



An internet-based multidisciplinary online medical consultation system to help cope with pediatric medical needs during the COVID-19 outbreak: a cross-sectional study

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Background: Telemedicine is becoming an emerging innovative supplement to the traditional medical system in China. In the present study, we described the rapid implementation of the telemedicine in pediatrics during the coronavirus disease 2019 (COVID-19) outbreak and explored its value in response to the demand for pediatric medical services during the epidemic.

Methods: An Internet-based platform for multidisciplinary online medical consultation was established on February 8, 2020, by a national children's medical center in China. The medical data of the traditional hospital visits and novel online visits from the first two months (February 8 to March 31) after the establishment of the platform were collected and analyzed. The demographic features, changes in the disease spectrum and characteristics of online medical services were described.

Results: The total number of visits was significantly lower (by 75.3%) than that of in the same period in the previous year. The disease spectrum was different with a significant decrease of >95% in the number of patients with infectious or contagious diseases. The online visits accounted for 14.7% of all visits. Online patients came from all over the country, covering 91% of the administrative regions of China, and the largest proportion of inquiries were for infants (33.7%) ($P < 0.01$). The response rate of experts to requests for online consultations was 100%. During the study period, 266 experts from 25 pediatric specialties completed 12,318 effective consultations, proving different degrees of online supplementation for various specialties (4.3–168.4%). Online consultations mainly addressed two types of problems: (I) accessibility of the traditional hospital visits and (II) consultations regarding an illness. Data from pediatric nephrology showed that 96% of the patients with stable chronic kidney disease successfully received follow-up medication adjustment guidance through the online platform.

Conclusions: The traditional hospital medical services have been affected by the COVID-19 outbreak. The multidisciplinary online medical consultation system is a strategy to actively respond to the medical needs of children during unique periods.

Keywords: Telemedicine; online medical consultation; pediatrics; chronic disease; coronavirus disease 2019 (COVID-19)

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Introduction

To mitigate the spread of the virus during the coronavirus disease 2019 (COVID-19) outbreak, a series of interventions have been implemented, such as stay-at-home orders, city lockdowns and traffic restrictions, which may affect the hospital visits of non-COVID-19 patients, especially those who seek medical services across provinces. Meanwhile, due to concerns about the epidemic, many parents cannot or are not willing to take their sick children to the hospital. However, patients still have non-COVID-19 related medical needs, and delays in obtaining a medical diagnosis and treatment may result in adverse consequences (1). As science and technology continue to develop, Internet-based platforms for delivery of medical services may be an effective supplementary measure to meet the needs of patients during unique periods, such as during epidemics, by reducing unnecessary hospital visits for some patients (2). Telemedicine is becoming an emerging innovative supplement to the traditional medical system in China. In the present study, we report the establishment of an Internet-based multidisciplinary online medical consultation system in a national children's medical center in China. We analyzed the characteristics of the hospital visits and online visits during the COVID-19 outbreak, explored the value of the new online service in response to the demand for pediatric medical services during the epidemic, and discussed the continued usefulness of such a platform in non-epidemic periods. We present the following article in accordance with the STROBE reporting checklist (available at <http://dx.doi.org/10.21037/tp-20-348>).

Methods

Study design

The Children's Hospital of Fudan University is a national children's medical center and the designated hospital for the treatment of COVID-19 in Shanghai. During the epidemic, this hospital utilized the Internet and the WeChat to launch a platform for nationwide multidisciplinary online medical consultations, developed an online service process (Figure 1), built an online consulting team and established an online management protocol. During the first two

