Review Article

The influence of novel coronavirus pneumonia on chronic disease management of asthma—a narrative review

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Background and Objective: The coronavirus disease 2019 (COVID-19) pandemic has taken a huge global toll on all fronts, creating new challenges for the diagnosis and treatment of respiratory diseases. For chronic management of asthma, on the one hand, the presence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) may affect the asthma disease itself; on the other hand, in order to control the spread of the pandemic, forced isolation, mask-wearing and various disinfection measures also have an impact on the condition and medication of asthma patients. This article reviews the changes in chronic asthma management under the COVID-19 pandemic to provide reference for chronic disease management of asthma after the pandemic and for various public health emergencies in the future.

Methods: Online searching of literature was performed. The National Center for Biotechnology Information (NCBI), PubMed, Google Scholar, and EMBASE were searched.

Key Content and Findings: COVID-19 has had a huge impact on the world, and has also brought new challenges to the diagnosis and treatment of asthma and chronic disease management. On the one hand, the existence of the 2019 novel coronavirus directly affects the asthma disease itself, on the other hand, due to the particularity of the asthma disease itself, different levels of isolation and controls can cause patients with different degrees of medical difficulties; in addition, the application of various disinfectants in the environment also increases the risk of acute attacks of asthma patients, as well as mask-wearing, vaccination, anxiety about the disease, panic, etc., all of which have posed various degrees of impact on the condition and psychology of asthma patients.

Conclusions: The pandemic of COVID-19 has brought many difficulties to the chronic disease management of asthma, and has had a certain impact on the disease control of asthma patients. In the era with overflowing information, internet hospital is the current trend, and there is a long way to go for effectively penetrating medical resources virtually via the internet into chronic disease management of asthma.

Keywords: Asthma; chronic disease management; coronavirus disease 2019 (COVID-19); internet medicine; severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

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Introduction

As one of the common chronic airway diseases, bronchial asthma has been a global public health problem. Prevalence survey data show that more than 358 million people worldwide suffer from asthma, and 346,000 people still die from asthma each year (1). In recent years, under the joint efforts of global asthma experts and all aspects of society, the status quo of asthma control has been improved, symptoms have been controlled in more and more patients, and the number of acute attacks has been reduced. In China, through the implementation of asthma special clinics, the standardized chronic disease management of asthma has played a very key role on the improvement.

The coronavirus disease 2019 (COVID-19) has had a huge impact on the world, and has also brought new challenges to the diagnosis and treatment of asthma and chronic disease management. On the one hand, the existence of the 2019 novel coronavirus may directly affect the asthma disease itself, on the other hand, due to the particularity of the asthma disease itself (it is a chronic airway disease, requiring long-term standardized diagnosis and treatment, and allergens or environmental triggers can lead to acute attacks), under the influence of the pandemic, different levels of isolation and controls can cause patients with different degrees of medical difficulties; in addition, the application of various disinfectants in the environment also increases the risk of acute attacks of asthma patients, as well as mask-wearing, vaccination, anxiety about the disease, panic, etc., all of which have posed various degrees of impact on the condition and psychology of asthma patients. The COVID-19 pandemic makes the clinical management of chronic disease for asthma patients more complicated. This article reviews the changes in chronic asthma management under the COVID-19 pandemic to provide reference for chronic disease management of asthma after the pandemic and for various public health emergencies in the future. We present this article in accordance with the Narrative Review reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1139/rc).

Methods

An online search of literature was conducted. The National Center for Biotechnology Information (NCBI), PubMed, Google Scholar and EMBASE were searched. All literature published in English between January 2014 to January 2023 were included. On searching, we combined various words; main searching keyword 'asthma' was combined with the following words such as 'COVID-19', 'severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)', 'chronic disease', 'Internet-Based Intervention', 'Internet', etc. The search strategy is summarized in *Table 1*.

