselee only asks about the procedural steps of the medical service process.	"Does the physical examination require an empty stomach?" "How can I make an appointment for a 3D ultrasound?"
Irrelevant content	The description of the counselee is none of the above, or exceeds the scope of services provided by this platform or is irrelevant with medicine.	"Have you got married?" "I am just wondering if I can get your phone number."

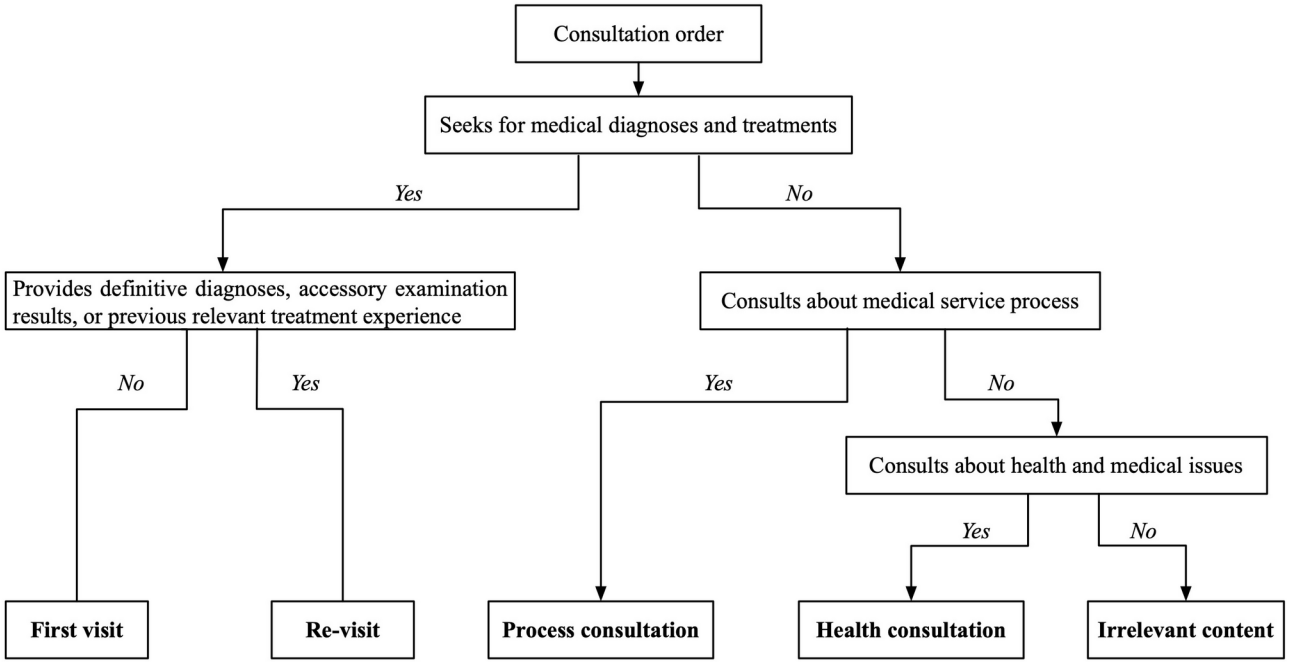

Fig. 1 The process of manual classification

types of medical consultations belong to online medical consultations services. According to the criteria, the orders in 2020 were divided into five consultation types by manual identification.

The repeated consultation refers to the orders submitted by the same counselee with the same content. The consultation types and the repeated consultation orders were both manually judged by two trained researchers, which independently classified both consultation types and repeated consultations while remaining blinded to all contextual data (including demographics, temporal patterns, and professional titles), accessing only de-identified free-text content. Prior to formal analysis, researchers completed rigorous standardization training: (1) Studying the classification manual containing operational definitions, 70 exemplar cases, and boundary scenario resolution protocols; (2) Achieving excellent inter-rater reliability (Cohen's $\kappa > 0.90$) on 100 pilot cases. During the classification process, all discordant judgments underwent structured resolution through daily consensus meetings with senior co-authors. Post-classification analysis demonstrated sustained excellent agreement with Cohen's $\kappa = 0.92$ (95% CI: 0.89–0.94).

The order completion status depends on whether the order has been answered or not. An order will be considered completed automatically in the system if it has been answered by a consultant, whereas an order without receiving an answer will be considered uncompleted. The reasons of being unanswered contain consultant reasons, counselee reasons and system reasons. Consultant reasons include time out without response, lack of time for response, recommendation to offline outpatient. Time out with no response refers to the automatic termination of a consultation order if none of consultants respond within 24 h. Lack of time for response is an option for consultants to reject the corresponding requests if they do not have time to response. Counselee reasons refer to the cancellation of orders by counselees due to the following reasons including consulting the wrong departments, improper operation, non-payment and no particular reasons. System reasons include invalidation of the medical treatment card, system errors and other causes.

Time-related information consists of order time, response time and waiting time. The order time is the time of order submission, while response time is the time when the consultant responds. The waiting time represents the duration between the order time and the response time.

Statistical analysis

This study evaluated the status of online consultation services from four aspects: (1) the characteristics of counselees, (2) the service capacities of consultants, (3) the consultation contents, and (4) the quality of online consultation service. The characteristics of counselees were described by the distribution of their age, gender in different departments. The service capacities of consultants were evaluated based on their occupational categories and professional titles. The consultation contents were described by the distribution of order types. The quality of service was assessed by the waiting time and response rate of the consultation orders.

Exploratory data analysis was performed. Since all of continuous variables showed skewed distributions with normality test, we chose median (Inter-Quartile Range,

IQR) to represent the continuous variables. All categorical variables were described by number (percentage). Meanwhile, the non-parametric method of Kruskal-Wallis test of the one-way analysis of variance model was adopted to test the difference of waiting time costed by consultants with various professional titles.

To find out the influencing factors affecting whether an order is answered, the order completion status was set as the outcome, the other order-related attributes including the counselees' age group (0–19, 20–39, 40–59, and 60+), the provision of present diagnosis, the provision of medical history, and the professional title of the consultants were set as the exposures. Taking each order as an independent sample, we use multivariate logistic regression to find the independent risk factors for order completion. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated.

To explore the relationship between order volume and response rate of consultants, locally weighted regression (LOESS) was applied. LOESS is a nonparametric technique that uses local weighted regression to fit a smooth curve through points in a scatter plot. This method was prioritized over parametric regression approaches due to its ability to model nonlinear and locally varying trends without assuming a predefined global functional form, which was essential for our exploratory analysis. The smoothing parameter (span), determining the proportion of data used in each local regression, was optimized with the Generalized Cross-Validation (GCV) criterion. After optimization, the optimal span was determined as 0.63, which minimized the GCV score (GCV = 0.13).

All statistical analyses were conducted using R (versions 3.6.3) and visualized by ggplot2 3.3.2 package [25]. A p value less than 0.05 was considered statistically significant.

Results

Information of the counselees

There were 244,678 counselees involved in this study, including 78,615(32.13%) males and 166,063(67.87%) females. As illustrated in Fig. 2, the top three departments of receiving counselees were gynecology (n = 40,612, 16.60%), pediatrics (n = 31,288, 12.79%) and obstetrics (n = 28,694, 11.73%), while the bottom three were radiology (n = 152, 0.06%), physical examination (n = 165, 0.07%) and cardiac surgery (n = 285, 0.12%).

The median age of counselees was 29 years (IQR 24–35 years). The age showed a bimodal distribution as illustrated by the black line in Fig. 3, with two peaks at 1 (n = 9,967, 4.14%) and 30 years old (n = 12,220, 5.81%). Population over 60 years only accounted for 5.00% (n = 12,241). Pediatrics was the only department with the age of counselees centering on age 0–5, while patients of other departments centered on age 20–39. Among all counselees, males and females accounted for 78,615 (32.13%) and 166,063 (67.87%). The amount of female counselees was more than that of male in 35 departments. Irrational patients' identities were found, as there were 6,523 (20.85%) pediatric counselees over 18 years old, and male counselees accounted for 1.60% (n = 1,466) in gynecology and 1.49% (n = 1,364) in obstetrics serving females.

