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Original Research Article

Trends in prevalence of asthma and COVID-19 pandemic-related factors in South Korea: a post-hoc analysis

Ann Nguyen[1#], Jaeyu Park[2#], Mafaz Kattih[1], Ai Koyanagi[3], Lee Smith[4], Min Seo Kim[5], Masoud Rahmati[6,7,8], Seong H. Cho[9*], Nikolaos G. Papadopoulos[10,11]

[1]Department of Medicine, University of South Florida Morsani College of Medicine, Tampa, FL, USA
[2]Center for Digital Health, Medical Science Research Institute, Kyung Hee University College of Medicine, Seoul, South Korea
[3]Research and Development Unit, Parc Sanitari Sant Joan de Deu, Barcelona, Spain
[4]Centre for Health, Performance and Wellbeing, Anglia Ruskin University, Cambridge, UK
[5]Cardiovascular Disease Initiative, Broad Institute of MIT and Harvard, Cambridge, MA, USA
[6]CEReSS-Health Service Research and Quality of Life Center, Aix-Marseille University, Marseille, France
[7]Department of Physical Education and Sport Sciences, Faculty of Literature and Humanities, Vali-E-Asr University of Rafsanjan, Rafsanjan, Iran
[8]Department of Physical Education and Sport Sciences, Faculty of Literature and Human Sciences, Lorestan University, Khoramabad, Iran
[9]Division of Allergy and Immunology, Department of Internal Medicine, USF Morsani College of Medicine, Tampa, FL, USA
[10]Allergy Department, 2nd Paediatric Clinic, National and Kapodistrian University of Athens, Athens, Greece
[11]Division of Immunology, Immunity to Infection and Respiratory Medicine, Faculty or Biology, Medicine and Health, The University of Manchester, Manchester, UK

Abstract

Objective: There are only a few studies investigating the effects of the COVID-19 pandemic on the prevalence of asthma, especially between different age groups. Thus, we aimed to examine the trends of age-stratified asthma prevalence in South Koreans before and during the COVID-19 pandemic.

Methods: This study utilized data derived from the Korea National Health and Nutrition Examination Survey (KNHANES) between 1998 and 2021. The objective of our study was to investigate the annual change associated with asthma, over a period of 24 years from 1998 to 2021.

Results: From 1998-2021, a total of 206,687 subjects participated in the KNHANES surveys. Asthma prevalence in Korean increased in the pre-pandemic era (from 1.61% to 2.92% from 1998 to 2019) but decreased significantly during the pandemic (from 2.83% to 2.97% from 2020 to 2021). Overall, only changes in asthma prevalence in school age children and adults (19-39 years) decreased after including data from years during the COVID-19 pandemic (from 0.12% [95% CI, 0.08 to 0.15] to 0.09% [95% CI, 0.02 to 0.16] and from 0.13% [95% CI, 0.10 to 0.16] to 0.11% [95% CI, 0.07 to 0.16], respectively).

Conclusions: In this study of asthma prevalence in the age-stratified Korean population, both asthma prevalence trends and annual percent changes differed amongst the different age groups before and during the COVID-19 pandemic. Asthma prevalence decreased for preschool and school-aged children, while no clear trends were observed in adults. These results help improve our understanding of asthma prevalence trends in different generations of the Korean population and highlight the need for further investigation of the effects of the COVID-19 pandemic.

Keywords: Asthma, trend, prevalence, Korea

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# These authors contributed equally to this work

***Correspondence**:
Seong H. Cho
E-mail: scho2@usf.edu

ORCID
Seong H. Cho
https://orcid.org/0000-0003-0933-953X

1. Introduction

Asthma is a chronic respiratory disease which, in the majority of cases, involves type-2 inflammation and hypersensitivity to allergens.[1] Previous studies have shown that allergic diseases, such as asthma, has increased in prevalence worldwide over the past decades.[2] The World Health Organization (WHO) estimates that by 2025, over 400 million individuals will have asthma.[3] The economic burden of asthma in South Korea reached an estimated $1.78 billion dollars in 2005.[3] However, in South Korea before the COVID-19 pandemic, studies reported conflicting evidence on whether the prevalence of asthma decreased or increased, especially between different age groups.[4, 5]

The first reported case of COVID-19 occurred in December, 2019 in Wuhan, China and quickly spread worldwide, leading to the deaths of over 6.9 million individuals with over 750 million cases reported to the WHO.[6] Asthma, amongst other chronic diseases, was listed by the WHO as a potential risk factor for developing COVID-19 despite studies concluding that asthma itself is not a premorbid condition and can even decrease risk of COVID-19 mortality.[7-10] To prevent and mitigate the spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the South Korean government implemented strict public health measures including vaccinations, lockdowns, social distancing, and mask mandates.[10] These restrictive measures acted as physical barriers between key triggers, such as allergens, pollutants, and rhinoviruses, and individuals susceptible to allergic diseases, thus decreasing the overall prevalence of asthma, as well as other allergic diseases in South Korea.[10] However, in other countries, preventative and restrictive public health measures such as face masks were found to increase psychological distress in those with asthma.[11, 12] In summary, the relationship between asthma and COVID-19 is not straightforward, though poorly controlled asthma is not desirable in any circumstance, especially in combination with COVID-19.[13] There are only a few large studies investigating the effects of the COVID-19 pandemic on the prevalence of asthma in South Korean individuals, especially between different age groups. Some key results were communicated in a letter[14], therefore we considered there is scope to communicate the detailed results in this paper. We aimed to examine comprehensive trends of age-stratified asthma prevalence in South Koreans before and during the COVID-19 pandemic.

