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Allergic diseases, COVID-19 pandemic, and underlying mechanisms

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Abstract

The impact of COVID-19 on allergic diseases in adolescents is not well described. Although there has been a previous study that examined changes in prevalence one year into the pandemic, there is a need for follow-up due to the nature of the infectious disease. Therefore, this article explored the extent to which the pandemic had a potential mediating effect on the prevalence of allergic diseases in adolescents. Previous study suggested the weighted prevalence of asthma decreased from 2009 to 2021 both before and during the pandemic. The weighted prevalence of allergic rhinitis increased from 2009 to 2019; however, there was a decrease in 2020 followed by a minute increase in 2021. Similarly, the weighted prevalence of atopic dermatitis increased from 2009 to 2019, and decreased from 2020 to 2021. These results suggest that the prevalence of allergic diseases decreased during the pandemic, with some exceptions. In light of the findings, we would like to encourage continued efforts to monitor allergic diseases in the years to come, even after the pandemic is over. It is also recommended that researchers from other countries conduct their own research on the respective topic that can develop a general consensus and confirm the reliability and validity.

Keywords: asthma, allergic rhinitis, atopic dermatitis, allergic morbidity

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1. Introduction

Coronavirus disease 2019 (COVID-19) is a contagious respiratory disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1, 2] Since its first case was identified in Wuhan, China, on December 1, 2019, the disease spread worldwide, and the World Health Organization declared the outbreak a global pandemic on March 11, 2020. [1-3] The number of confirmed cases has reached 550 million worldwide, with almost 6.33 million deaths thus far.[4] Many countries have implemented strict public health measures in order to prevent and mitigate the transmission of the virus.[5] For example, there have been business hour restrictions, self-isolation measures, social distancing guidelines, mask mandates, nationwide lockdowns, school closures, vaccination recommendations, and many more. It has been almost three years since we have adjusted to the “new normal,” and accordingly, society has experienced a multitude of grave changes.[6] These include changes in both lifestyle and environment, which may affect the onset and exacerbation of respiratory and allergic diseases.[7]

Asthma, allergic rhinitis, and atopic dermatitis are some of the most common causes of chronic illnesses.[8] They are increasing in prevalence, which also adds to the burden of health care costs.[9] South Korea has experienced a great deal of allergic burden in children, for which asthma ranks second in disability-adjusted life years with a score of 13.1 years of life lost.[10] However, some reported a reduction in both emergency department utilization and symptom severity during the pandemic.[11] This article will interpret large-scale data from a population of nearly one million, and produce a comprehensive review in regards to changes in the prevalence of allergic diseases before and during the pandemic.

In our previous paper, we looked at the changes in prevalence up to the beginning of the pandemic.[12, 13] In this review paper, we added new observations on the prevalence two years into the pandemic. Since lifestyle and environmental factors have changed as the pandemic period continues, it is meaningful to follow up on the trends in the prevalence of allergic diseases. Many previous studies on the association between allergic diseases and COVID-19 have focused on whether the allergic disease affects SARS-CoV-2 infection and mortality rates, and how to treat infected patients with allergic disease.[14, 15] Since the COVID-19 pandemic is continuing and such a pandemic may resurge periodically in the future, tracking the prevalence of allergic diseases during the pandemic will be useful for policy-making and predicting future changes. It is hypothesized that despite COVID-19, the prevalence of allergic disease will increase continuously.

2. Summarize previous findings

Previous study examined the national trends in the prevalence of allergic diseases among Korean adolescents before and during the pandemic.[13] It is important to observe such changes because there is a lack of research about the subsequent impact of the pandemic on allergic diseases. The estimated weighted prevalence of allergic morbidity continuously increased from 2009 to 2019, although there has been a decrease since 2019. In particular, the prevalence of asthma decreased the most rapidly, followed by allergic rhinitis, and lastly atopic dermatitis with the least decrease. The following section will discuss the trends, compare with the previous studies, and evaluate the strengths and weakness of the research. Also we found asthma and atopic dermatitis have decreased in age-standardized prevalence rates from 1990 to 2019, from Global Burden of Diseases study 2019 (Fig. 1 and 2).