Information of the consultants

This study involved a total of 5,781 consultants, including 5,312 (91.89%) doctors, 377 (6.52%) nurses, 84 (1.45%) pharmacists, 4 (0.07%) therapists and 4 (0.07%) technicians. Since only doctors are allowed to diagnose and treat diseases, this group accounts for 91.89% of the total. The numbers of medical workers with senior, sub-senior, intermediate and junior title were 1,083(18.73%), 1,703(29.46%), 1,903(32.92%) and 1,092(18.89%). Pediatrics (n = 512, 8.86%), gynecology (n = 438, 7.58%) and general surgery (n = 371, 6.42%) were the top three departments with largest amount of consultants (Table 2 and Fig. 4).

Information of the orders

The total number of consultations was 594,695, with 165,763 (27.87%) and 428,932 (72.13%) orders generated by male and female respectively. Each counselee initiated 2.43 consultation orders on average. Each male initiated 2.11 orders and each female initiated 2.58 orders. The most popular department was pediatrics (n = 106,058, 17.83%), followed by obstetrics (n = 91,599, 15.40%) and gynecology (n = 91,528, 15.39%) (Fig. 5).

The numbers of orders selecting consultants with senior, sub-senior, intermediate and junior titles were 260,444 (43.79%), 215,309 (36.20%), 91,608 (15.40%) and 27,334 (4.60%). As shown in Fig. 6, the consultation time of completed orders presented a bimodal distribution, peaking at 10:00 (n = 34,861, 8.11%) and 16:00 (n = 31,366, 7.29%). The median of consultation time and response time were 14:00 (IQR 10:00–18:00) and 17:00 (IQR 13:00–21:00). The response time for consultants exhibited a three-peak distribution at 12:00 (n = 25,170, 5.38%), 16:00 (n = 28,405, 6.61%) and 21:00 (n = 28,515, 6.63%). The mean waiting time for completed orders was 3.64 h. For junior, intermediate, sub-senior, and senior titles, the mean waiting time were 2.24 h, 3.34 h, 3.45 h and 4.06 h. Comparison of different professional titles showed statistically significant difference in the waiting time (p < 0.001, Kruskal-Wallis test).

After the manual classification of 286,767 consultations in 2020, the number of orders for first visit, re-visit, health consultation, process consultation and irrelevant content were 99,123 (34.57%), 128,722 (44.89%), 48,999 (17.09%), 9,294 (3.24%) and 629 (0.22%). The number of orders for disease diagnosis and treatment reached 227,845 (79.45%).

Consultations in most departments were mainly first visits and re-visits (Fig. 7). More than 50% of total consultations from 10 department were first visits, with the highest

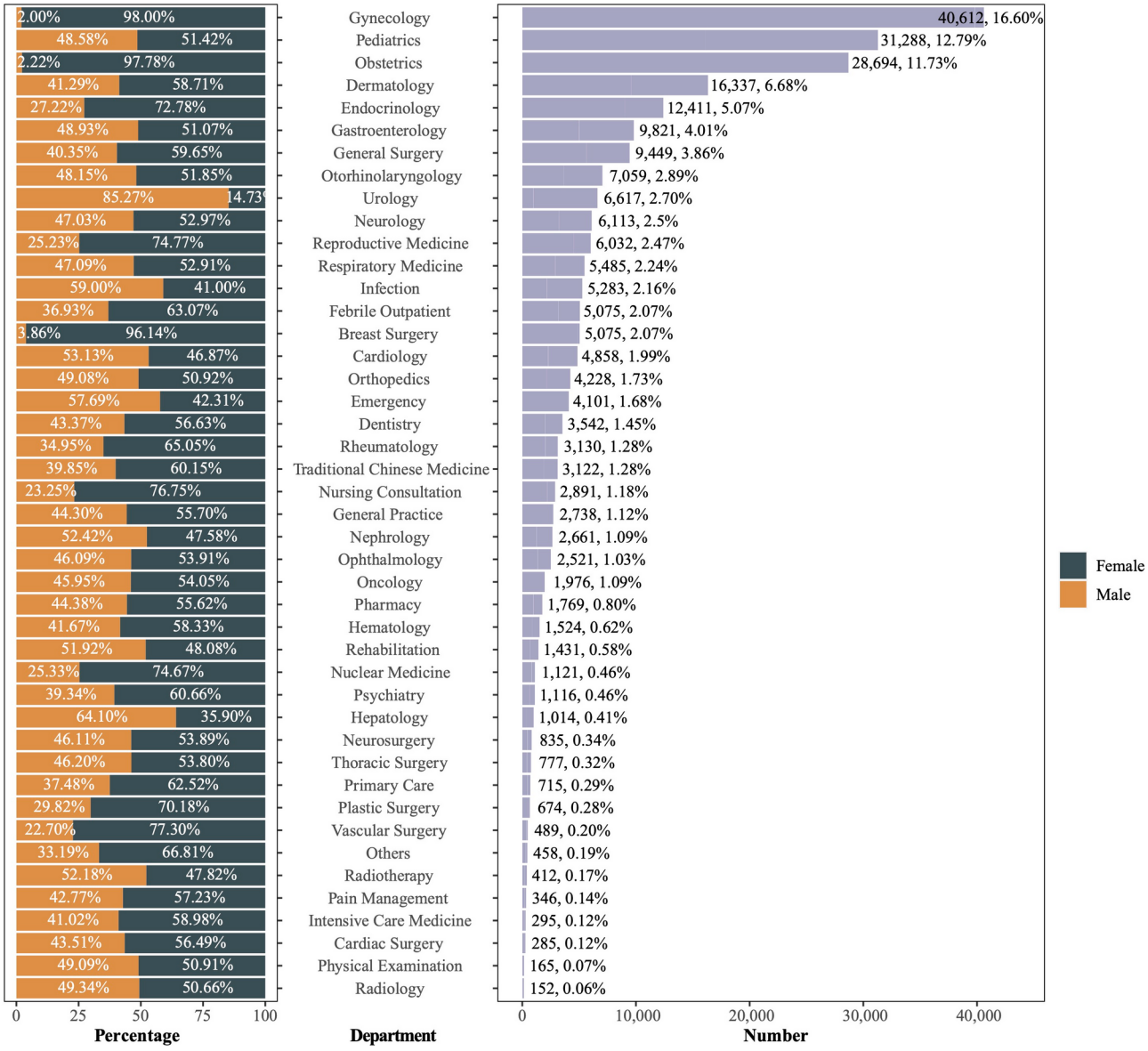

Fig. 2 Distribution of counselees in 44 medical departments

proportion in primary care (91.40%), pediatrics (77.38%) and dentistry (70.54%). In addition, hematology (95.11%), hepatology (92.82%) and otolaryngology (91.04%) ranked top three in terms of the proportion of re-visits. There were orders for first visits (45.89%) and re-visits (17.70%) for the purpose of disease diagnosis and treatment present in nursing consultation. Departments with highest proportions of health consultation were gynecology (81.66%). Besides, departments with highest proportions of process consultation were rehabilitation (41.04%). The orders of repeated consultation accounted for 10.38% ($n=31,972$) in total.

Orders completion status

The completion and incompletion rate were 72.31% ($n=430,033$) and 27.69% ($n=164,662$) in 594,695 consultations. The response rates in 2020 were 75.40% ($n=74,738$) for first visits, 74.64% ($n=96,072$) for re-visits, 68.05% ($n=33,343$) for health consultation, 74.64% ($n=6,937$) for process consultation and 70.75% ($n=445$) for irrelevant content. Among the uncompleted orders, 75.87% ($n=124,929$) were due to consultant reasons, 12.45% ($n=20,507$) were due to counselee reasons, and the rest 11.68% ($n=19,226$) were due to system reasons (Fig. 8).