Results

The impact of COVID-19 on asthma

The new virus has been named as "SARS-CoV-2" by the International Committee on Taxonomy of Viruses, and the disease caused by SARS-CoV-2 infection is known as the COVID-19 as defined by the World Health Organization (WHO). Hypertension, diabetes, obesity, cardiovascular disease, chronic obstructive pulmonary disease, and chronic kidney disease are risk factors for severe COVID-19 patients (2). Studies have shown that COVID-19 patients who have been hospitalized and have chronic lung disease have a worse prognosis (3). Respiratory viral infections, such as influenza viruses and rhinoviruses, are recognized as one of the important causes of acute exacerbations of asthma in children and adults. People with chronic respiratory diseases, especially asthma and chronic obstructive pulmonary disease, are generally at higher risk of complications from acute respiratory viral infections (4). Therefore, both the WHO and the U.S. Centers for Disease Control and Prevention have said that asthma is a risk factor for COVID-19 morbidity and mortality and should be taken seriously.

However, there are limited data to support an increased risk of severe COVID-19 in people with asthma (5), even it shows a reduced risk of SARS-CoV-2 infection in people with asthma during the current pandemic. In a study of 330 subjects with induced sputum samples, there was no significant difference in sputum angiotensin-converting enzyme 2 (ACE2) positive rates between asthmatics and healthy subjects, suggesting that asthmatics may not have an increased risk of contracting COVID-19 (6). But these 330 patients with asthma were not grouped, and whether there is a difference in ACE2 expression between patients with severe asthma and those with mild asthma needs further data support from clinical studies. Patients with asthma infected with SARS-CoV-2 did not have acute asthma attacks during the course of the disease (7,8), there have been reports from Chicago that patients with asthma take longer to intubate than non-asthmatic patients (9), other studies suggest that asthma does not increase the risk

Table 1 The search strategy summary

Items	Specification
Date of search	January 31, 2023 (final day)
Databases and other sources searched	The National Center for Biotechnology Information (NCBI), PubMed, Google Scholar and EMBASE
Search terms used	'asthma', 'COVID-19', 'severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)', 'chronic disease', 'Internet-Based Intervention', 'Internet'
Timeframe	January 2014 to January 2023
Inclusion criteria	Study types: original article, systemic review, meta-analysis, review, clinical trials, observational study; language restriction: English only; species: human; age: adult
Selection process	Corresponding author independently reviewed the titles and abstracts of all retrieved studies to exclude irrelevant studies. Full-text reviews of all included studies were independently performed by both investigators. Disagreements were resolved by discussion

COVID-19, coronavirus disease 2019.

Table 2 Factors associated with respiratory virus infection and asthma attack

Factors	Functions
IL-33	The mechanism of asthma exacerbation caused by respiratory virus infection is that the virus induces the secretion of IL-33 in bronchial epithelial cells and alveolar cells in the airway, and SARS-CoV-2 cannot induce the secretion of IL-33 in the respiratory tract, which may be the reason why asthmatic patients infected with SARS-CoV-2 do not have acute asthma attacks during the course of the disease (17-19)
ACE2	SARS-CoV-2 directly invades human body by binding to ACE2 receptor, entering cells with the help of TMPRSS2, and infecting upper respiratory tract and lung tissue cells after replication (20)
ADAM-17	Increased ADAM-17 activity is a potential mechanism for specific down-regulation of ACE2 receptor expression. Therefore, increased ADAM-17 activity reduces susceptibility to SARS-CoV-2 (21)
IL-13	The expression of IL-13 is increased in asthmatic patients. IL-13 can down-regulate the expression of ACE2, thus reducing the susceptibility of asthmatic patients to SARS-CoV-2 (21)

IL-33, interleukin 33; ACE2, angiotensin converting enzyme 2; ADAM-17, A Disintegrin and Metallopeptidase 17; IL-13, interleukin 13; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

of intubation or mechanical ventilation, and there is no significant association between asthma and increased risk of COVID-19 in severely ill and non-severely ill COVID-19 patients (10). Meanwhile, asthma is not associated with an increased risk of death in COVID-19 patients (11,12). However, if people with asthma have had an acute exacerbation in the year prior to infection with SARS-CoV-2, mortality may be increased, especially in the elderly and men (13). Therefore, special attention needs to be paid to asthma control during the COVID-19 pandemic to minimize the risk of acute exacerbations of asthma. Studies have reported that increased eosinophils in asthmatic or non-asthmatic patients with COVID-19 are associated with lower mortality (14-16). A meta-analysis published in the European Respiratory Journal in August 2021 (17) showed that patients with asthma had a lower risk of SARS-CoV-2 infection compared with non-asthmatic patients, but the risk of hospitalization, Intensive Care Unit (ICU) admission, ventilator use, and death was similar for both groups of patients who tested positive for COVID-19 (17). Interestingly, asthmatics in Asia have a lower risk of contracting SARS-CoV-2 than asthmatics in the Americas and Europe (17). Each country has a very high testing system, and the specific reasons for this difference need to be further studied. In conclusion, there is no clear evidence that asthmatic patients have a higher risk of SARS-CoV-2 infection, or it seems even that asthmatic patients have a lower susceptibility.