2. Methods

2.1 Patient selection and data collection

This study utilized data derived from the Korea National Health and Nutrition Examination Survey (KNHANES).[15] The survey spanned a period of 24 years, with participant counts per year group as follows: 96,269 in 1998–2005; 22,607 in 2007–2009; 23,005 in 2010–2012; 20,695 in 2013–2015; 30,438 in 2016–2019; 7,018 in 2020; and 6,655 in 2021.

The research protocol received approval from both the Institutional Review Board of Kyung Hee University (KHUH 2022-06-042). Written informed consent was obtained from all participants prior to their involvement in the study. Additionally, the KNHANES provides public access to its data, making it a valuable resource for conducting various epidemiological investigations.

2.2 Ascertainment of asthma

The objective of our study was to investigate the annual change in the prevalence of asthma, over a period of 24 years from 1998 to 2021. We collected data on various potential risk factors associated with the development of asthma, such as age, sex, lifestyle habits, and socioeconomic status.

2.3 Covariates

The covariates considered in the analysis encompassed various factors, including age categorized into different groups (2-5, 6-18, 19-39, 40-59, ≥60 years), sex, region of residence (urban and rural)[16], BMI group (underweight, normal, overweight, obese, and unknown), household income (lowest, second, third, and highest quartile), education level (elementary school or lower, middle school, high school, and college or higher education), alcohol consumption (1-5 days/month, ≥6 days/month, and non-drinker), and smoking status (non-smoker, ex-smoker, and smoker). BMI was classified according to the Asian-Pacific guidelines into underweight (<18.5 kg/m^2), normal weight (18.5-22.9 kg/m^2), overweight (23-25 kg/m^2), and obese (≥25.0 kg/m^2) categories.[17]

2.4 Statistical analyses

The findings of this study were presented using qualitative data represented as proportions or percentages. To compare the estimates of each relevant factor before and during the COVID-19 pandemic, weighted multivariate regression models were employed.[18, 19] The results were reported in terms of weighted odds ratios (ORs) along with their corresponding 95% confidence intervals (CIs). To enhance the reliability of the findings, stratification analysis was conducted, taking into account variables such as sex, educational level, region of residence, and income in all regression models. This approach aimed to provide a comprehensive and robust evaluation of the association between asthma prevalence and the examined factors. Furthermore, the annual change was calculated to yearly variation before and during the COVID-19 pandemic. Overall, this study aimed to compare the annual change before the COVID-19 pandemic with the annual change during the COVID-19 era to evaluate the impact of the COVID-19 pandemic on the prevalence of asthma. The SAS software (version 9.4; SAS Institute, Cary, NC, USA) was used for statistical analyses. A two-sided p-value ≤0.05 was considered statistically significant.

3. Results

From 1998-2021, there was 9,792 preschool children (2-5 years), 32,387 school age children (6-18 years), 59,994 adults (19-39 years), 60,572 adults (40-59 years), and 43,942 older people (60 years or more).

Table 1 illustrates the annual change in weighted asthma prevalence before the pandemic (1998-2019) and during the pandemic (1998-2021) for preschoolers, school age children, adults, and older people in Korea. Overall, only changes in asthma prevalence in school age children and adults (19-39 years) decreased after including data from years during the COVID-19

Table 1. Absolute annual change in weighted % (95% CI) for preschool, school age, adults in Korea during 1998-2019 and 1998-2021, in the data obtained from the KNHANES