In terms of uncompleted orders due to consultant reasons, "Time out with no response" ($n=121,452$, 73.76%) was the most common reason, followed by "Lack of time for response" ($n=2,307$, 1.40%) and "Recommended to offline treatment" ($n=1,170$, 0.71%). Among the uncompleted orders due to counselee reasons, "Cancellation by counselee" ($n=15,467$, 9.39%) was the top one, followed

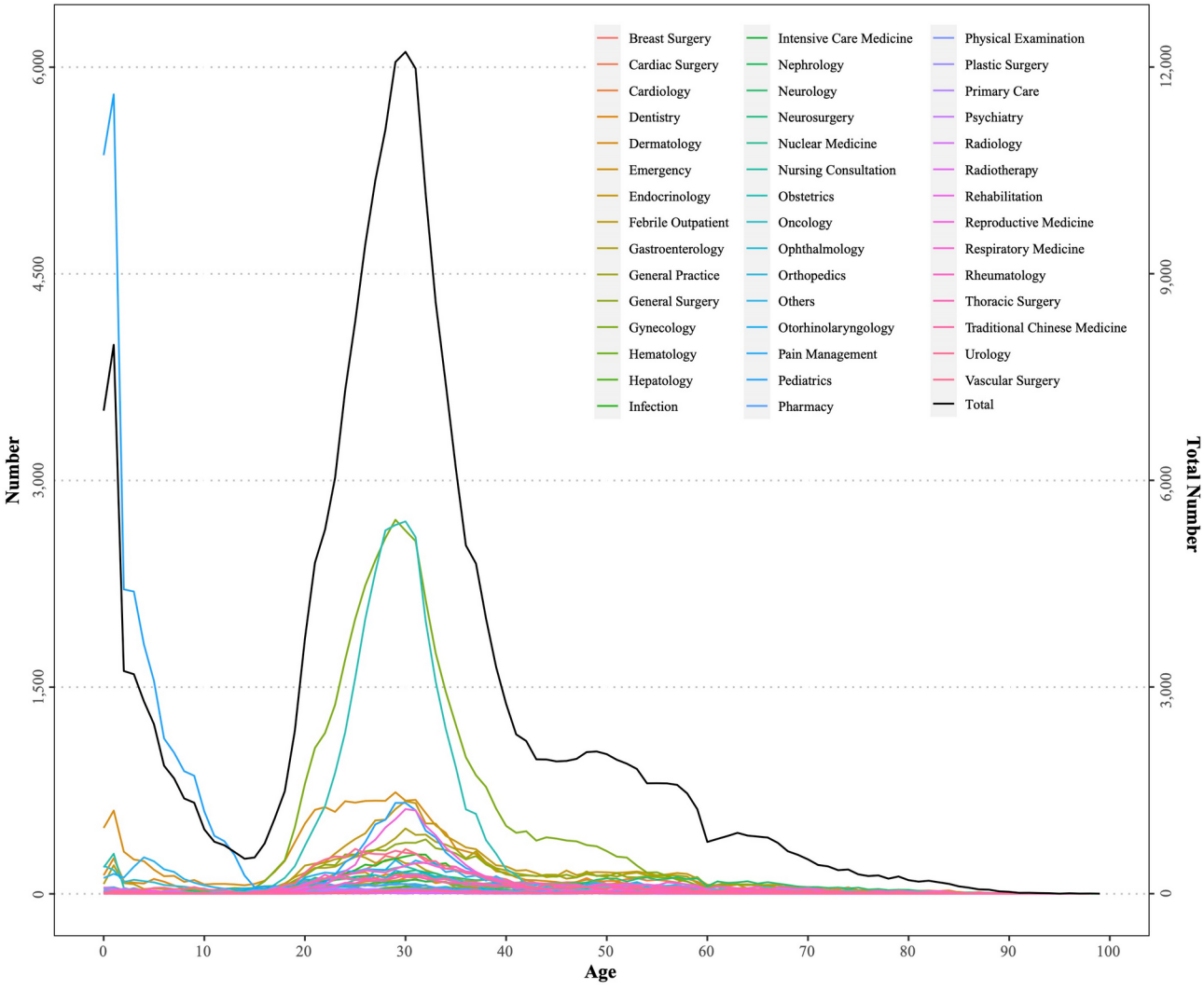

Fig. 3 Age distribution of counselees in 44 medical departments

Table 2 The number and rate of consultants with different professional titles

Categories	Title			
	Senior	Sub-senior	Intermediate	Junior
Doctors	1,063 (18.39%)	1,593 (27.56%)	1,668 (28.85%)	988 (17.09%)
Nurses	8 (0.14%)	82 (1.42%)	197 (3.41%)	90 (1.56%)
Pharmacists	12 (0.21%)	27 (0.47%)	35 (0.61%)	10 (0.17%)
Therapist	0 (0)	0 (0)	2 (0.03%)	2 (0.03%)
Technicians	0 (0)	1 (0.02%)	1 (0.02%)	2 (0.03%)
Total	1,083 (18.73%)	1,703 (29.46%)	1,903 (32.92%)	1,092 (18.89%)

by "Non-payment" ($n=3,937$, 2.39%), "Consulting wrong department" ($n=1,068$, 0.65%) and "Improper operation" ($n=35$, 0.02%). The remaining were cancelled because of other reasons, consisting of "Other causes" ($n=11,934$, 7.25%), "Invalidation of medical treatment card" ($n=7,256$, 4.41%) and "System error" ($n=36$, 0.02%).

Regarding to orders with present diagnosis have a completion rate of 75.23%, compared to 70.70% when not filled. Similarly, orders with medical history show a completion rate of 76.08%, versus 69.39% when unfilled. Orders providing both present and past medical history achieve a slightly higher rate of 75.26%, while those with neither drop to 69.31% (Table 3).

As shown in Table 3, the completion rates of orders vary among different types of medical personnel. Notably, nurses exhibit the highest completion rate at 87.10%, followed closely by pharmacists at 86.75%. Doctors have a