3. Plausible mechanism

The prevalence of asthma was continuously declining even before the pandemic. Although there could be different contributing factors, the most plausible mechanisms include improved asthma education, less smoking, and fewer humidifier use. First, there has been a continuous effort by the government and physicians to educate the general public about asthma. There are a total of 17 different Atopy Asthma Education Information Center within Korea that offers effective education and counseling service on the prevention and treatment of atopic dermatitis and asthma.[16] This intervention is comprised of five different main businesses: professional

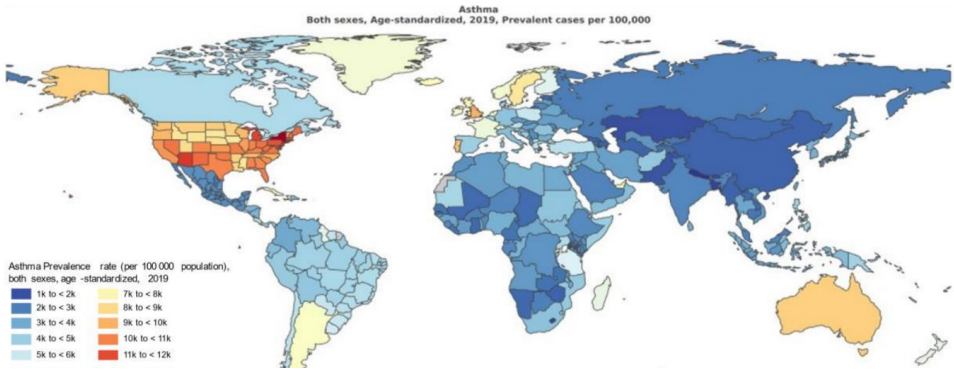

Fig. 1. Age-standardized prevalence from asthma at the country level, 2019

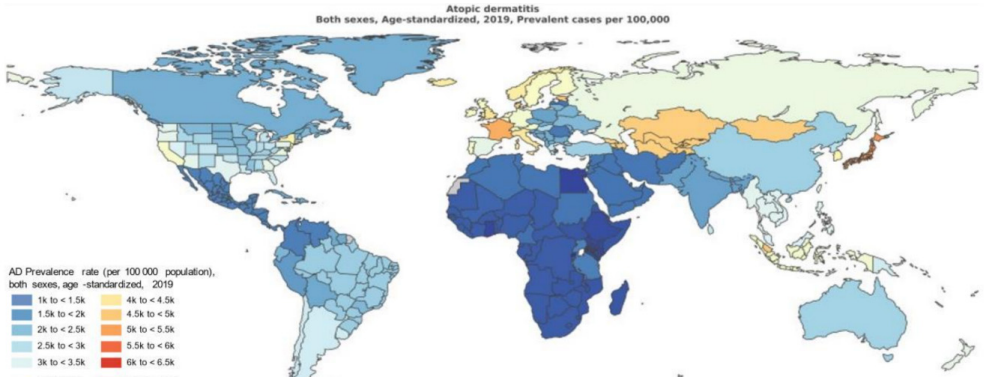

Fig. 2. Age-standardized prevalence from atopic dermatitis at the country level, 2019

counseling, provision of information on allergy and asthma, provision of education and knowledge, support for atopic dermatitis and asthma prevention projects, monitor risk factors of allergic diseases. The management scheme has helped to reduce the sociocultural and economic burden of asthma through a network that administers the trajectory of the disease. Second, there has been a significant decrease in the use of cigarettes. It is well known that smoking impairs lung function, hence a risk factor for developing symptoms of asthma.[17] This coincides with the results in Table 1 in which the prevalence of smoking decreased by one-third from 2009 to 2011 as compared to 2021. The reduction in smoking is due to National Tobacco Control Program (NTCP) which provides school programs, monitors tobacco control laws, and strengthens cessation facilities. The government policy on smoking has, in turn, helped to decrease the prevalence of asthma due to interdependence. Third, there has been a significant decrease in the use of humidifier disinfectant after the incident in 2011.[18] This was when the link between the unknown deaths and the use of chemicals in humidifier disinfectant by Reckitt Benckiser was proved by authority figures. The chemicals chloromethylisothiazolinone and methylisothiazolinone were associated with several adverse health effects, most notably respiratory diseases such as idiopathic lung fibrosis and asthma.[18] Due to an awareness of this incident, an avoidance of humidifier disinfectant was developed. This resulted in a decreased cumulative irritant effect, which decreased the prevalence of asthma.[19] Therefore,

Table 1. Response rate of KYRBS

Year	Target population	Actual population	Participation rate (%)
2009	76,937	75,066	97.6
2010	74,980	73,238	97.7
2011	79,202	75,643	95.5
2012	76,980	74,186	96.4
2013	75,149	72,435	96.4
2014	74,167	72,060	97.2
2015	70,362	68,043	96.7
2016	67,983	65,528	96.4
2017	64,991	62,276	95.8
2018	62,823	60,040	95.6
2019	60,100	57,303	95.3
2020	57,925	54,948	94.9
2021	59,426	54,848	92.9
Total	901,025	865,614	96.0

it can be said that the prevalence of asthma decreased over time due to the combination of factors outlined above.