	1998-2019	P-value	1998-2021	P-value
Overall				
Preschool (2-5 years)	0.02 (-0.04 to 0.07)	0.564	**-0.07 (-0.10 to -0.03)**	**<0.001**
School age (6-18 years)	**0.12 (0.08 to 0.15)**	**<0.001**	**0.09 (0.02 to 0.16)**	**0.008**
Adults (19-39 years)	**0.13 (0.10 to 0.16)**	**<0.001**	**0.11 (0.07 to 0.16)**	**<0.001**
Adults (40-59 years)	0.01 (0.00 to 0.03)	0.112	0.02 (-0.01 to 0.05)	0.113
Older population (≥60 years)	**-0.06 (-0.09 to -0.02)**	**0.001**	-0.04 (-0.09 to 0.01)	0.087
Male				
Preschool (2-5 years)	0.04 (-0.05 to 0.12)	0.382	**-0.10 (-0.14 to -0.06)**	**<0.001**
School age (6-18 years)	**0.12 (0.08 to 0.17)**	**<0.001**	**0.15 (0.03 to 0.28)**	**0.016**
Adults (19-39 years)	**0.15 (0.11 to 0.19)**	**<0.001**	**0.10 (0.04 to 0.17)**	**0.002**
Adults (40-59 years)	-0.01 (-0.03 to 0.01)	0.383	0.02 (-0.02 to 0.06)	0.397
Older population (≥60 years)	**-0.09 (-0.14 to -0.04)**	**<0.001**	**-0.13 (-0.19 to -0.06)**	**<0.001**
Female				
Preschool (2-5 years)	-0.01 (-0.06 to 0.05)	0.758	-0.03 (-0.08 to 0.03)	0.304
School age (6-18 years)	**0.11 (0.07 to 0.15)**	**<0.001**	0.03 (-0.02 to 0.08)	0.274
Adults (19-39 years)	**0.10 (0.07 to 0.14)**	**<0.001**	**0.12 (0.06 to 0.19)**	**<0.001**
Adults (40-59 years)	**0.04 (0.01 to 0.06)**	**0.004**	0.03 (-0.02 to 0.08)	0.204
Older population (≥60 years)	-0.03 (-0.07 to 0.02)	0.206	0.03 (-0.05 to 0.10)	0.502
Urban				
Preschool (2-5 years)	0.00 (-0.06 to 0.05)	0.879	**-0.07 (-0.11 to -0.03)**	**<0.001**
School age (6-18 years)	**0.10 (0.07 to 0.14)**	**<0.001**	0.09 (0.01 to 0.17)	0.020
Adults (19-39 years)	**0.12 (0.09 to 0.15)**	**<0.001**	**0.12 (0.07 to 0.17)**	**<0.001**
Adults (40-59 years)	0.01 (-0.01 to 0.03)	0.342	0.02 (-0.01 to 0.06)	0.155
Older population (≥60 years)	-0.04 (-0.08 to 0.00)	0.069	-0.03 (-0.09 to 0.03)	0.282
Rural				
Preschool (2-5 years)	0.14 (-0.04 to 0.31)	0.120	-0.05 (-0.10 to 0.00)	0.057
School age (6-18 years)	**0.20 (0.10 to 0.31)**	**<0.001**	**0.10 (0.00 to 0.20)**	**0.050**
Adults (19-39 years)	**0.20 (0.10 to 0.29)**	**<0.001**	0.06 (-0.02 to 0.14)	0.149
Adults (40-59 years)	0.04 (0.00 to 0.09)	0.052	0.02 (-0.04 to 0.09)	0.470
Older population (≥60 years)	**-0.10 (-0.15 to -0.04)**	**0.001**	-0.06 (-0.15 to 0.04)	0.222
High school or lower education				
Preschool (2-5 years)	NA	NA	NA	NA
School age (6-18 years)	NA	NA	NA	NA
Adults (19-39 years)	**0.11 (0.06 to 0.17)**	**<0.001**	**0.08 (0.01 to 0.15)**	**0.034**
Adults (40-59 years)	0.01 (-0.01 to 0.03)	0.456	-0.01 (-0.05 to 0.02)	0.489
Older population (≥60 years)	**-0.04 (-0.08 to -0.01)**	**0.026**	-0.02 (-0.07 to 0.04)	0.515
College or higher education				
Preschool (2-5 years)	NA	NA	NA	NA
School age (6-18 years)	NA	NA	NA	NA
Adults (19-39 years)	**0.14 (0.11 to 0.17)**	**<0.001**	0.13 (0.07 to 0.18)	<0.001
Adults (40-59 years)	**0.05 (0.02 to 0.08)**	**0.001**	0.08 (0.03 to 0.14)	<0.001
Older population (≥60 years)	-0.04 (-0.15 to 0.06)	0.410	-0.05 (-0.19 to 0.09)	0.498

Table 1. Continued

	1998-2019	P-value	1998-2021	P-value
Income (lowest-second quartile)				
Preschool (2-5 years)	NA	NA	NA	NA
School age (6-18 years)	NA	NA	NA	NA
Adults (19-39 years)	**0.14 (0.09 to 0.19)**	**<0.001**	**0.11 (0.04 to 0.18)**	**<0.001**
Adults (40-59 years)	0.00 (-0.03 to 0.03)	0.954	0.03 (-0.04 to 0.11)	0.409
Older population (≥60 years)	**-0.05 (-0.10 to -0.01)**	**0.013**	**-0.07 (-0.13 to -0.01)**	**0.024**
Income (third-highest quartile)				
Preschool (2-5 years)	NA	NA	NA	NA
School age (6-18 years)	NA	NA	NA	NA
Adults (19-39 years)	**0.13 (0.09 to 0.16)**	**<0.001**	**0.12 (0.06 to 0.18)**	**<0.001**
Adults (40-59 years)	**0.03 (0.01 to 0.04)**	**0.008**	0.03 (0.00 to 0.06)	0.076
Older population (≥60 years)	-0.05 (-0.10 to 0.01)	0.084	0.02 (-0.06 to 0.10)	0.664

Abbreviations: CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey.

pandemic (from 0.12% [95% CI, 0.08 to 0.15] to 0.09% [95% CI, 0.02 to 0.16] and from 0.13% [95% CI, 0.10 to 0.16] to 0.11% [95% CI, 0.07 to 0.16], respectively).