Acute asthma attacks are associated with respiratory viruses (*Table 2*). It has been reported that the mechanism of asthma exacerbation caused by respiratory virus infection is that the virus induces the secretion of interleukin (IL)-

33 from bronchial epithelial cells and alveolar cells in the airway (18-20). At present, there are no relevant reports of respiratory tract secretion of IL-33 induced by SARS-CoV-2, which may be the reason why asthmatic patients infected with SARS-CoV-2 do not have acute asthma attacks during the course of their disease. Currently, SARS-CoV-2 virus is thought to directly invade the human body by binding to ACE2 receptor, entering cells with the help of transmembrane serine protease 2, and infecting upper respiratory tract and lung tissue cells after replication. Alveolar epithelium can express ACE2, and high expression of ACE2 can increase susceptibility to SARS-CoV-2 (21). On the one hand, the decreased expression of alkaline amino acid protease and the increased expression of A Disintegrin and Metallopeptidase 17 (ADAM-17) in airway epithelial cells of asthma patients, and the enhanced activity of ADAM-17 may be the potential mechanism of the specific downregulation of ACE2 receptor expression (22). On the other hand, the expression of IL-13 is increased in asthmatic patients, and IL-13 can down-regulate the expression of ACE2 (22), thus reducing the susceptibility of asthmatic patients to SARS-CoV-2. Interestingly, previous studies have shown that IL-13-induced airway epithelial cell proliferation is mediated by ADAM-17 (23). The interconnections between the different mechanisms need to be further explored.

The impact of COVID-19 prevention and control measures on the condition, diagnosis and treatment of asthma patients

Since the outbreak of the pandemic, disinfection measures taken in public places and the use of various cleaners have increased the risk of wheezing in asthma patients. Long-term mask-wearing may also have adverse effects on asthma patients while preventing the spread of the virus, but the specific situation and extent of the relevant data have not been reported extensively in literature.

Influence of disinfection measures on patients with asthma

SARS-CoV-2 virus belongs to β coronavirus, as a new type of coronavirus, commonly used disinfectants including ethyl ether, 75% ethanol, chlorine-containing disinfectants, peracetic acid and chloroform and other fat solvents can effectively inactivate the virus. At the same time, the virus is sensitive to ultraviolet light and high temperatures. Common disinfectants can be divided into nine types according to the composition: chlorine disinfectant, peroxide disinfectant, aldehyde disinfectant, iodine disinfectant, phenol disinfectant, alcohol disinfectant, ethylene oxide, biguanide disinfectant and quaternary ammonium salt disinfectant. These disinfectants generate a wide variety of products with complex ingredients; different types have different sterilization principles and ranges of action, and need to be selected according to actual needs.

Chlorhexidine is a cationic surfactant, which can be used as a topical antibacterial agent and disinfectant, and is widely used in the medical field. There are many cases reported that chlorhexidine induces allergic reactions. Therefore, asthmatic patients with allergies should be cautious when using chlorine-containing disinfectants during the pandemic (24). As early as 2013, the European Association of Allergy and Clinical Immunology has clearly stated (25) that cleaning and disinfection work is associated with acute attacks of bronchial asthma. Disinfectants (such as ethanolamine, etc.), ammonia, cleaning sprays and bleach are risk factors for acute attacks of bronchial asthma. Therefore, during the pandemic, how to guide patients with bronchial asthma to choose disinfection products is a new area of chronic disease management that clinicians need to pay attention to.