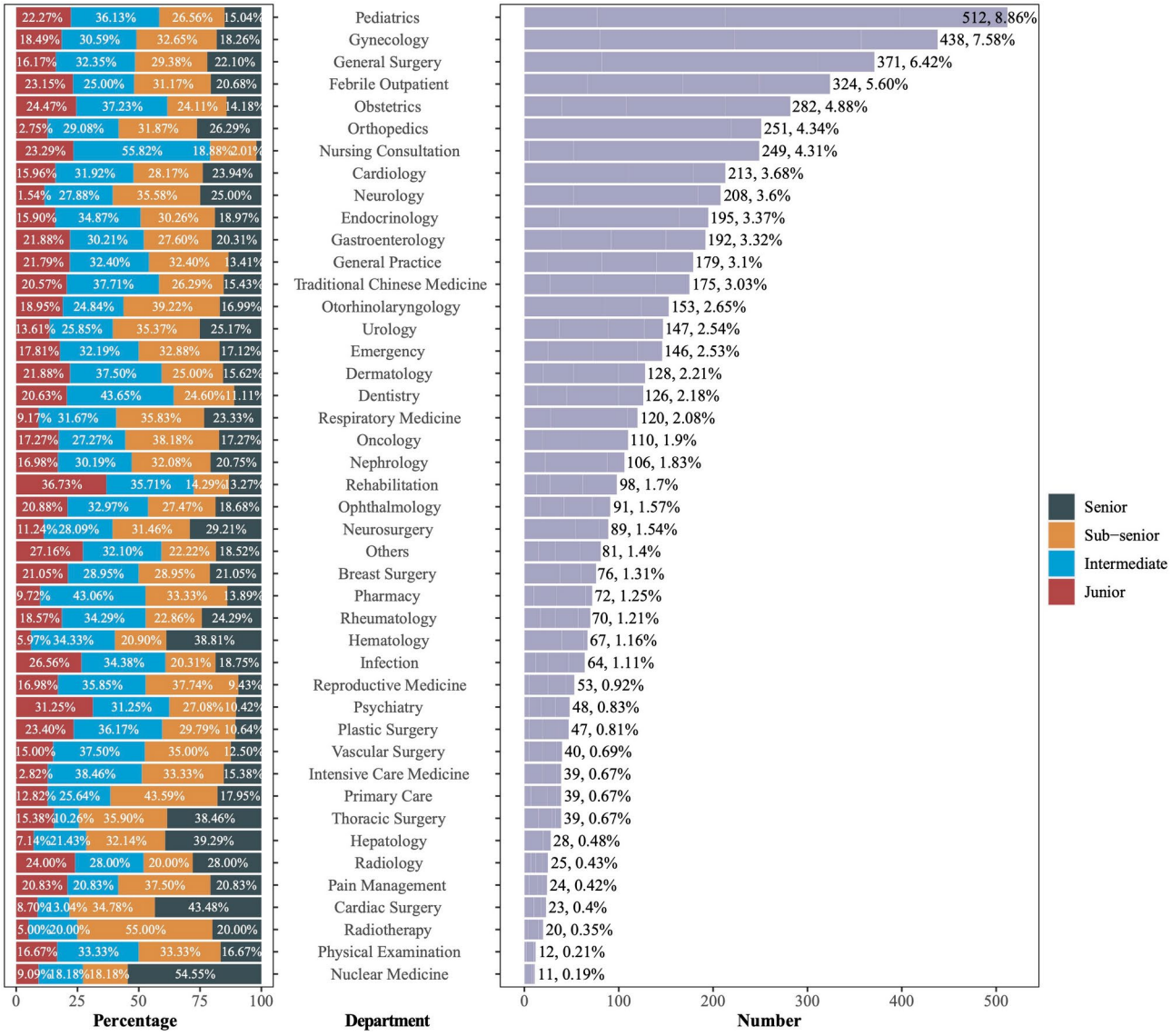

Fig. 4 Distribution of consultants in 44 medical departments

completion rate of 71.85%, therapists at 76.92%, and technicians have the lowest rate at just 50% (Table 4).

Multivariate logistic regression revealed several factors associated with order completion status (Fig. 9). Male counselees (OR = 0.96, 95% CI: 0.95–0.98) and Order time (OR = 0.90, 95% CI: 0.89–0.92) were associated with statistically significant but clinically negligible reductions in response probability. 40–59 years had slightly higher completion odds (OR = 1.12, 95% CI: 1.09–1.15), while 20–39 years counselees showed reduced odds (OR = 0.92, 95% CI: 0.90–0.94). Notably, counselees providing medical history showed a substantially higher likelihood of order completion (OR = 2.14, 95% CI: 2.08–2.19), whereas those reporting present diagnoses had marginally lower odds (OR = 0.91, 95% CI: 0.88–0.93). Sub-senior consultants had a small yet significant advantage in order completion (OR = 1.11, 95% CI: 1.09–1.13), whereas junior title consultants showed no difference from the reference group (OR = 1.00, 95% CI: 0.97–1.04). Senior title consultants demonstrated slightly lower odds (OR = 0.77, 95% CI: 0.76–0.79) of completing orders compared to junior titles, though the effect size was modest.

The relation between the number of orders received by each consultant and the response rate was shown in Fig. 10. The colors of the dots represented the consultant frequency with the same order number and response rate. The correlation between the response rate and the order volume was positive when consultants received less than 78 orders. Among the consultants receiving 78 – 1,700 consultation orders, the order volume and response rate of consultants had no obvious correlation. For the consultants with more

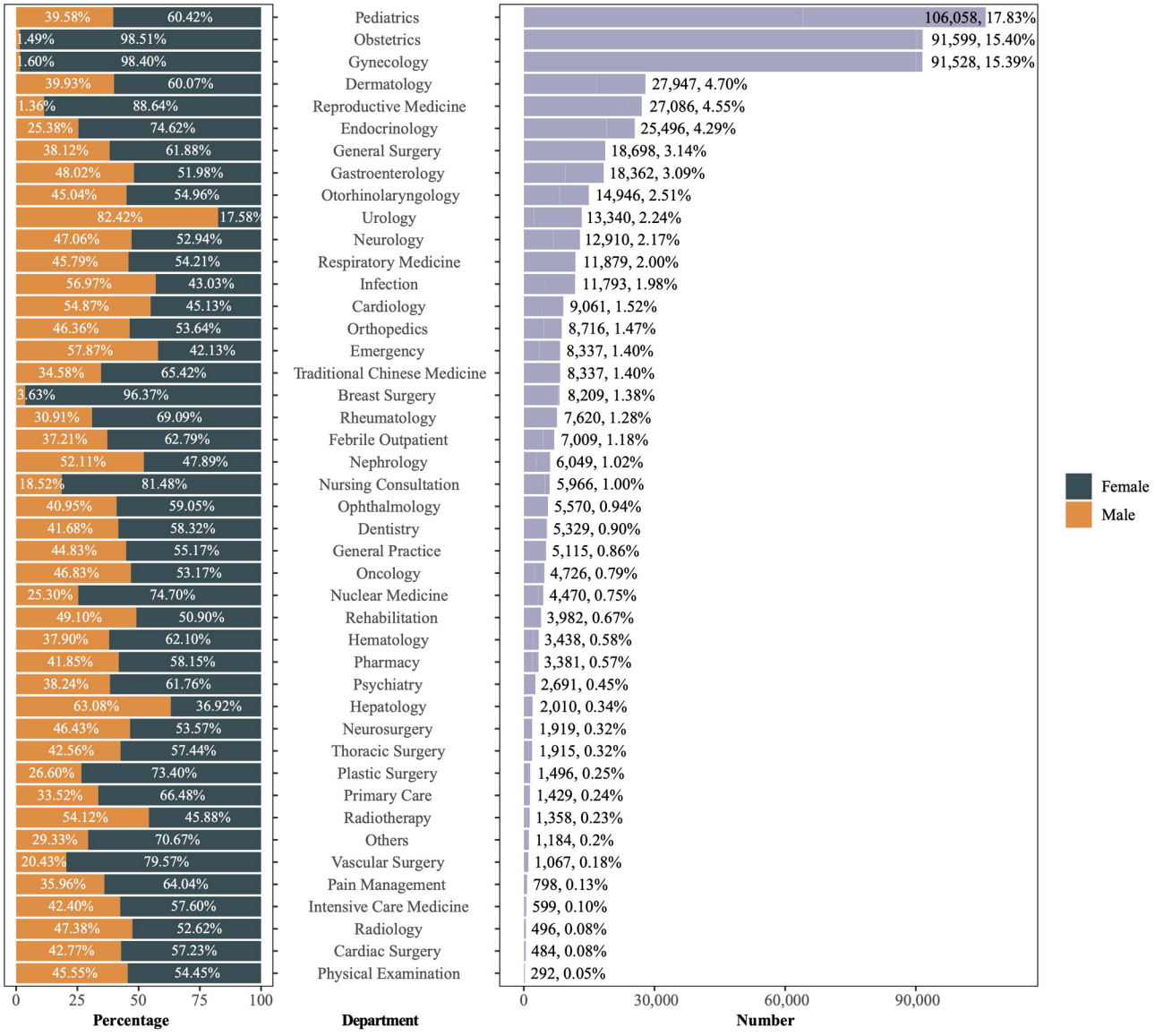

Fig. 5 Distribution of orders in 44 medical departments

than 1,700 consultation orders, the response rate showed a downward trend.