Table 2 illustrates the 24-year trends in asthma prevalence among Korean. Asthma prevalence in Korean increased in the pre-pandemic era (from 1.61% to 2.92% from 1998 to 2019) but decreased significantly during the pandemic (from 2.83% to 2.97% from 2020 to 2021). Table 3 described weighted odds ratio of before and during the pandemic.

Table 2. National trends of the prevalence of asthma and β-coefficients of odds ratios before and during the COVID-19 pandemic in Koreans, weighted % (95% CI), in the data obtained from the KNHANES

Year	Pre-pandemic					During the pandemic		Trends in the pre-pandemic era, β(95% CI)	Trends in the pandemic era, β(95% CI)	β_{diff} between 1998-2019 and 2019-2021 (95% CI)	P-value for β_{diff}
	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021				
Overall	1.61 (1.50 to 1.73)	3.12 (2.85 to 3.39)	3.50 (3.17 to 3.83)	3.13 (2.84 to 3.42)	2.92 (2.68 to 3.16)	2.83 (2.34 to 3.32)	2.97 (2.44 to 3.50)	**0.200 (0.127 to 0.272)**	0.028 (-0.254 to 0.310)	-0.17 (-0.46 to 0.12)	0.248
Sex											
Male	1.59 (1.43 to 1.75)	2.99 (2.65 to 3.33)	3.62 (3.15 to 4.08)	2.85 (2.45 to 3.24)	2.85 (2.51 to 3.19)	3.02 (2.30 to 3.74)	2.62 (1.91 to 3.32)	**0.174 (0.074 to 0.273)**	-0.117 (-0.504 to 0.269)	-0.29 (-0.69 to 0.11)	0.153
Female	1.64 (1.49 to 1.79)	3.24 (2.86 to 3.62)	3.39 (2.96 to 3.81)	3.40 (3.02 to 3.78)	2.99 (2.68 to 3.30)	2.63 (2.00 to 3.27)	3.33 (2.60 to 4.07)	**0.225 (0.130 to 0.320)**	0.173 (-0.221 to 0.568)	-0.05 (-0.46 to 0.35)	0.802

Table 2. Continued

Year	Pre-pandemic					During the pandemic		Trends in the pre-pandemic era, β(95% CI)	Trends in the pandemic era, β(95% CI)	β_{diff} between 1998-2019 and 2019-2021 (95% CI)	P-value for β_{diff}
	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021				
Region of residence											
Urban	1.47 (1.35 to 1.59)	3.04 (2.73 to 3.34)	3.66 (3.28 to 4.05)	3.04 (2.73 to 3.36)	2.80 (2.55 to 3.06)	2.75 (2.20 to 3.31)	2.98 (2.38 to 3.58)	**0.195 (0.118 to 0.273)**	0.088 (-0.227 to 0.402)	-0.11 (-0.43 to 0.22)	0.515
Rural	2.29 (1.98 to 2.59)	3.45 (2.89 to 4.01)	2.84 (2.26 to 3.41)	3.53 (2.85 to 4.20)	3.56 (2.82 to 4.30)	3.25 (2.24 to 4.26)	2.94 (1.95 to 3.93)	**0.236 (0.044 to 0.429)**	-0.309 (-0.921 to 0.303)	-0.55 (-1.19 to 0.10)	0.096
Education											
High school or lower education	1.93 (1.78 to 2.07)	3.27 (2.93 to 3.61)	3.60 (3.16 to 4.04)	3.51 (3.11 to 3.92)	3.15 (2.82 to 3.49)	3.63 (2.86 to 4.40)	3.27 (2.57 to 3.98)	**0.255 (0.162 to 0.348)**	0.062 (-0.315 to 0.440)	-0.19 (-0.58 to 0.20)	0.331
College or higher education	0.86 (0.70 to 1.02)	1.96 (1.55 to 2.37)	2.49 (2.00 to 2.98)	2.72 (2.22 to 3.22)	3.02 (2.59 to 3.45)	2.72 (1.87 to 3.57)	3.25 (2.36 to 4.14)	**0.462 (0.334 to 0.590)**	0.120 (-0.365 to 0.606)	-0.34 (-0.84 to 0.16)	0.182
Income											
Income (lowest-second quartile)	2.23 (2.04 to 2.43)	3.75 (3.33 to 4.18)	3.91 (3.45 to 4.38)	3.30 (2.86 to 3.75)	3.47 (3.08 to 3.86)	3.66 (2.87 to 4.44)	3.48 (2.78 to 4.18)	**0.162 (0.049 to 0.275)**	0.007 (-0.389 to 0.404)	-0.15 (-0.57 to 0.26)	0.461
Income (third-highest quartile)	1.10 (0.98 to 1.23)	2.69 (2.35 to 3.03)	3.18 (2.73 to 3.64)	3.01 (2.62 to 3.40)	2.56 (2.25 to 2.86)	2.34 (1.77 to 2.91)	2.68 (1.99 to 3.37)	**0.241 (0.148 to 0.335)**	0.063 (-0.307 to 0.432)	-0.18 (-0.56 to 0.20)	0.358

Abbreviations: CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey.