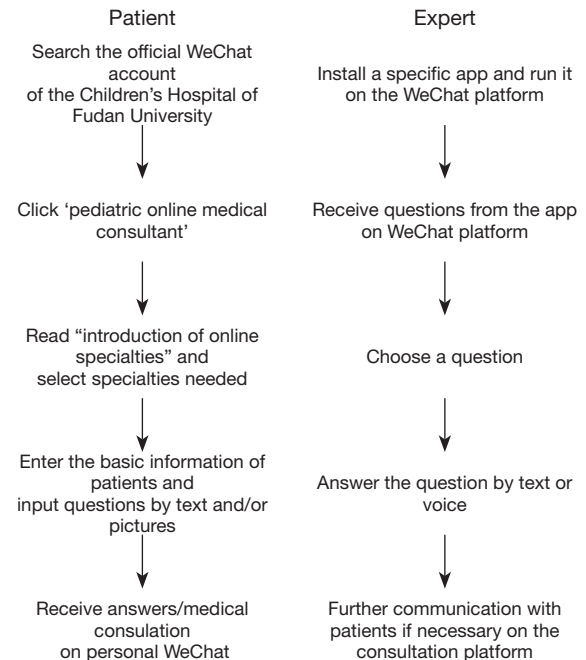


Figure 1 Online service process of the multidisciplinary online medical consultations.

months (February 8 to March 31) after the establishment of the platform, 266 experts from 25 pediatric specialties volunteered to participate in online consultation services (Figure S1). This was a cross-sectional study. Data of both the traditional hospital and novel online medical services delivered from February 8 to March 31, 2020 were collected and compared with the data of traditional hospital medical services from the same period in the previous year (SPPY). The demographic features, changes in the disease spectrum and characteristics of online medical services during the COVID-19 outbreak were described to explore the value of combining the online system with the traditional medical system to meet pediatric medical needs during unique periods, such as the COVID-19 outbreak. The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study protocol was

approved by the ethical committee of Children's Hospital of Fudan University (No. 2020-174) and individual consent for this retrospective analysis was waived

Data collection, clean and definition

The medical data of hospital visits including the outpatient and emergency departments from February 8 to March 31, 2020, and from SPPY (February 8 to March 31, 2019) were extracted from the Hospital Information System, including the number of visits, age, sex, residence, clinics visited, international classification of disease (ICD) diagnostic codes and patient wait time. The residence information collected was the name of the provincial administrative region according to the contact address or the regional information corresponding to the ID card number recorded in the patient's medical chart. Online medical data from the consultation platform from February 8 to March 31, 2020, were collected, including the number of visits, age, sex, geographical location of patients, specialties visited, consultation reason and consultation response. The online patient wait time was defined as the interval between the time of the request for an online consultation and start time of the consultation. The patient wait time for in-person hospital visits was defined as the interval between registration and face-to-face consultations.

Statistics analysis

Data management and statistical analysis were performed with the hospital SQL Server 2010 system. Standard descriptive statistics were used: continuous variables, such as daily visits and patient wait time, were presented as the medians, and categorical variables were expressed as frequencies. Comparisons were performed using the chi-squared (χ^2) test for categorical variables. P values <0.05 were considered statistically significant. Statistical analyses were performed using SPSS 20.0 (IBM, NY). The geographic map was based on 34 administrative regions (provinces, municipalities, autonomous regions and special administrative regions) in China.

Results

Demographic features of the patients attending hospital visits and online visits during the COVID-19 outbreak

The visits from February 8 to March 31, 2020, were compared with the data from SPPY (Table 1). The total

number of visits decreased significantly by 75.3%. Among these visits, the number of outpatient visits had a more significant decrease than the number of emergency visits (80.1% vs. 68.5%, $P < 0.01$). The newly established online medical consultation system was involved in 12,318 visits, which accounted for 14.7% of the total visits during the study period. The geographic distribution of patients was not affected during the period of the COVID-19 outbreak. As the hospital is a national children's hospital, patients come from almost all over the country. From February 8 to March 31, 2020, the patients attending "hospital + online" visits came from 32 regions (provinces, municipalities, autonomous regions and special administrative regions), covering 94% of the national administrative regions of China, and the patients attending the online visits came from 31 regions. The age distribution of patients was different during the period of the COVID-19 epidemic. Data from the combination of hospital and online visits showed that the proportions of children under 1 year old, 1–3 years old, 4–6 years old, 7–12 years old and >12 years old were 22.4%, 24.1%, 18.0%, 30.4% and 4.2% respectively, and that the proportion of children aged 1–6 years had decreased. Data from the online visits showed that the proportions of children under 1 year old, 1–3 years old, 4–6 years old, 7–12 years old and >12 years old were 33.7%, 22.3% and 15.3% respectively. Notably, the online proportion of children under 1 year old was higher than that of hospital visits (15.9%) in the same year and that of hospital visits (20.5%) in the previous year ($P < 0.01$).