Discussion

Principal findings

This study comprehensively evaluated the status of online consultation service provided by Internet hospitals in China from four aspects including the characteristics of counselees, the service capacities of consultants, the consultation contents, and the service quality through large-scale pooled analysis of multicenter business data. Judging from the characteristics of the counselees, the younger age distribution indicated that the actual users of online consultations did not match the target population of elderly patients with chronic diseases. In terms of the service capabilities of consultants, there were consultants with different identities other than doctors, which do not conform to the access rules of offline consulting, introducing personnel qualification issues. Counselees tend to consult with senior professional titles, and have a greater demand for gynecology, obstetrics and pediatrics, putting forward higher requirements for the service ability of relevant consultants. The consultation content showed that there are a large amount of orders that do not comply with the content of chronic disease follow-up which was regulated by the current policies in China. From the perspective of service quality, the response rate is relatively low with long waiting time, indicating the service quality has not been effectively guaranteed. Providing complete medical history information and leading the counselees to consult less with senior consultants may improve

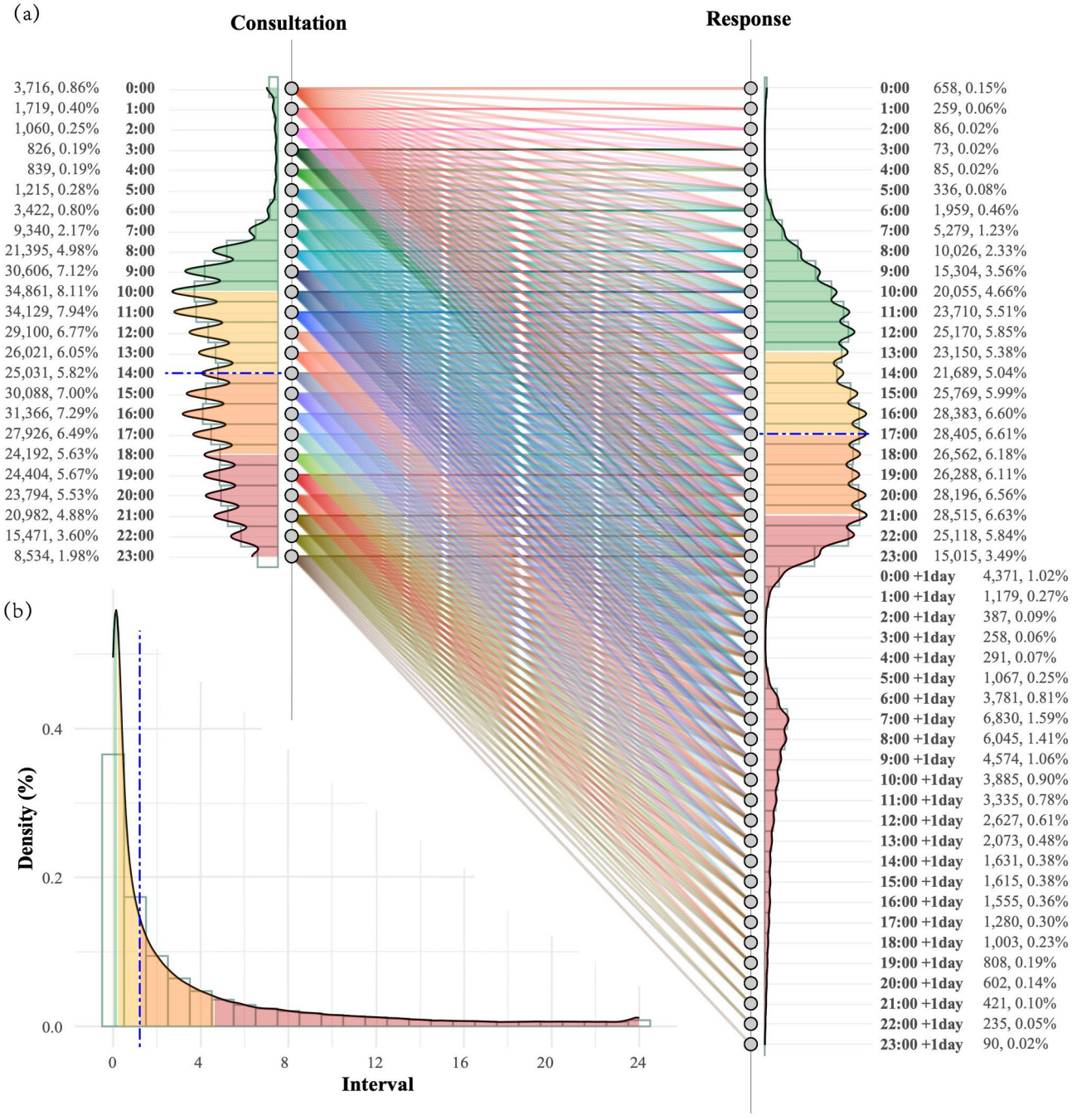

Fig. 6 Order time and response time of all completed orders. **a** The left axis represents the order time and the right represents the response time (24h format); **b** The probability density of waiting time. All probability density were divided into four equal parts according to interquartile, represented by different colors. The blue dash-dotted line indicates the median

the response rates. Resolving these issues to optimize the benefit of online consultation remains a clinical challenge, which should be the focus of continuous exploration in future.

Disparity of the intended audiences and the actual users

The online consultation services were mainly designed to service re-visit patients, particularly those with chronic conditions. Being susceptible to chronic diseases and having mobility constraints, the elderly should be the main intended audiences. However, we found that the majority of counselees were children and young adults in our study, which is consistent with some previou research [17].

This same result indicates that the coverage of this service for the elderly is insufficient. Due to the disparities in digital literacy and cognitive ability [26], the elderly