Table 3. Weighted odds ratio of before and during the pandemic, OR (95% CI), in the data obtained from the KNHANES

	1998–2005 (reference) versus 2007-2009	P-value	2007-2009 (reference) versus 2010-2012	P-value	2010-2012 (reference) versus 2013-2015	P-value	2013-2015 (reference) versus 2016-2019	P-value	2016-2019 (reference) versus 2020	P-value	2020 (reference) versus 2021	P-value
Overall												
Preschool (2-5 years)	**2.87 (1.88 to 4.37)**	**<.0001**	1.31 (0.87 to 1.98)	0.189	**0.51 (0.31 to 0.82)**	**0.005**	0.62 (0.35 to 1.11)	0.105	**0.27 (0.07 to 0.97)**	**0.045**	0.55 (0.05 to 5.62)	0.614
School age (6-18 years)	**4.70 (3.48 to 6.35)**	**<.0001**	1.19 (0.94 to 1.50)	0.159	0.90 (0.68 to 1.18)	0.438	**0.72 (0.54 to 0.95)**	**0.021**	0.82 (0.51 to 1.33)	0.420	1.10 (0.57 to 2.13)	0.774

Table 3. Continued

	1998–2005 (reference) versus 2007-2009	P-value	2007-2009 (reference) versus 2010-2012	P-value	2010-2012 (reference) versus 2013-2015	P-value	2013-2015 (reference) versus 2016-2019	P-value	2016-2019 (reference) versus 2020	P-value	2020 (reference) versus 2021	P-value
Adults (19-39 years)	**2.88 (2.17 to 3.83)**	**<.0001**	**1.47 (1.09 to 1.98)**	**0.012**	1.08 (0.82 to 1.44)	0.579	1.14 (0.88 to 1.47)	0.334	1.13 (0.78 to 1.62)	0.527	0.86 (0.53 to 1.37)	0.516
Adults (40-59 years)	**1.59 (1.27 to 1.99)**	**<.0001**	0.98 (0.74 to 1.31)	0.912	0.84 (0.62 to 1.14)	0.252	0.92 (0.70 to 1.22)	0.569	0.99 (0.63 to 1.55)	0.947	1.18 (0.69 to 2.02)	0.543
Older population (≥60 years)	1.07 (0.90 to 1.27)	0.426	0.90 (0.74 to 1.10)	0.316	0.86 (0.69 to 1.06)	0.154	0.92 (0.75 to 1.13)	0.410	0.88 (0.66 to 1.17)	0.368	1.20 (0.84 to 1.72)	0.321
Male												
Preschool (2-5 years)	**3.12 (1.89 to 5.15)**	**<.0001**	1.24 (0.76 to 2.03)	0.394	**0.51 (0.29 to 0.90)**	**0.020**	0.69 (0.35 to 1.33)	0.266	0.34 (0.09 to 1.27)	0.109	NA	NA
School age (6-18 years)	**4.84 (3.32 to 7.05)**	**<.0001**	1.24 (0.93 to 1.65)	0.149	0.80 (0.58 to 1.11)	0.187	**0.70 (0.50 to 0.99)**	**0.043**	1.09 (0.64 to 1.86)	0.740	1.15 (0.53 to 2.49)	0.721
Adults (19-39 years)	**2.44 (1.58 to 3.76)**	**<.0001**	**1.84 (1.18 to 2.88)**	**0.007**	0.92 (0.61 to 1.38)	0.670	1.35 (0.94 to 1.94)	0.106	1.13 (0.72 to 1.78)	0.602	0.70 (0.36 to 1.33)	0.273
Adults (40-59 years)	1.39 (0.99 to 1.96)	0.058	0.87 (0.55 to 1.39)	0.563	0.99 (0.59 to 1.65)	0.960	0.71 (0.44 to 1.15)	0.166	1.40 (0.70 to 2.81)	0.342	1.12 (0.48 to 2.60)	0.793
Older population (≥60 years)	0.82 (0.62 to 1.07)	0.135	0.96 (0.70 to 1.32)	0.800	**0.59 (0.42 to 0.84)**	**0.004**	1.36 (0.95 to 1.93)	0.090	0.86 (0.53 to 1.40)	0.538	0.84 (0.43 to 1.62)	0.595
Female												
Preschool (2-5 years)	**2.43 (1.14 to 5.19)**	**0.021**	1.53 (0.76 to 3.06)	0.232	0.49 (0.22 to 1.10)	0.082	0.48 (0.18 to 1.25)	0.130	NA	NA	NA	NA
School age (6-18 years)	**4.52 (2.82 to 7.26)**	**<.0001**	1.10 (0.76 to 1.59)	0.632	1.08 (0.72 to 1.62)	0.704	0.74 (0.50 to 1.11)	0.149	0.47 (0.20 to 1.10)	0.082	0.98 (0.32 to 3.05)	0.971
Adults (19-39 years)	**3.44 (2.35 to 5.03)**	**<.0001**	1.13 (0.75 to 1.68)	0.562	1.34 (0.91 to 1.96)	0.137	0.91 (0.64 to 1.30)	0.599	1.12 (0.63 to 2.00)	0.696	1.11 (0.56 to 2.19)	0.767
Adults (40-59 years)	**1.76 (1.30 to 2.38)**	**0.000**	1.06 (0.74 to 1.50)	0.758	0.75 (0.52 to 1.08)	0.117	1.09 (0.79 to 1.52)	0.602	0.78 (0.43 to 1.42)	0.414	1.24 (0.59 to 2.58)	0.569
Older population (≥60 years)	**1.29 (1.03 to 1.60)**	**0.025**	0.87 (0.67 to 1.13)	0.290	1.02 (0.78 to 1.33)	0.895	**0.77 (0.60 to 0.98)**	**0.034**	0.89 (0.63 to 1.26)	0.515	1.44 (0.94 to 2.21)	0.095