Changes in the pediatric disease spectrum during the COVID-19 outbreak

By comparing diagnoses from February 8 to March 31, 2020, with those in SPPY, the number of different ICD diagnostic codes significantly decreased by 19.7% from 2,609 to 2,095 (Table 1). The disease spectrum changed, as indicated by the significant decrease in the number of patients with infectious or contagious diseases. The analysis of the 100 most commonly used ICD diagnostic codes showed that 95% of them had a >50% decrease in the frequency of use, indicating that there were significant decrease in the numbers of patients with those diseases (Table S1). Among them, the ICD diagnostic codes that decreased by 95% or more compared with SPPY were the codes for acute lower respiratory infection (99.9%), flu (99.7%), hand-foot-mouth disease (99.6%), acute bronchitis (98.5%), rotavirus enteritis (96.9%), acute upper respiratory infection (95.7%), scarlet fever (95.6%), acute asthmatic bronchitis (95.5%)

Table 1 Demographic features of the patients attending hospital visits and online visits before and during the COVID-19 outbreak

| | February 8 to March 31, 2019 | | February 8 to March 31, 2020 | |
|--------------------------------|------------------------------|---------------|------------------------------|---------------|
| | Total/Hospital visits | Total | Hospital visits | Online visits |
| Visits | 338,284 | 83,639 | 71,321 (–78.9%) | 12,318 |
| Outpatient (n, %) | 304,244 | – | 60,610 (–80.1%) | – |
| Emergency (n, %) | 34,040 | – | 10,711 (–68.5%) | – |
| Sex | | | | |
| Male (n, %) | 188,421 (55.7) | 44,540 (53.3) | 38,442 (53.9) | 6,098 (52.2) |
| Female (n, %) | 149,863 (42.9) | 38,468 (46.0) | 32,879 (46.1) | 5,589 (45.4) |
| Unknown (n, %) | 0 | 631 (0.7) | 0 | 631 (5.1) |
| Age (y) (n, %) | | | | |
| <1 | 53,663 (15.9) | 18,770 (22.4) | 14,619 (20.5) | 4,151 (33.7) |
| 1–3 | 111,072 (32.8) | 20,179 (24.1) | 17,435 (24.4) | 2,744 (22.3) |
| 4–6 | 83,798 (24.8) | 15,061 (18.0) | 13,175 (18.5) | 1,886 (15.3) |
| 7–12 | 80,160 (23.7) | 25,444 (30.4) | 22,879 (32.1) | 2,565 (20.8) |
| >12 | 16,349 (2.8) | 3,515 (4.2) | 3,213 (4.5) | 302 (2.5) |
| Unknown | 0 | 670 (0.8) | 0 | 670 (5.4) |
| Numbers of different ICD codes | 2,609 | | 2,095 | |
| Median PWT (min) | – | | 30 | 14 |

ICD, international classification of disease; PTW, patient wait time.

and acute gastroenteritis (95.0%), which are all infectious or contagious diseases. Analysis of the top 10 most commonly used ICD diagnostic codes revealed that four diagnostic codes for respiratory infections, namely, acute bronchitis, flu, pneumonia and bronchopneumonia, no longer existed in the top 10 list during the COVID-19 outbreak, while the diagnostic codes for chronic diseases, such as early puberty, precocious puberty, epilepsy and allergic rhinitis, became the new codes included in the top 10.

In addition, by comparing data from different clinical specialties, we found that in terms of the number of total visits, except for the specialties of nursing and neonatal medicine, all the other specialties had a significantly decreased numbers of visits to various extents during the COVID-19 outbreak (–19.6–100%) ($P < 0.01$) (Table S2). The specialties with the largest decreases in the numbers of visits were pathology, infectious or contagious diseases, general pediatrics and rehabilitation, which decreased by 100%, 94.1%, 93.9% and 92.4%, respectively. The reason for the sharp decreases in the numbers of visits in some

disciplines was partially due to the complete or partial suspension of hospital clinics during the COVID-19 outbreak and lack of online availability, such as was the case for pathology and rehabilitation.