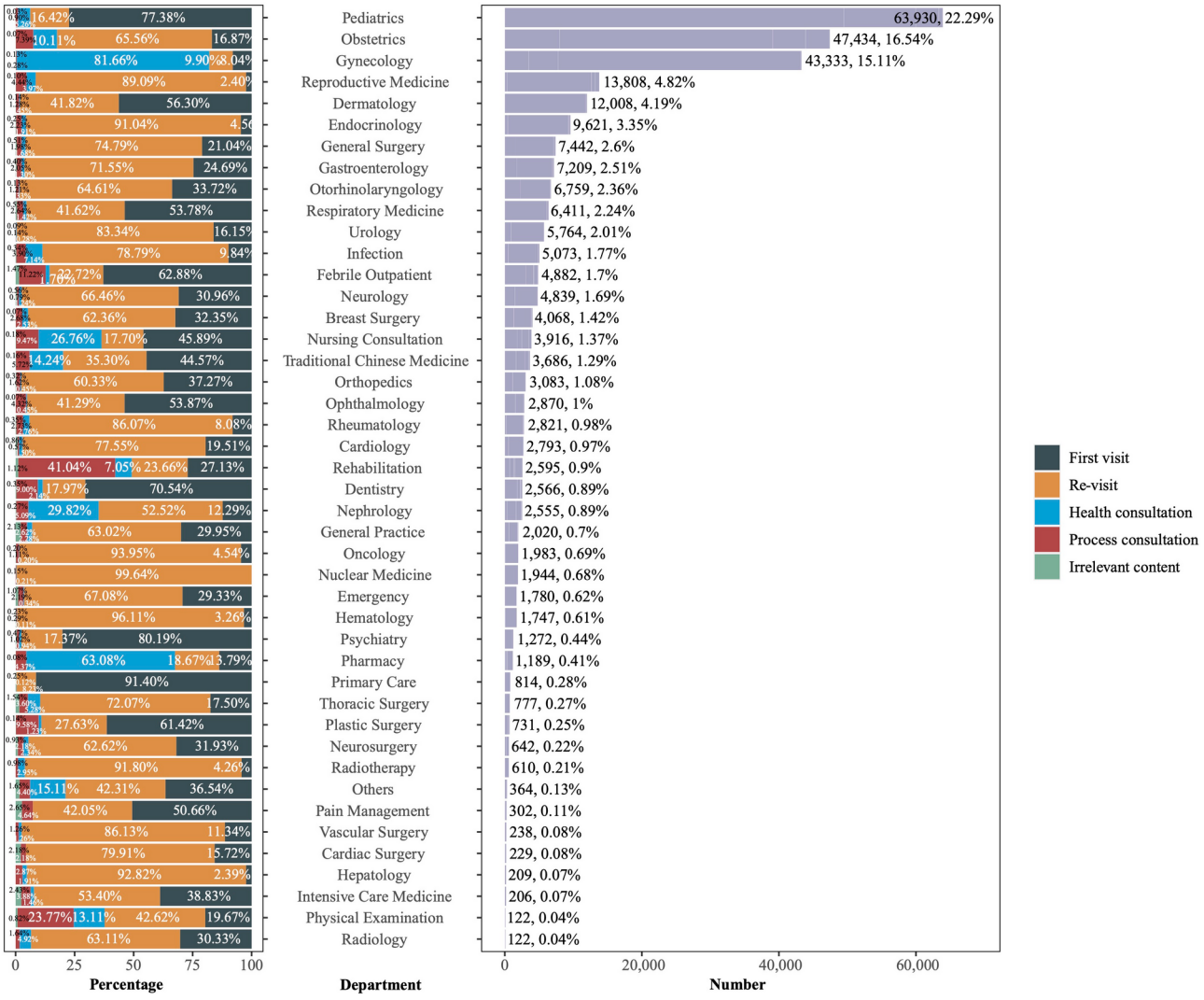

Fig. 7 Order types of 44 medical departments in 2020

are more likely to have trouble handling new media gadgets [27, 28], as well as the platforms of Internet hospitals using smartphones. The complex interface designs of many Internet hospital platforms, which prioritize functionality over usability, exacerbate these challenges. Current platforms rarely incorporate geriatric-friendly features such as enlarged fonts, voice-assisted navigation, or simplified workflows, exacerbating usability issues [29]. Another critical factor is the relatively low receptiveness of elderly to emerging technologies and novel service models. Many elderly users, particularly those with chronic diseases requiring complex management, may perceive online consultations as inadequate substitutes for in-person visits.

To reduce and even eliminate the "digital divide" for the elderly, the designer of online consultation platforms should take needs of elders into consideration. First, the operation interface should be reformed to improve its ease of use [30]. Feedback from the users should be analyzed to improve the using experience under full consideration of their cognitive, auditory, and visual abilities [31, 32]. Second, the compatibility of the applications should be improved to better adapt to older devices and operating systems. Third, the functions of real-time tracking and collaboration among authorized family members can be added after sufficient authorization from the patients, so that family members can track the elders' current consultation progress in real time, assist with relevant medical information and receive medical advice simultaneously. Family members' involvement can not only help the elderly to overcome operational difficulties, but also result in greater patient-surrogate congruence [33]. In brief, allowing the elderly to enjoy convenient Internet medical services with simplest operation is critical for fully utilizing online consultation platforms and developing an age-friendly smart medical system.

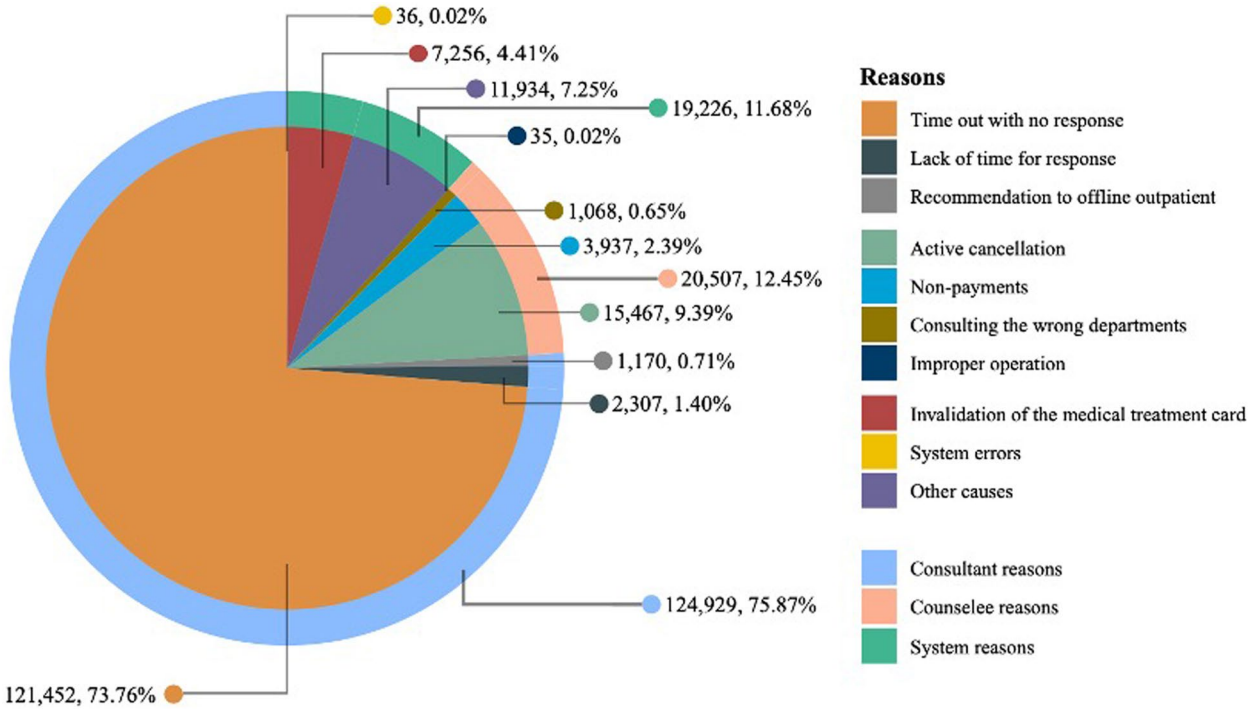

Fig. 8 Reasons for order incompletion

Table 3 Completeness of present diagnosis and medical history vs. Consultation completion rates

		Orders			
		Total	Completion	Incompletion	Completion rate
Present diagnosis	Filled	211,796	159,342	52,454	75.23%
	Unfilled	382,899	270,691	112,208	70.70%
Medical history	Filled	259,683	197,562	62,121	76.08%
	Unfilled	335,012	232,471	102,541	69.39%
Both	Filled	206,567	155,455	51,112	75.26%
	Unfilled	329,783	228,584	101,199	69.31%

Table 4 Orders completion rates by personnel titles and types

Categories	Title				Total
	Senior	Sub-senior	Intermediate	Junior	
Doctors	70.38%	74.54%	70.28%	69.74%	71.85%
Nurses	89.21%	87.07%	86.86%	87.13%	87.10%
Pharmacists	80.19%	92.03%	84.76%	77.05%	86.75%
Therapist	-	-	75.00%	77.78%	76.92%
Technicians	-	-	0	62.50%	50.00%

The inconformity of the account owner and the actual patient

The appearance of adult counselees in pediatrics and male counselees in gynecology and obstetrics indicated that a significant amount of counselees created consultation orders on behalf of other people. This constitutes a noteworthy innovation revealed in our study, as such proxy consultation behaviors have not been documented in prior literature. In addition, in some departments where a high proportion of elderly patients receive offline services, the proportion of online patients is significantly lower. It is also possible that there might be a discrepancy between the account owner and the actual patient. The inconformity of the account owner and the actual patient may cause confusion in medical records, insurance payment problems, medical risks and other issues. For many years, the offline healthcare has strictly enforced real-name visits, which effectively assures the consistency of medical records and patients [34], thus avoids the issues of medical security, medical insurance and other related problems. In the context of online medical services,