Table 3. Continued

	1998–2005 (reference) versus 2007-2009	P-value	2007-2009 (reference) versus 2010-2012	P-value	2010-2012 (reference) versus 2013-2015	P-value	2013-2015 (reference) versus 2016-2019	P-value	2016-2019 (reference) versus 2020	P-value	2020 (reference) versus 2021	P-value
Urban												
Preschool (2-5 years)	**2.59 (1.66 to 4.06)**	**<.0001**	1.37 (0.87 to 2.14)	0.171	**0.46 (0.27 to 0.80)**	**0.006**	0.59 (0.30 to 1.15)	0.118	0.36 (0.09 to 1.34)	0.125	0.54 (0.05 to 5.55)	0.606
School age (6-18 years)	**4.49 (3.27 to 6.15)**	**<.0001**	1.23 (0.96 to 1.58)	0.104	**0.73 (0.54 to 0.99)**	**0.043**	0.76 (0.55 to 1.04)	0.088	0.71 (0.40 to 1.25)	0.236	1.38 (0.65 to 2.92)	0.406
Adults (19-39 years)	**3.12 (2.30 to 4.22)**	**<.0001**	**1.45 (1.06 to 1.99)**	**0.021**	1.09 (0.81 to 1.48)	0.571	1.01 (0.77 to 1.33)	0.942	1.19 (0.80 to 1.76)	0.385	0.89 (0.54 to 1.47)	0.642
Adults (40-59 years)	**1.35 (1.04 to 1.76)**	**0.024**	1.15 (0.83 to 1.60)	0.396	0.77 (0.55 to 1.08)	0.132	0.93 (0.69 to 1.27)	0.663	1.05 (0.65 to 1.70)	0.857	1.19 (0.66 to 2.13)	0.568
Older population (≥60 years)	1.13 (0.90 to 1.42)	0.279	0.98 (0.77 to 1.27)	0.901	0.79 (0.61 to 1.03)	0.079	0.94 (0.74 to 1.20)	0.625	0.85 (0.61 to 1.18)	0.329	1.19 (0.78 to 1.83)	0.416
Rural												
Preschool (2-5 years)	**5.48 (1.56 to 19.30)**	**0.008**	1.09 (0.41 to 2.87)	0.864	0.73 (0.27 to 1.95)	0.526	0.83 (0.27 to 2.55)	0.747	NA	NA	NA	NA
School age (6-18 years)	**9.02 (3.44 to 23.64)**	**<.0001**	0.93 (0.46 to 1.85)	0.829	**2.48 (1.24 to 4.97)**	**0.011**	0.63 (0.34 to 1.18)	0.148	1.55 (0.72 to 3.30)	0.261	0.37 (0.13 to 1.06)	0.064
Adults (19-39 years)	1.50 (0.68 to 3.29)	0.313	1.67 (0.71 to 3.92)	0.243	1.03 (0.44 to 2.38)	0.955	**2.76 (1.31 to 5.80)**	**0.008**	0.78 (0.29 to 2.10)	0.619	0.54 (0.15 to 1.92)	0.337
Adults (40-59 years)	**2.73 (1.71 to 4.37)**	**<.0001**	0.59 (0.32 to 1.11)	0.100	1.18 (0.57 to 2.43)	0.658	0.91 (0.48 to 1.70)	0.759	0.72 (0.21 to 2.40)	0.589	1.16 (0.29 to 4.68)	0.830
Older population (≥60 years)	0.99 (0.77 to 1.26)	0.902	0.74 (0.54 to 1.01)	0.057	1.04 (0.72 to 1.48)	0.847	0.85 (0.60 to 1.19)	0.333	0.99 (0.58 to 1.69)	0.980	1.21 (0.62 to 2.35)	0.580
Education (high school or lower education)												
Preschool (2-5 years)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
School age (6-18 years)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Adults (19-39 years)	**2.88 (1.83 to 4.53)**	**<.0001**	1.51 (0.89 to 2.55)	0.129	1.22 (0.69 to 2.15)	0.497	0.94 (0.54 to 1.66)	0.837	1.86 (0.87 to 4.00)	0.110	0.42 (0.16 to 1.09)	0.074