Effects of mask-wearing on patients with asthma

In theory, people with asthma should insist on wearing masks during the COVID-19 outbreak to reduce their exposure to allergens and viruses. Current studies have claimed that the use of N95 masks can affect the breathing of patients with chronic respiratory diseases with poor lung function, increasing the risk of respiratory failure (26). Long-term wearing of masks may have adverse effects on patients with asthma, and long-term wearing of masks is generally not recommended for patients with severe asthma. A randomized controlled clinical study showed no significant difference between surgical masks and N95 masks in preventing and treating influenza virus infection (27). Therefore, for patients with asthma who are not on the frontline of anti-pandemic work or who are not being in high-risk areas, medical surgical masks can achieve protective effects.

Influence of isolation measures on return visit of asthmatic patients

Traditional chronic disease management mainly focuses on in-hospital management, which is mainly carried out by regular offline outpatient visits and regular patient

education activities. Since the pandemic of COVID-19, in order to control the pandemic outspread, various provinces and cities had adopted mandatory isolation measures according to the government requirements, making it more difficult for asthma patients to get medicine and pay return visit, and some patients were even forced to stop taking medicine. Patients with asthma failed to seek medical treatment in time, which seriously affected the control of the condition. At the same time, it should be noted that during the pandemic, patients with asthma who needed to go to a medical institution for a long-term chronic disease or for an acute attack, were facing an increased risk of exposure to SARS-CoV-2.

Economic impact on patients

The COVID-19 pandemic has not only seriously jeopardized the health of people around the world, but also to the world economy. For asthma patients, on the one hand, isolation at home due to pandemic prevention and control measures may have blocked their income sources; on the other hand, the reexamination of lung function assessment required additional payment of nucleic acid testing and blood routine. The acute attacks of asthma induced by the use of disinfectants mentioned above not only bring harm to the body, but also increase the medical burden of asthma patients.

Psychological impact on patients

Anxiety and depression are the most common psychological disorders in people with asthma (28). González-Freire *et al.* conducted a psychological survey on 373 patients with bronchial asthma, and found that 35.4% of patients had anxiety, 14.3% had depression, and 11% had combined anxiety and depression (29). Poorly controlled asthma can worsen anxiety and depression (30). At the same time, patients with bronchial asthma complicated with anxiety, depression and other psychological disorders are significantly correlated with poor control of the disease (31). The documented link between viral pandemics and psychological distress dates back to more than 100 years ago, when Menninger linked the 1918 Spanish flu pandemic to psychiatric complications. During a large infectious disease outbreak, people's emotional responses can include extreme fear due to unknown knowledge of the disease, which, combined with separation from family and friends and restricted freedom, can ultimately lead to a significant mental health burden (32). Studies have shown that during the COVID-19 pandemic, asthmatic patients had worse anxiety and depression symptoms than usual, and were more afraid of being infected with SARS-CoV-2, thus avoiding offline medical services (33). This eventually leads to poor asthma control and a vicious cycle.

During isolation, young asthmatics experienced a greater decline in mental health, which may be related to the fear of losing their jobs due to the pandemic (34). In a survey of 1,656 quarantined patients, 7% showed symptoms of anxiety and 17% showed feelings of anger, which dropped to 3% (anxiety) and 6% (anger) 4 to 6 months after the release of isolation (35). Longer isolation is associated with poorer mental health, and the economic loss caused by isolation is one of the risk factors for psychological abnormalities in patients. Taking into account the known incubation period, limiting the time of isolation to a scientifically reasonable range without taking excessive precautions can minimize the impact on humans (32).

The dilemma of chronic asthma disease management under the novel coronavirus pneumonia pandemic

Before the COVID-19 pandemic, asthma management was an important public health and healthcare issue. Under the joint efforts of respiratory doctors and all aspects of society, although the control status of asthma patients has been significantly improved, the overall control rate of asthma in urban areas in China is only 28.5% (36), which is still very low. At present, there are still many patients who do not know that they have asthma, and the chronic disease management of asthma still has a big gap compared with developed countries. On the one hand, the awareness rate of asthma is low, the public has an insufficient understanding of asthma, and the operation of the inhalant device of asthma patients is not standardized, which fails to achieve the therapeutic effect; on the other hand, the general doctors lack of understanding of asthma and experience in chronic disease management of asthma, resulting in a high rate of misdiagnosis and missed diagnosis.