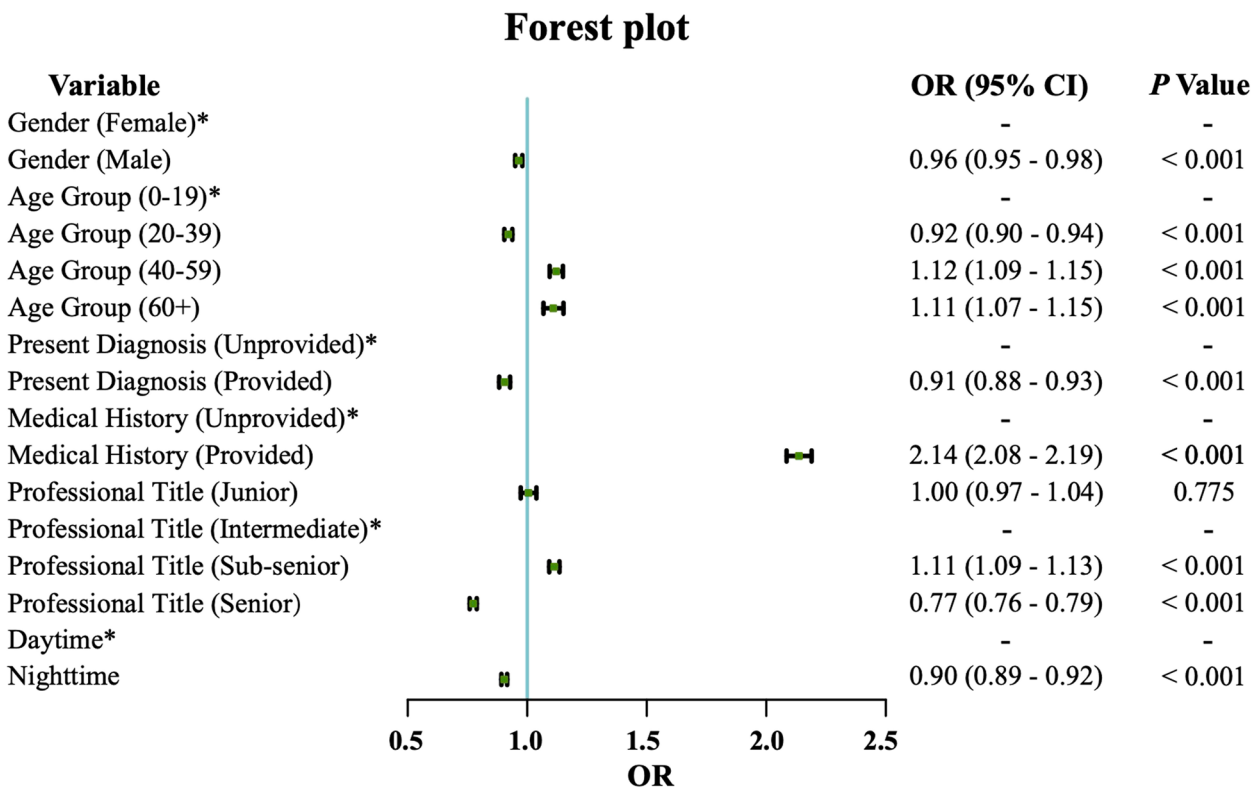

Fig. 9 Forest plot of the multivariate logistic regression model

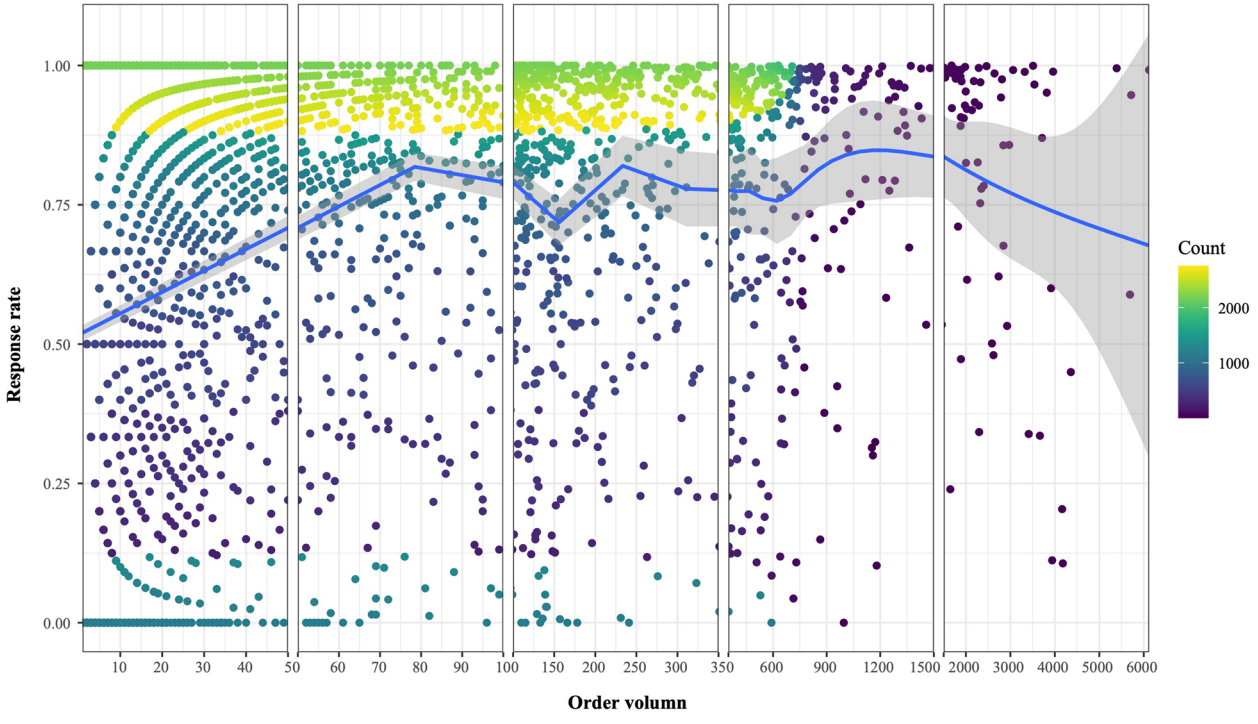

Fig. 10 Order volume and response rate of consultants

ensuring the consistency between the account owner and the actual patient is critical to maintaining security and accuracy in medical data management.

Identity recognition technologies, including password management systems, facial recognition, and even biometric authentication, provide effective solutions to address this challenge [35–37]. For example, telemedicine platforms like Teladoc Health have implemented multi-factor authentication (MFA) mechanisms to verify user identity before granting access to sensitive medical information. Furthermore, the integration of facial recognition technology with cloud computing has demonstrated significant potential in enhancing the accuracy and efficiency of medical record management [38, 39]. By leveraging cloud-based systems, healthcare providers can automatically match medical records to the correct patient using facial recognition algorithms.

In addition, the function of associating family members with authorization can be established. On this scenario, the real counselees' identity information as well as the associated medical records can be directly selected by the account owner, so that the medical information can be correctly provided and recorded. A practical example of this is the MyChart platform [40], which enables users to access and manage other members' health records through a centralized interface with role-based permissions. This proxy access mechanism ensures that medical data remains securely stored in individual accounts while allowing authorized individuals to view or update information as needed.

Imperfection of access rules and practice regulations for different types of consultants

According to our analysis, even though the doctors contributed as the main service providers in the Internet hospital, a proportion of online consultations were responded by other types of consultants including pharmacists, nurses, therapists, and technicians. Only qualified doctors are permitted to deliver diagnosis and treatment services according to current policies in China. Even other types of consultants are not permitted to provide diagnosis and treatment services, they can still provide medical advice which will also have an impact on the counselee's health-improvement efforts. For example, part of the nursing consultation orders with intention seeking for diagnosis and treatment were classified as first visit and re-visit in our study, but they were all answered by nurses.

Therefore, the diversity of consultant for online consultation brings not only potential benefits of more pluralistic health-care services, but also risks of iatrogenic damage caused by the absence of proper regulations. The lack of appropriate access rules to guarantee that all of the online consultation service are performed by qualified health-care professionals is a main policy gap currently. The practice regulations defining the service scope and process standards of online consultation for different consultants should be established based on actual demand. In some countries, associations have already provided standard manuals of practice guidance for medical personnel engaged in online services, with the aim of ensuring the quality of services and the safety of patients [41, 42]. But such efforts are lacking in China.