Table 3. Continued

	1998–2005 (reference) versus 2007-2009	P-value	2007-2009 (reference) versus 2010-2012	P-value	2010-2012 (reference) versus 2013-2015	P-value	2013-2015 (reference) versus 2016-2019	P-value	2016-2019 (reference) versus 2020	P-value	2020 (reference) versus 2021	P-value
Adults (40-59 years)	**1.54 (1.21 to 1.96)**	**<.0001**	1.06 (0.77 to 1.45)	0.733	0.77 (0.53 to 1.12)	0.178	0.88 (0.61 to 1.26)	0.488	1.08 (0.54 to 2.16)	0.835	0.68 (0.28 to 1.67)	0.401
Older population (≥60 years)	1.13 (0.95 to 1.34)	0.178	0.90 (0.73 to 1.10)	0.305	0.94 (0.76 to 1.17)	0.601	0.86 (0.70 to 1.06)	0.163	1.09 (0.81 to 1.45)	0.585	1.03 (0.73 to 1.47)	0.861
Education (college or higher education)												
Preschool (2-5 years)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
School age (6-18 years)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Adults (19-39 years)	**2.85 (1.97 to 4.13)**	**<.0001**	**1.46 (1.01 to 2.10)**	**0.046**	1.11 (0.80 to 1.54)	0.532	1.16 (0.87 to 1.55)	0.305	0.99 (0.65 to 1.50)	0.956	0.99 (0.58 to 1.69)	0.962
Adults (40-59 years)	**2.20 (1.26 to 3.82)**	**0.005**	0.85 (0.47 to 1.52)	0.581	1.28 (0.74 to 2.20)	0.377	0.95 (0.62 to 1.43)	0.791	0.91 (0.51 to 1.63)	0.750	1.64 (0.83 to 3.26)	0.158
Older population (≥60 years)	**0.42 (0.18 to 0.97)**	**0.043**	1.24 (0.45 to 3.41)	0.675	0.76 (0.32 to 1.82)	0.532	**2.02 (1.02 to 4.00)**	**0.045**	0.36 (0.12 to 1.05)	0.062	2.67 (0.73 to 9.78)	0.137
Income (lowest-second quartile)												
Preschool (2-5 years)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
School age (6-18 years)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Adults (19-39 years)	**2.90 (1.79 to 4.71)**	**<.0001**	1.46 (0.88 to 2.41)	0.145	0.83 (0.50 to 1.36)	0.455	1.53 (0.95 to 2.46)	0.082	1.22 (0.67 to 2.23)	0.514	0.70 (0.33 to 1.48)	0.346
Adults (40-59 years)	1.30 (0.94 to 1.80)	0.109	0.82 (0.52 to 1.28)	0.371	0.74 (0.43 to 1.27)	0.274	1.28 (0.77 to 2.12)	0.335	1.59 (0.89 to 2.84)	0.119	0.86 (0.38 to 1.94)	0.719
Older population (≥60 years)	1.11 (0.92 to 1.34)	0.284	0.86 (0.69 to 1.07)	0.172	0.88 (0.69 to 1.13)	0.307	0.95 (0.74 to 1.20)	0.646	0.85 (0.60 to 1.21)	0.355	1.07 (0.69 to 1.67)	0.754
Income (third-highest quartile)												
Preschool (2-5 years)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
School age (6-18 years)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 3. Continued

	1998–2005 (reference) versus 2007-2009	P-value	2007-2009 (reference) versus 2010-2012	P-value	2010-2012 (reference) versus 2013-2015	P-value	2013-2015 (reference) versus 2016-2019	P-value	2016-2019 (reference) versus 2020	P-value	2020 (reference) versus 2021	P-value
Adults (19-39 years)	**2.90 (2.02 to 4.15)**	**<.0001**	1.47 (1.00 to 2.18)	0.051	1.22 (0.85 to 1.76)	0.277	1.00 (0.73 to 1.36)	0.987	1.09 (0.71 to 1.67)	0.693	0.93 (0.53 to 1.65)	0.811
Adults (40-59 years)	**2.02 (1.48 to 2.75)**	**<.0001**	1.10 (0.77 to 1.57)	0.610	0.88 (0.61 to 1.26)	0.480	0.79 (0.57 to 1.11)	0.176	0.71 (0.38 to 1.33)	0.283	1.50 (0.73 to 3.07)	0.267
Older population (≥60 years)	0.95 (0.64 to 1.41)	0.792	1.10 (0.69 to 1.76)	0.683	0.82 (0.53 to 1.27)	0.374	0.87 (0.60 to 1.26)	0.455	1.02 (0.63 to 1.66)	0.937	1.46 (0.82 to 2.63)	0.200

Abbreviations: CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey; OR, odds ratio.