The changes in allergic rhinitis and atopic dermatitis showed similar trends. There are several factors that account for the changes in regard to the increased prevalence of allergic rhinitis and atopic dermatitis before the pandemic. Here, environmental factors account for a large proportion of well-known risk factors for allergic diseases. It is known that the prevalence of such diseases is more frequently reported in high-income countries.[20] One longitudinal study has demonstrated an increase in immunological disorders as a country grows and becomes more affluent.[21] The growth of domestic product has nearly doubled from 2009 to 2021, from 943.94 billion to 1.8 trillion United States Dollars. Therefore, it could be said that the effects of urbanization and industrialization, such as a westernized lifestyle and air pollution, are associated with the increased risk of having allergic diseases.[22] These environmental factors may enhance the abundance of allergens and induce chemical modifications of allergens.[23] These increase oxidative stress in the human body, which is known to be associated with allergic disorders by skewing the immune system towards allergic reactions. The increase in pollen concentration is partially due to climate change and this is correlated with the increase in allergic diseases.[24]

The decrease in the prevalence of asthma, allergic rhinitis and atopic dermatitis could be interpreted as a result of the pandemic and its subsequent measures. There were multiple social distancing measures enacted due to the pandemic,[5] including mask mandates, school closures, reductions in operating hours, restrictions in high-risk areas, and many more. These restriction measures were effective enough to reduce the prevalence of allergic diseases because they acted as a physical barrier that not only reduced transmission but also reduced contact and penetration

of allergens.[25, 26] Since allergic diseases is a hypersensitive immune system against allergens that involves the overproduction of the immunoglobulin E antibodies. The complete blockage of such allergens will be effective enough to reduce the prevalence of allergic diseases. The allergic diseases are affected by both lifestyle and environmental factors, and the limitation of outdoor activities seemed to have a detrimental effect.[27] Also, there has been a reduction in manufacturing in China after the outbreak, which was one of the most important contributing factors to improving air quality.[28] These factors all combined could explain the downward slope in the prevalence of allergic diseases during the pandemic. In support of this, in atopic dermatitis, where respiratory allergens are not the main etiology, there was less significant decrease in prevalence during the pandemic.

4. Previous studies

There were several studies that also examined the prevalence and trends in allergic diseases. First, there was a study on asthma in Brazil (n=1,434,144).[29] The epidemiological observation study proved that the hospitalization decreased during the pandemic, especially in the pediatric population and the elderly population. This may be due to a reduction in the incidence of many respiratory viral infections impacted by the COVID-19 mitigation strategy. There has been another study in Singapore, which reported a significant and sustained reduction in asthma admissions with a concomitant reduction in respiratory viral infections during the pandemic.[30] The sustained reduction in asthma admissions and PCR-proven respiratory virus infections coincided with the widespread adoption of public health measures during the pandemic. For allergic rhinitis, there has been a study from India (n=128).[31] The report compared the number of patients with symptoms of allergic rhinitis during the pandemic (March to July 2020) and during the preceding three months (January to March 2020) and reported a decrease over two periods. However, the studies above have some limitations which are that they mostly utilize small and heterozygous samples, and that is also a cross-sectional study which is likely to contribute to the inconsistency of the results. However, these previous studies could provide a point of comparison in regards to this current study in Korea.

5. Suggestions

Overall, there has been a decrease in the prevalence of allergic diseases during the examined period. However, more efforts should be made to mitigate the disease further.[32] There was a program in Finland that could be benchmarked in South Korea. Finland has implemented a society-wide (population 5.5 million) proactive program named “The Finnish Allergy Program” to reduce the allergy burden.[32] This program operated for 11 years from 2008 to 2018, and it successfully met government expectations. The program advocated “allergy health” – to have a good life despite allergy. The program was successful: allergic diseases caused fewer symptoms, less disability, and less than 50% of hospitalizations. Similarly, Korea has a society-wide allergy prevention scheme that only targets asthma and atopic dermatitis. This includes monitoring centers in both schools and public health centers

that educate and provide medical support to those who suffer from allergic diseases. However, despite the efforts, the prevalence of allergic diseases has not decreased as much compared to that of Finland. Therefore, policymakers should revise their asthma and atopic dermatitis management program. The program should also reflect on allergic rhinitis since it takes up the largest percentage of allergic diseases, although it has less severity. It would be most effective if Korea could utilize Finland's mitigation strategies so that those who already share the burden of allergic morbidity and those who are susceptible to the disease can be managed effectively.[32]

6. Strengths and weaknesses of previous study

The significance of the study is that this study grasps the prevalence and trends of allergic diseases in the past 13 years.[13] There has been similar research that examines the progression of the diseases, however, there was a lack of evidence during the outbreak. To do so, this research divided the period into seven different categories, with a special emphasis put on the last two years that are classified as the post-COVID-19 period (2020 and 2021). This enables more comprehensive research to take place on allergic diseases.