The imbalance of service supply and demand

Along with the fact that online consultation is more popular among young patients, the demands of various departments were also uneven. Our study showed that pediatrics, obstetrics and gynecology received the largest volume of online consultation orders, reaching more than half of the total. Patients of internal medicine such as cardiology, endocrinology and nephrology, are considered to be more suitable for regular re-visits via online medical services. However, the amounts of orders in these departments were vanishingly small. Besides, 43.79% of the consultation orders were received by the consultants with senior professional titles, the number of whom accounted just for 18.37% of the total. It indicated that the patients were inclined to consult medical professionals with higher professional titles which was consistent with their offline medical seeking behaviors [43]. The dual pressures from both online and offline service demands significantly exacerbate the workload burden on senior-title providers, thereby contributing to their prolonged average waiting durations. With the conflict of high demand and relatively low supply of high-quality medical resources [44], medical institutes should adjust their medical resource supply according to the actual needs. For example, develop an intelligent scheduling algorithm that automatically limits the consultation orders waiting for senior consultants based on three parameters: current workload (pending consultations/hour), historical response speed (average hours), and patient satisfaction scores. Also, the algorithm could prioritize transferring follow-up cases of chronic internal medicine patients to specific junior consultants who are approved by seniors and platform. These can allow excessive medical demands to be reallocated among consultants to alleviate the online medical pressure.

The incompatibility between the scope of practice and actual consulting contents

As the main business of online consultation services, online diagnosis and treatment services are only applicable to the patients with diseases that have been clearly diagnosed by medical institutions in advance and have not significantly changed recently for safety concerns [4]. Even though this is a fundamental policy to define the

scope of practice of online medical platforms in China, it is quite difficult to implement in practice. To obey such rules, the offline visit records are sometimes mandatory formally for online consultation users. However, this kind of formalism has several vulnerabilities. On the one hand, some eligible patients from other medical institutions may be banned due to the insufficient data interconnection among different hospitals. On the other hand, the requirement of offline visit records may be unnecessary for health and process consultation, in which the diagnosis and treatment process is not involved. Besides, it is hard to ensure that the current consulting contents are relevant with the previous offline medical records. Even if the consultants are supposed to reject the orders which are not considered as re-visits, it is hard for them to differentiate the order types due to the ambiguity and incompleteness of the provided information. Previous studies have not thoroughly explored the scope of counsultants' practice and the actual consulting content they handle. Through our innovative content classification method, the study revealed that qualified re-visits accounted for less than half of the consultations, while one-third were categorized as first visits, indicating a clear mismatch between the counsultants' scope of practice and the actual consulting contents in the platform.

To facilitate the online consultation practice for diagnosis and treatment, the pre-diagnostic information should be obtained as comprehensive as possible. To achieve such goal, the improvement of data interconnection among medical institutes is necessary. Question prompt lists may be used for better doctor-patient communication. Further descriptions from the counselees should be required if the medical records are incomplete [45]. On this basis, the ex-ante judgment of the consultation types can be made with the assistance of artificial intelligence [46–49]. The counselees should be informed of medical risks and recommended to offline visits if their consultations were judged as first visits [50]. Recent advancements in large language models (LLMs) such as GPT-4 and Med-PaLM have demonstrated impressive capabilities in extracting and analyzing content from unstructured patient narratives [51]. Moreover, the scope of application for first visits, especially in emergency situations, can be explored by further researches. Internet hospitals might make good use of smart wearable devices [52] to explore new fields, such as postoperative pain management [53, 54], remote patient monitoring [55, 56], etc. During the COVID-19 pandemic, some temporary policies were issued that patients with respiratory symptoms were encouraged to seek online consultation even at the initial visit in China [10]. This attempt had launched meaningful exploration for first-visit services while more empirical studies are needed to evaluate the potential risks and benefits.

The insufficient service quality control for response rate and timeliness

The user experience of online consultation service is intuitively associated with whether an order was promptly responded. However, nearly one-third of online consultation orders were not completed, mainly due to the consultant reasons, of which "Time-out with no response" accounted for the majority. As the result of multivariate logistic regression showed, senior professional title was an influencing factor for order incompletion. Apart from the imbalance of service supply and demand mentioned above, the lack of extra time due to massive offline workload for senior consultants is a likely cause. Within China's healthcare ecosystem, these senior professionals typically bear multifaceted responsibilities encompassing clinical practice, medical education, and research supervision. This role multiplicity creates systemic time poverty that might compromises their energy to engage in online consultations. Besides, the providing of medical history can significantly promote the response rates, indicating the availability of comprehensive medical data can enhance the consultants' confidence in offering safe medical services.

Additionally, an obvious time lag between the submission and response of consulting orders was observed. Under current policies, the working time on online platforms for consultants are not scheduled. Most consultants respond online orders in their spare time, which may cause potential delay of order response. This may lead to poor user experience and risks of disease deterioration especially in emergency cases.

Limitations and further directions

Our study has some limitations. First, the data were exclusively sourced from Internet hospital platforms, with no access to counselees' directions offline medical records, thereby precluding cross-validation during consultation type classification. Furthermore, the medical information provided by the counselees may be of limited relevance to their current health conditions. While we implemented rigorous control measures in the manual classification process, potential subjectivity remains inherently inevitable. Second, due to the unavailability of detailed medical information from doctor-patient conversations and the absence of longitudinal follow-up data, the service quality of online consultations could not be comprehensively evaluated. Third, since follow-up could not be conducted as our data were desensitized, we couldn't assess the long-term effectiveness and benefits of online consultation. This limitation prevents assessment of whether online consultations: (1) led to measurable health improvements, (2) reduced unnecessary offline visits through effective triage, or (3) conversely, resulted in delayed care due to missed diagnoses or long

waiting online. Fourth, the data in this study were generated during the outbreak of COVID-19 and might not be representative of the condition in the post COVID-19 period. The absence of pre-pandemic baseline data and post-pandemic comparison cohorts makes it difficult to distinguish between transient pandemic effects and long-term trends in the development of Internet hospitals. Fifth, our study's sample was exclusively sourced from a platform developed by the affiliated company. Although rigorous strategies were employed to enhance diversity and representation, the dataset remains insufficient to fully represent all Chinese Internet hospital users. Sixth, this study is based on quantitative operational data but lacks a multidimensional quality assessment incorporating user experience surveys and provider interviews. Further studies should incorporate more information, including offline medical records, online doctor-patient conversations, tracking patient outcomes post-consultation, and conducting a comparative analysis of pre- and post-pandemic data, in order to more precisely and comprehensively evaluate the effectiveness of online consultations. Meanwhile, more useful experience should be actively explored to develop specific guidelines for online diagnosis and treatment, looking forward to promote the safety and effectiveness of online consultation service.

Conclusion

The online consultation services on Internet hospitals are still in the nascent stages of development with many challenges to be solved urgently. The current platform's substantial number of first-visits contradicts regulatory guidelines restricting Internet hospitals to re-visit patients, while the relative absence of elderly and chronic disease patients exposes inadequate coverage of target demographics. The lack of regulation governing prevalent proxy consultation challenges compromises the security and data integrity of medical. Furthermore, the coexistence of multidisciplinary consultants without standardized practice guidelines highlights systemic regulatory gaps. When combined with resource allocation imbalances caused by user preference toward high-demand departments and senior professionals, this further leads to inadequate service response rates and timeliness.

Addressing these multidimensional challenges requires coordinated advancements in platform design, identity authentication systems, consultant qualification protocols, and intelligent resource distribution mechanisms. Future development should focus on harmonizing technological innovation with geriatric-friendly interfaces, establishing evidence-based standards, and introducing LLMs to ensure service quality and patient safety. By bridging these gaps, online consultation service can maximize their potential in the areas of public health as well as disease prevention and treatment.

Abbreviations

CI	Confidence intervals
IQR	Inter-Quartile Range
LOESS	Locally weighted regression
OR	Odds ratio
LLMs	Large language models

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

KG contributed to the study concept and provided overall guidance. ZC and ZL contributed to the acquisition of data. MY and YY contributed to the statistical analysis and drafted the manuscript. HL and YZ contributed to data annotation. ZX, JR and KG critically revised the manuscript. All authors contributed to the interpretation of the results and gave final approval of the manuscript.

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Data availability

We are unable to share data publicly because of ethical and legal restrictions. The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Medical Research Ethics Committee of the First Affiliated Hospital of Xiamen University, Xiamen, China (protocol number SL-2021KY044-01). Informed consent was waived by our Medical Research Ethics Committee because of the data anonymization and the retrospective nature of our study. All procedures followed were in accordance with the ethical standards of the World Medical Association's Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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