Characteristics of the multidisciplinary online medical consultation system

From February 8 to March 31, 2020, 266 experts from 25 specialties participated in online medical consultations, and 12,318 effective consultations (excluding 18 test data) were completed, with a median of 230 daily visits. By analyzing the characteristics of these online consultations, we found that they constituted an effective means of supplementing traditional hospital consultations. Among the 25 online specialties, 21 corresponded to the specific traditional specialties (Figure S1). All played a complementary role to the specialties in varying degrees, indicated by a 4.3–168.4% increase in the median number of daily visits during the study period (Figure 2A). Neonatal

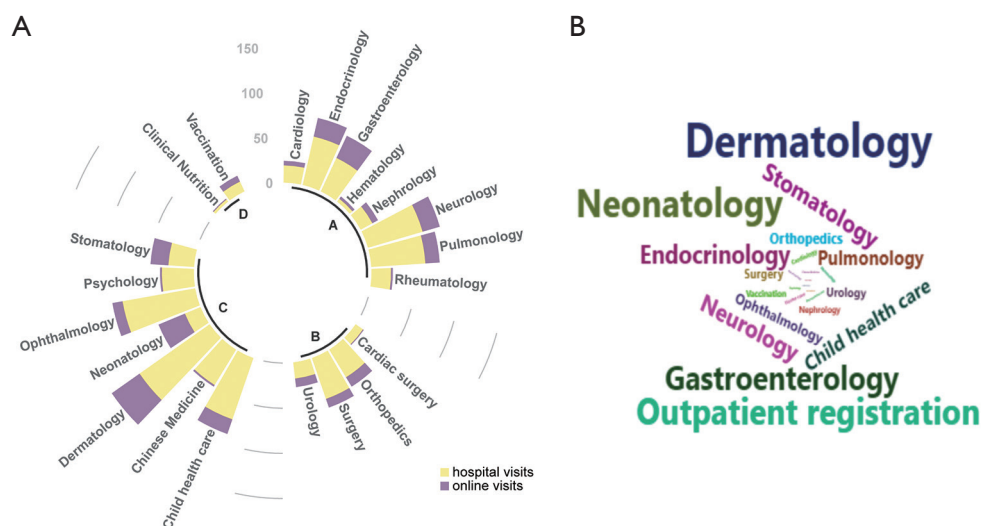


Figure 2 Different complementary effects of online specialties. The median numbers of daily hospital visits and online visits of 21 specialties from February 8 to March 31, 2020 (A) and the frequency of median daily visits of 21 online specialties in order (B).

medicine had the greatest increase in the number of daily visits (168.4%). When comparing data from SPLY, in terms of the neonatology, the number of hospital visits decreased from 2,424 to 1,087 (−55.3%) during the study period. However, due to the complementary effects of online services, including the platform for text and picture inquiries, the number of online visits reached 1,344 during the study period, making the total visits of 2,431, similar as the data from SPLY (Table S2). The other specialties that had >50% increases in the number of daily visits during the study period due to the availability of combining online and hospital services were hematology (75.0%), stomatology (70.2%), gastroenterology (65.9%), vaccination evaluation (58.3%) and urology (52.8%) (Figure 2A). The online specialty with the highest median number of daily consultations was dermatology (38) (Figure 2B). It is noteworthy that the patient wait time for online consultations was two-time shorter than that for traditional hospital visits, with a median wait time of only 14 minutes. In addition, online medical consultations provided a more convenient and economical way of delivering medical services, as it saved the time and expense of traveling from home to the hospital; this was especially true for patients coming from other regions. The efficiency and quality of the medical services were further improved for some patients by the combination of receiving examinations or work-ups in local hospitals with online medical consultations with experts from the national children's hospital.