The COVID-19 pandemic has brought many difficulties to the chronic disease management of asthma, which is still worsening. On the one hand, asthma symptoms overlap with COVID-19 symptoms, making it difficult for clinicians to correctly diagnose asthma (37). Due to the fact that lung function measurement can promote virus transmission, The Global Initiative for Asthma (GINA) guidelines suggest that patients with confirmed and suspected COVID-19 should avoid lung function testing, and lung function measurement should be postponed except in emergency situations.

Doctors lack the means to objectively diagnose and evaluate patients' condition, and it is easy to misdiagnose by relying only on medical history, which further hinders doctors' clinical diagnosis and treatment level. Clinicians need to correctly identify whether asthma is worsening or SARS-CoV-2 is being infected. For some groups, exposure to secondhand smoke increases with more time spent at home, and asthma rates may increase in children and adults, especially in less advantaged communities. Systematic review of the evidence shows that children with asthma who are exposed to secondhand smoke are twice as likely to be hospitalized for the condition as children with asthma who are not regularly exposed to secondhand smoke (38).

From the perspective of asthma treatment, nosocomial transmission of respiratory pathogens is a major threat in the context of the COVID-19 pandemic, and the use of nebulizing therapy is of even greater concern. Aerosol particles produced by sprayers are 1–5 mm in size and may be discharged into the surrounding environment (39). These particles may carry viruses, and may spread farther than the natural diffusion mode (40). It is easy to increase the risk of infection of medical staff and patients, so for asthmatic patients infected with SARS-CoV-2, atomization should be avoided as much as possible. The National Asthma Council of Australia recommends that in cases where the use of nebulizer is unavoidable, patients should be isolated, preferably in a zone of negative pressure, and if this is not possible, patients should be placed in a single room.

The use of hormones in the management of COVID-19 patients with asthma is controversial. At the beginning of the outbreak, the U.S. Centers for Disease Control and Prevention and the WHO objected against the use of oral corticosteroids (OCS) to treat COVID-19. This objection was based on experience with influenza,

Severe acute respiratory syndrome (SARS), and middle east respiratory syndrome (MERS), in which the use of OCS in coronavirus infections had prolonged viral replication, clearance time, and was associated with complication rates, risk of mechanical ventilation, and mortality (41). People who had recently required oral glucocorticoids for asthma had an increased risk of death from COVID-19 (42). But later updated guidelines suggested that glucocorticoids were effective in patients with severe pneumonia. Since the COVID-19 pandemic, it is critical to understand which asthma patients are at high risk and how inhaled corticosteroids (ICS), the cornerstone of asthma treatment, affect COVID-19-related morbidity and mortality. Whether ICS prevent COVID-19 or cause a worse prognosis for COVID-19 has been debated (43,44). Studies have shown that the use of ICS can reduce the body's antiviral ability and increase the incidence of COVID-19 (45). *In vitro* studies have shown that glucocorticoids may weaken the antiviral innate immune response, and the use of ICS may lead to delayed virus clearance (46). However, previous use of ICS was not significantly associated with COVID-19 patients, nor did it affect the clinical outcomes of COVID-19 patients (47). There is also no clear evidence that common asthma treatments such as ICS increase asthma patients' susceptibility to SARS-CoV-2. GINA recommends that people with asthma continue to use inhaled asthma control medications. A meta-analysis of using ICS on the effect of COVID-19 outcomes in patients with chronic respiratory disease has concluded that there is currently insufficient evidence to dissuade asthma patients from ICS treatment during the outbreak (43). Some studies suggest that ICS may reduce SARS-CoV-2 replication (48). Underlying immune regulation due to asthma or asthma treatment may have a mitigating effect on COVID-19, but more research is needed to explain this. Neither asthma nor ICS use is currently believed to be associated with an increased risk of hospitalization for COVID-19 (49).