4. Discussion

4.1 Key results

This study analyzed the trends in asthma prevalence before and during the COVID-19 pandemic using the KNHANES database, a nationally representative survey of over 200,000 South Koreans from 1998 to 2021. To our knowledge, this is the first large, long-term study examining 24-year asthma prevalence trends and associated factors in the age-stratified Korean population, including the COVID-19 pandemic era. Similarly, school aged children and adults (13-39 years) both saw their annual percent changes in asthma prevalence decrease after taking into account asthma prevalence during the COVID-19 pandemic. In Korean adults (40-59 years) and the older population (60 years or more), there were no statistically significant trends or changes in asthma prevalence due to the pandemic.

4.2 Global epidemiology and mechanism

From 1998 to 2012, a combination of environmental factors, health hazards, and increasing public awareness of asthma led to increased diagnosis of asthma and contributed to the observed positive trends in asthma prevalence.[4] However by 2012, asthma became well-known and health care professionals became well-versed on how to prevent and treat asthma.[20] This improvement in healthcare could partially explain the downward trend of asthma prevalence that was observed post-2012 in most age groups.

The study showed a rough divide in the population where those under the age of 40 had decreasing rates of asthma prevalence while those over 40 had no changes or trends. Our observed decreasing trend of asthma prevalence in children is consistent with decreasing trends observed globally.[21] Environmental and social change can explain consistent decreases in prevalence of allergic disease in children over the past decade.[4, 22] These decreasing trends were further aided by less exposure to triggers and greater treatment adherence during the COVID-19 pandemic.[23]

Adult onset asthma is defined as asthma that is diagnosed by a physician later in life.[24] It becomes the dominant phenotype in women by age 40 and is affected by a multitude of risk factors including obesity, atopy, smoking, and mental health.[25] Additionally, asthma often goes underdiagnosed in older individuals.[26] The mixed differences in asthma prevalence between younger and older Koreans could be due to the etiology of late onset asthma and its different characteristics.[27]

There have also been reports of new-onset asthma following COVID-19 in adults in South Korea.[28] Thus, what was an overall decrease in asthma prevalence in the population as a whole, could have been offset by rising rates of late-onset asthma or asthma precipitated by the COVID-19 pandemic. The unclear asthma trends in older individuals confirms the need to further explore the epidemiology of asthma in this age group as it is poorly understood, especially after the COVID-19 pandemic.

It is difficult for retrospective studies to establish a causative link between the COVID-19 pandemic and asthma prevalence. One possible explanation for decreased rates of asthma prevalence could be attributed to fewer hospital visits in Korea regarding asthma overall.[29] The most common explanation for this decrease is that individuals feared contracting COVID-19, which led to less healthcare seeking behavior. However, it has been shown in European countries that this is unlikely since mortality from asthma did not increase, which would have been expected if patients avoided care due to fear.[30] On the contrary, other studies have argued that asthma, in fact, increases healthcare seeking behavior rather than decrease it out of fear that asthma is a risk factor for COVID-19 pandemic.[13] Nonetheless, changes in healthcare seeking behaviors and fear of COVID-19 are likely insufficient sole explanations for changes in trends of asthma prevalence in different Korean age groups.

4.3 Strengths and limitations

We also cannot fully establish association between COVID-19 measures and asthma trends due to lack of information on prior exposures. This study only uses data from the KNHANES and although it is a nationally representative survey, cannot be used to generalize global trends. The data ranges from 1998-2021, which includes only data from the middle stages of the COVID-19 pandemic. Data from 2021 onwards is necessary to fully understand the impacts of the pandemic on asthma prevalence trends. Despite these limitations, the strength of this study lies in its large sample size that is representative of the Korean population. Age-stratification of the population allows for clear observation of the nuances between age groups before and during the COVID-19 era.

5. Conclusion

In this study of asthma prevalence in the age-stratified Korean population, both asthma prevalence trends and annual percentage changes differed amongst the different age groups before and during the COVID-19 pandemic. Asthma prevalence decreased for preschool and school-aged children, while no clear trends were observed in adults.

Capsule Summary

In this study of asthma prevalence in the age-stratified Korean population, both asthma prevalence trends and annual percent changes differed amongst the different age groups before and during the COVID-19 pandemic.

Ethics Statements

The research protocol received approval from both the Institutional Review Board of Kyung Hee University (KHUH 2022-06-042). Written informed consent was obtained from all participants prior to their involvement in the study. Additionally, the KNHANES provides public access to its data, making it a valuable resource for conducting various epidemiological investigations.

Patient and public involvement

No patients were directly involved in designing the research question or conducting the research. No patients were asked to interpret or write up the results. However, we plan on disseminating the results of this study to any of the study participants or wider relevant communities on request.

Data Availability Statement

Data are available on reasonable request.

Transparency statement

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

Author Contribution

Dr SHC had full access to all of the data in the study and took 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: all authors; Acquisition, analysis, or interpretation of data: all authors; Drafting of the manuscript: all authors; Critical revision of the manuscript for important intellectual content: all authors; Statistical analysis: JP; Study supervision: all authors. DYK supervised the study and is guarantor for this study. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. AN and JP were equally contributed.

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Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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