Analysis of the content of the online consultations showed that online inquires could be classified into two main categories (Figure 3A). One was related to the temporary change in the delivery of hospital service during the epidemic, and the inquiries were about the accessibility of and processes involved in accessing in-person hospital medical services. The other was mainly related to consultations about illnesses, including inquiries regarding symptoms or diseases, inquires about the necessity or urgency of visiting the hospital, and the possibility of and approach to online interventions. The response rate of experts to requests for online consultations was 100%. It was easy and effective to respond to inquiries about the accessibility and process involved in obtaining in-person hospital medical services through the online platforms, while the consultations for illnesses were relatively complex. For mild or stable chronic diseases, experts gave guidance directly online, including disease assessment, treatment guidance, follow-up suggestions and health education. In some cases, experts had to request hospital physical examinations, laboratory tests or imaging results to provide further online guidance. For emergencies or severe cases, experts advised patients to seek nearby hospital medical services as soon as possible.

In the present study, we selected pediatric nephrology, a specialty that generally addressed chronic diseases, and performed a detailed analysis. The data showed that 84.8% of the 468 online consultations for pediatric

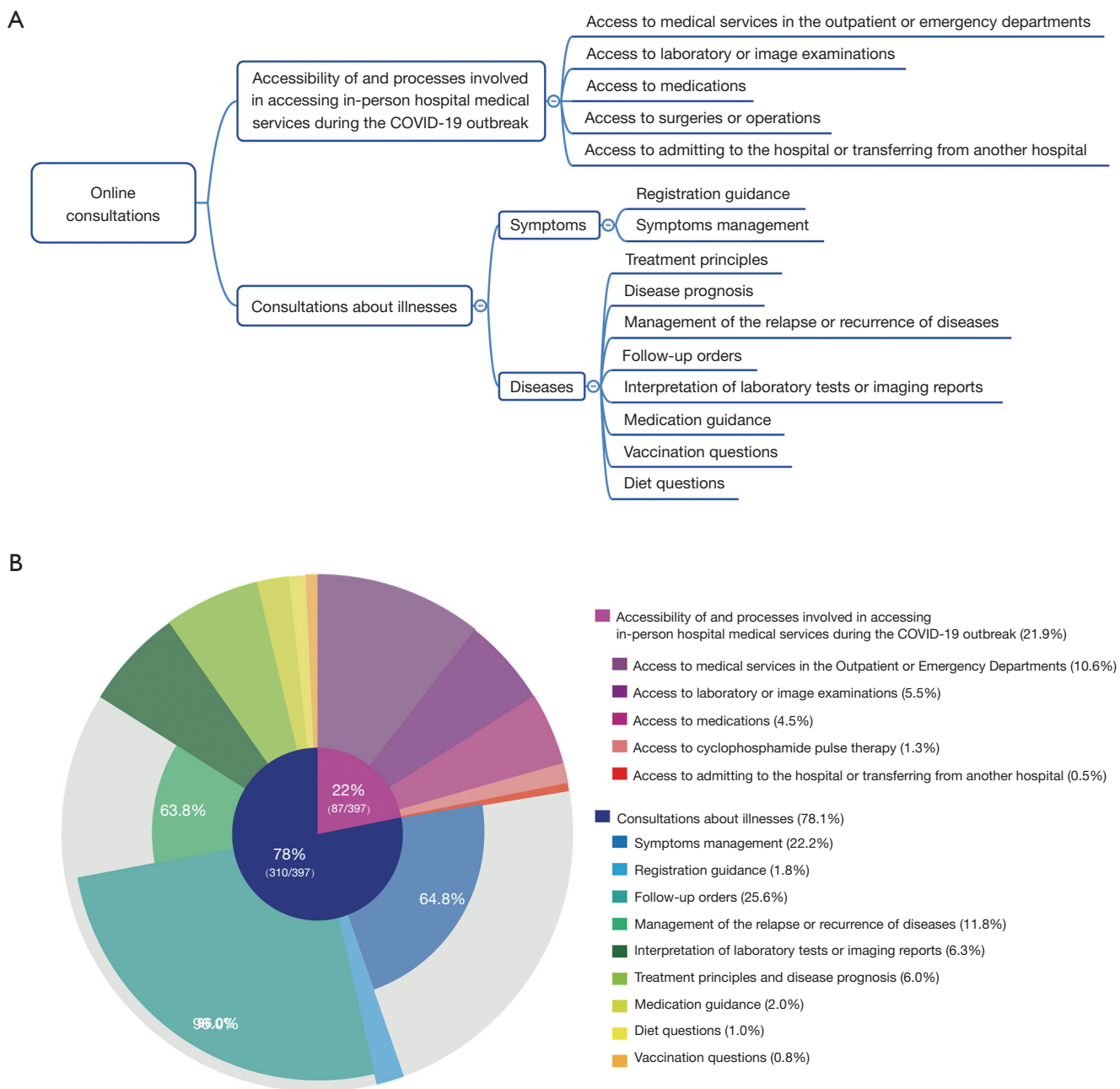


Figure 3 The contents of the online consultations. The categories of the content of the online consultations (A) and the detail information of online consultations for pediatric nephrology (B). The circle represented the 100% response rate of experts to requests for online consultations. The colors represented the different contents of the consultations. The area of sector represents the resolution rate of direct online consultations.

nephrologists were regarding problems specific to pediatric nephrology, and consultations about illness accounted for 78.1% (Figure 3B). Inquiries about accessibility and the process involved in obtaining services in the outpatient

and emergency departments constituted the most common reason for needing a consultation (~50%) in that category, and inquires about diseases constituted the main reason for needing a consultation (~70%) in the illness category;

these diseases included a variety of kidney diseases, such as glomerulonephritis, Henoch-Schönlein purpura nephritis, IgA nephropathy, nephrotic syndrome, enuresis, membranous nephropathy, Bartter syndrome, kidney stones, congenital abnormalities of kidney and urinary tract (CAKUT), overactive bladder, pyelonephritis, peritoneal dialysis and kidney transplantation. All inquiries such as those regarding the accessibility and processes involved in obtaining hospital medical services, registration guidance, interpretation of laboratory tests or imaging reports, treatment principles, disease prognosis, medication guidance, and diet and vaccine questions, were solved directly online. All