The management of patients with severe asthma during the COVID-19 pandemic was a serious challenge, especially those treated with biologics. The British Thoracic Society noted that patients receiving biotherapy for severe asthma during the COVID-19 pandemic were considered to be at very high risk. For eligible patients with severe asthma, biotherapy should be used to minimize the need for OCS. When a patient starts a new biologic, in addition to considering the usual risks and benefits of treatment, it is important to ensure that the patient's biologic therapy does not face disruption once it has begun. Discontinuation of biologics may lead to an increased risk of asthma attacks, increased use of OCS, and increased likelihood of emergency department visits and hospitalizations, which put patients at increased risk of SARS-CoV-2 infection. Therefore, discontinuation of biologics in patients with severe asthma who do not have COVID-19 is not recommended when benefits and risks are balanced according to the patient's condition. However, asthmatic patients infected with SARS-CoV-2, regardless of the degree of infection, should stop using biologic agents, and resume biologic treatment within 2 weeks after COVID-19 is controlled, as shown by negative nucleic acid test of novel coronavirus (50).

On the drug supply side, even before the COVID-19

pandemic, there have been increasing drug shortages worldwide in recent years (51). Major supply lines around the world have been even more severely disrupted, as has the drug supply chain, with some areas experiencing shortages of asthma control drugs, or the failure to purchase medicines in time due to pandemic prevention and control measures, affecting patients' regular medication and doctors' continued management of asthma patients.

The novel coronavirus vaccine offers hope for ending the COVID-19 pandemic and is one of the remarkable achievements in the history of medical development. In order to end the COVID-19 pandemic as soon as possible, building herd immunity around the world is one of the important measures (52). The European Society of Allergy and Clinical Immunology has proposed that there is no contraindication to the use of the novel coronavirus vaccine on allergic patients who do not have a history of allergic reactions to any of the vaccine components (53). In clinical work, clinicians need to pay attention to the side effects of COVID-19 vaccine after vaccination, there should be more stringent monitoring of the history of allergy and allergic disease with this risk factor. More than half of the allergic reactions occurred after the first dose (54), and most patients developed allergic symptoms within 1 hour after vaccination (55). Asthma is not a contraindication to vaccination against the novel coronavirus. Experts and clinicians from the European Union, the United States, and the United Kingdom all believe that only patients who are allergic to vaccine ingredients or have severe allergic reactions are prohibited from receiving the novel coronavirus vaccine, but at present, there are no relevant survey data on asthma patients receiving the novel coronavirus vaccine at home and abroad.

Progress in mobility management of asthma

Before the COVID-19 pandemic, chronic disease management of the respiratory system attracted increasing attention from respiratory doctors and received extensive support from all walks of life. The information management mode of chronic respiratory diseases launched by medical institutions represented by the Respiratory Department of Nanjing First Hospital mainly manages chronic respiratory diseases through application (APP), cloud platform service and personal APP medical terminal, and provides remote medical services with cloud technology and cloud computing, thus bringing more convenient medical services to patients (56). In this management mode, patients can use the personal APP medical terminal to monitor their breathing at any time, and upload the data to the cloud platform for further analysis and processing. Medical staff can obtain patients' detailed medical record information and real-time monitoring data through cloud platform services, and carry out remote consultation or guide patients for treatment as needed. At the same time, patients can also manage and record their medication through the APP in order to better control their condition. The European Society of Allergy and Clinical Immunology has also proposed a new model for asthma control, namely mobile health technology. The role of mobile health in monitoring and predicting the efficacy of allergen immunotherapy is also emphasized.

The COVID-19 pandemic has brought an unprecedented disaster to the world. Taking this as a reference, how to effectively deal with other similar events that may occur in the future and how to strengthen the management of chronic asthma disease need the joint efforts of respiratory doctors and all sectors of society. With the advancement of 5G network and the progress of cloud technology, China will soon build a comprehensive information society, so as in the normalization stage of the pandemic, promoting "Internet + medical health" medicine and related projects will be the current trend nowadays. At present, many studies suggest that through the combination of online and offline, the medical convenience of remote consultation, remote prescription and home delivery of medicine has greatly improved the compliance of asthma patients. To this end, many low- and middle-income countries have expanded access to telemedicine to maintain essential health care services. In China's fight against the COVID-19 pandemic, hospitals at different levels in various provinces and cities have launched the internet medical services, effectively improving patients' medical experience and reducing their medical burden. According to data released by the National Health Commission, as of April 2021, China had more than 1,100 internet hospitals in the country to carry out services, and the number of hospitals above the second level to provide online services had reached 7,700. In addition, more than 50 percent of third-level hospitals allowed online appointments, and 3,300 hospitals succeeded to attend the appointments in the time segments accurate to 30 minutes. At the same time, more than 90 percent of tertiary public hospitals had realized information sharing. In addition, more than 24,000 medical institutions had realized a telemedicine collaboration network covering all prefecture-level cities. Thirty provinces across the country had also established