Nevertheless, there are several limitations to this study. First, this study is specific to South Korea. Since South Korea is a homogenous nation, different races and ethnicities could not be fully encompassed. However, this study does utilize a total of 840,488 individuals, a population that includes adolescents of all types of sociocultural and economic backgrounds. Therefore, the racial and ethnic limitations can be reconsidered given that the data is representative of a unique population to a certain extent. The survey may not account for those who are not enrolled in the public education system. However, the percentage of out-of-school youth in Korea is 4.3 and this is relatively small compared to other countries.[33-35] Therefore, those special cases should be negligible. The second limitation is associated with the nature of the longitudinal study that examines past events, which makes the study inherently prone to several biases. However, much research has proved that the survey has high reliability, which is also supported by its high kappa value. Third, there is a possibility of underdiagnosis due to the nature of the self-reported study because the pandemic decreased medical utilization use frequency. There is a public reluctance to visit hospitals due to the contagious nature of the respiratory disease.[36] There could be concerns that this may affect the results, however, this is highly unlikely because allergic diseases are a form of chronic illness, meaning that the diseases have progressed over a period of time. A single visit to the doctor would not make a dramatic difference in this case, thus this could be regarded as a separate cause that hardly interferes with the prevalence. The cause of the decrease in the prevalence of allergic diseases, which started in 2020 and continued until 2021, is thought to be due to a reduction in contact with allergens caused by wearing a mask and a decrease in air pollution rather than a decrease in access to hospitals. Fourth, although our research examines changes in the prevalence of allergic diseases in light of the pandemic, the study does not show the causal effects of the pandemic. It is hard to conclude that the changes are entirely due to the pandemic. However, the similarities in the two-year trend after the outbreak could potentially indicate that to some extent, the pandemic has accounted for the changes. Finally, it is hard to estimate to what degree the fall in each

allergic disease was due to self-isolation, or due to COVID-19 not being a respiratory virus that induces asthma exacerbation. Due to the nature of the survey, it is hard to assess the exact quantity and the extent of influence each factor possesses. This could be further analyzed potentially by separating the variables such as a respiratory virus.

7. Conclusions

To conclude, this study examined the national trends in the prevalence of allergic diseases among Korean adolescents before and during the pandemic.[13] To do so, the KYRBS data from 2009 to 2021 was utilized and various statistical analyses were performed to quantify the extent of change (Table 1). The overall morbidity of allergic diseases showed a continuous increase in the prevalence from 2009 to 2019, followed by a slight decrease after the pandemic. This is because extensive public health measures such as social distancing and mask mandates acted as physical barriers to the transmission of the disease. In light of the findings, we would like to encourage continued efforts to monitor allergic diseases in the years to come, even after the pandemic is over. This understanding of changes in the prevalence of allergic disease before and during the pandemic will provide useful information for establishing policies in another pandemic in the future. It is also recommended that researchers from other countries conduct their own research on the respective topic that can develop a general consensus and confirm the reliability and validity.

Capsule Summary

To conclude, this study examined the national trends in the prevalence of allergic diseases among Korean adolescents before and during the pandemic.

Ethics statements

Not applicable

Patient and public involvement

No patients were directly involved in designing the research question or in conducting the research. No patients were asked for advice on interpretation or writing up the results. There are no plans to involve patients or relevant patient community in dissemination at this moment.

Data availability statement

Data are available on reasonable request.

Transparency statement

The leading author (Dr. JHK) are an honest, accurate, and transparent account of the study being reported.

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None

Author Contribution

Dr JHK had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors approved the final version before submission. Study concept and design: MJK and JHK; Acquisition, analysis, or interpretation of data: MJK and JHK Drafting of the manuscript: MJK and JHK; Critical revision of the manuscript for important intellectual content: all authors; Statistical analysis: MJK and JHK; Study supervision: MJK and JHK. JHK is guarantor. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Conflicts of Interest

The authors have no conflicts of interest to declare for this study.

Provenance and peer review

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