inquiries about symptoms and the management of the relapse or recurrence of disease received 100% direct responses online, whereas approximately 35% were needed hospital laboratory tests or imaging examinations from a nearby hospital before further online medical guidance could be provided. Notably, 96% of the patients with stable chronic kidney disease received medication adjustment guidance according to the follow-up plan directly through the online platform, thus avoiding in-person hospital visits during the epidemic. A small number (2.5%) of patients with acute and severe diseases received recommendations to seek in-person hospital medical treatment as soon as possible.

Discussion

Advantages of the online medical consultation system

Telemedicine is a novel application of internet technology to the medical field, which is conducive to optimizing resource allocation, innovating service modes, improving service efficiency, reducing service costs, and meeting the growing medical and health needs of the people (3). In recent years, China has actively guided and supported the development of telemedicine (4), and it has played a significant role in fighting the COVID-19 epidemic (2). More than 80 million cases of COVID-19 have been confirmed worldwide (5) and all children are susceptible (6). In the context of such a crisis, the online consultation system established by the Children's Hospital of Fudan University provided another important way for children to seek medical services nationwide. The platform was launched during the period of rapid spread of the COVID-19 outbreak in China in early February. Data from the first two months indicated the positive effect of the online consultation system, accounting for nearly 15% of the total number of visits. The online inquiries came from all over the country, as far as northeast Heilongjiang Province,

southwest Yunnan Province and northwest Xinjiang Uygur Autonomous Region. The age of the children ranged from newborns to 18 years old, and consultations regarding infants (<1 year old) accounted for the largest proportion, indicating that the online system provides basic medical services for vulnerable groups of children for whom it is challenging to make the hospital visits during the epidemic. The content of the consultations involved every specialty available online. It is a system open to the public and is accessible to everyone without limitations based on region. It has played an active role in responding to the medical needs of children of all ages from all over the country during the COVID-19 outbreak. The comparison of various specialties showed that the complementary advantages of online consultation were especially obvious in the vulnerable neonatal population, immunosuppressed children and children with chronic diseases. Compared with the situation in February 2020, the epidemic situation in China was more stable in March, but the median number of daily online consultations was still growing, from 182 in February to 268 in March, indicating the continuous demand and sustainable development of the online consultation system in the future, even after the resolution of the epidemic.