internet medical service supervision platforms. These data show that China's "Internet + medical health" development has achieved remarkable results. More and more hospitals and medical institutions begin to use internet technology to provide more high-quality and convenient medical services, and also to accelerate the digital transformation of China's medical industry, providing strong hardware and software support for the management of mobile asthma.

Existing research encourages people with mild-to-moderate or well-controlled asthma to use digital health care services (57). But for those whose asthma is poorly controlled, whose asthma symptoms have worsened, or who has increased their asthma medication dose in the past few months, outpatient services should be prioritized (58). More and more hospitals in China have launched internet hospital services, patients seek medicine remotely, experts answer online, drug delivery to the door, chronic asthma patients do not have to travel, and do not have to worry about exposure to the risk of SARS-CoV-2 infection. Patients can get good medical services at home, which not only reduces the travel expenses during the visit, but also improves the level of chronic disease management of patients. Some asthma monitoring devices and internet applications abroad have begun to apply technologies such as Bluetooth and mobile networks (59), these devices and apps can measure asthma symptoms and monitor inhalant use in asthma patients in real time, and feed the data back to the cloud platform to provide real-time monitoring and data analysis for doctors and patients. Through the use of these devices and applications, clinicians can monitor the condition of asthma patients in real time, adjust treatment regimens in a timely manner, reduce the number of acute asthma attacks and the use of oral glucocorticoids, thereby improving treatment outcomes and reducing healthcare costs. In addition, for people with asthma, these devices and apps can also help them better manage their health and improve their quality of life. At present, China's asthma monitoring equipment and internet applications are also constantly developing and improving, more and more patients begin to use these devices and applications for self-monitoring and management, this also promote the digital transformation of China's medical industry.

At present, the mobile internet technologies used for chronic disease management services mainly include: mobile terminal APP, WeChat, wearable devices, etc. The above are also applicable to chronic disease management of asthma patients. The mobile asthma intelligent management system is set up on the mobile terminal, and doctors can carry out systematic education and clinical management for asthma patients through the mobile terminal. The function of the intelligent mobile asthma management system is mainly focused on asthma health education, such as introducing the nature, etiology, inducement of asthma to patients, and regulating the use of therapeutic drugs for patients. Patients fill in the questionnaire to establish asthma health records for information collection. The doctor evaluates the patient's condition through the survey information and makes the appropriate treatment plan. WeChat has a high usage rate in China, which is a platform and a good entry point for the implementation of telemedicine, mobile medical care and smart medical care, and fully broaden the skills of WeChat to implement internet + medical care, which is the trend of future medical services. For chronic asthma disease management, if the consistency, continuity and integrity of the online and offline service experience of patients can be achieved, the mobile medical service with WeChat as the medium will open a door for medical and health informatization.

The birth of internet medicine has brought good news to the management of chronic asthma disease, which has changed the diagnosis and treatment status of overcrowded large hospitals and emptied small hospitals, but there are also some drawbacks. Although more and more hospitals have launched internet hospitals, there is still no systematic online chronic disease management of asthma. The information systems of different hospitals are independent, and health care services are isolated, so the integrity and continuity of chronic disease management cannot be guaranteed. Even if a hospital has established a medical joint platform, it is limited to a few hospitals. The establishment of a broad medical union hospital is not only time-consuming, labor-intensive and expensive, but also costs a lot of manpower and material resources to maintain after completion and operation, and there are risks of patient privacy leakage and data loss.

Conclusions

The pandemic of COVID-19 has brought many difficulties to the chronic disease management of asthma, and has had a certain impact on the disease control of asthma patients. We need to clearly understand that the current chronic disease management model of asthma still needs to be improved. In the era with overflowing information, internet hospital is the current trend, and there is a long way to go for effectively penetrating medical resources virtually via

the internet into chronic disease management of asthma.

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