The online consultation system can serve as an effective platform for doctor-patient communication. Not only inquiries about COVID-19, but also any physical or psychological problems of children can be promptly addressed online. During the epidemic, the process of accessing in-person hospital medical service has changed (7). The online platform can be used as an effective way to communicate with patients in a timely manner about the updated process of accessing hospital services. For example, approximately 20% of online consultations in pediatric nephrology were related to this issue. The online responses provided patients with sufficient information to reach the target hospital in the safest and most convenient way. The online platform supported disease consultations as well. The contents of more than 300 online inquiries answered by pediatric nephrologists pertaining to almost all pediatric kidney diseases, enabled most patients to obtain the necessary guidance regarding follow-up plans in a timely manner and to avoid in-person hospital visits during the epidemic, thus ensuring the continuity of medical care for chronic diseases during this unique period. Although some patients needed to go to local medical institutions for relevant examinations based on the guidance received during the online consultation, this method still enable patients to avoid cross-provincial travel during the epidemic period, reduced the risk of virus transmission, and improved the treatment compliance

and safety of patients with chronic diseases during this unique period. Meanwhile, online communication also provided psychological support and helped patients cope with anxieties during the epidemic while they stayed at home (8).

Limitations of the online medical consultation system

To date, most physical examinations, laboratory tests, imaging modalities and operations are not available on the internet; therefore, the online medical system serves as a supplement to traditional medical system. Although communication through the internet is very convenient, it is not as direct, close and in-depth as direct contact with patients, especially for children. Some doctors may struggle to adapt to the modality of online consultation, as well as the complicated software or digital system. In the absence of professional standards and guidelines, the clinical information obtained online may be incomplete, resulting in missed diagnosis or misjudgment. Some guidelines for telemedicine are available in some disciplines (9), and experts in pediatric nephrology in China have started to focus on the exploration and creation of clinical practice guidelines for online medical consultation systems, providing a model for other disciplines (10,11). In addition, the construction of a structured online medical information system is warranted, to facilitate quality control of online medicine and the application and management of big medical data. In the long run, it is of great significance to seek a precise balance between hospital visits and online visits by means of best patient care and cost effectiveness.

Limitation of the present study

The multidisciplinary online medical consultation system was constructed using the official WeChat account of the Children's Hospital of Fudan University. Although over 1 million people are aware of this WeChat official account and the hospital has introduced the online system in multiple ways, such as through multi-media publicity and integration with the Child Health Initiative (CHI) project (12), public awareness of this newly established online platform may still be limited. The more than 12,000 online consultations performed in the initial stage of the platform might not provide a complete picture of the characteristics of online consultations in the field of pediatrics. Continuously publicization and further in-depth analyses should be carried out to enable more patients to benefit from the platform. In addition, effective observation indicators and evaluation mechanisms, such as

self-evaluation by experts, patient satisfaction evaluations, medical care quality and safety indicators, and economic benefit evaluations are needed to further inform and guide the sustainable development of online consultation.

Conclusions

An internet-based online medical consultation system is a strategy to actively respond to pediatric medical needs during unique periods, such as the COVID-19 epidemic. The use of such a system can not only improve public awareness of the epidemic, but also help address clinical problems, especially those involving children without COVID-19 while stay-at-home orders are in effect, and help alleviate the anxiety experienced by children and their parents during this unique period. The online medical consultation system can effectively divert patients, reduce the number of hospital visits during the epidemic period, thereby reducing the risk of cross-infection, and alleviate concerns. As an effective supplement to the traditional medical system, telemedicine is an area in which future development is needed. Especially during the COVID-19 period, the online consultation system has been shown to have the advantages of remote care, high efficiency and convenience. We believe that with the continuous development of internet technology and online platforms, this novel medical service mode can continue to play a positive role during non-epidemic periods.

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Footnote

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