***National trends in allergic rhinitis and chronic rhinosinusitis and COVID-19 pandemic related factors in South Korea, from 1998 to 2021.***

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**Abstract**

**Introduction:** Existing studies provide insights into the prevalence and environmental factors associated with allergic rhinitis (AR) and chronic rhinosinusitis (CRS) globally. However, limitations still persist in these studies, particularly regarding cohort sizes and the duration of follow-up periods, indicating a need for more comprehensive and long-term research in these fields.Our study aims to investigate the prevalence, long-term trends, and underlying factors of these conditions in the general population of adult participants (≥19 years) in Korea.

**Method:** We analyzed data from adult participants (≥19 years) from the Korea National Health and Nutrition Examination Survey (KNHANES) study to determine the prevalence of AR and CRS from 1998 to 2021. To analyze prevalence trends before and during the COVID-19 pandemic, we employed a weighted linear regression model and obtained β coefficients with 95% confidence intervals (CI).

**Results:** Between 1998 and 2021, over a span of 24 years, the comprehensive KNHANES study included 146,264 adult participants (mean age 47.80 [standard deviation, 16.49] years; 66,177 [49.3%] men). The prevalence of AR and CRS increased from 1998 to 2021, with AR prevalence rising from 5.84% (95% CI, 5.57-6.10) in 1998–2005 to 8.99% (8.09-9.91) in 2021 and CRS from 1.84% (1.70-1.97) in 1998–2005 to 3.70% (3.18-4.23) in 2021. However, the increasing trend has slowed down during the COVID-19 pandemic era.

**Conclusions:** The significance of continuous monitoring and focused interventions for AR and CRS is underscored by this study. The observed deceleration in the rising prevalence of AR and CRS during the pandemic indicates the possibility of beneficial impacts from lifestyle modifications triggered by the pandemic. These findings call for additional research to explore potential protective effects in greater depth.

**Introduction**

Existing studies provide insights into the prevalence and environmental factors associated with allergic rhinitis (AR) and chronic rhinosinusitis (CRS) globally.[1] Recent findings highlight the growing public health concern of AR, emphasizing the role of environmental exposures and lifestyle changes, especially during the COVID-19 pandemic.[2] Similarly, research on CRS reveals significant variations in prevalence and treatment trends worldwide, with substantial socio-economic impacts in regions like the USA and Europe.[3, 4] However, limitations still persist in these studies, particularly regarding cohort sizes and the duration of follow-up periods, indicating a need for more comprehensive and long-term research in these fields. Despite these advances, there is a noticeable gap in this research when it comes to specific populations, such as South Korea. Recognizing this, this study aims to investigate the prevalence, long-term trends, and underlying factors of these conditions in the general population of Korea. We utilize nationally representative data from the Korea National Health and Nutrition Examination Survey (KNHANES), conducted annually by the Korea Disease Control and Prevention Agency (KDCA).

**Methods**

Data gathered from multiple national surveys carried out by the KNHANES were utilized to determine the prevalence of AR and CRS among Korean adults, defined as individuals aged 19 and over.[5, 6] KNHANES is an annual survey that commenced in 1998 and aims to collect information on the health and dietary habits of the Korean population. Our research aimed to uncover the risk factors associated with the two most frequent types of rhinitis, AR and CRS, over a span of 24 year s from 1998 to 2021. We executed a survey involving a large population, posing two separate questions: "Have you been diagnosed by a doctor with AR?" and "Have you been diagnosed by a doctor with CRS? The respondents were given the options to answer either yes or no.[7, 8] Instances with missing data were excluded from the analysis. The specific detail of the factor smoking status, was defined as “Current smoking status of cigarettes”.

Weighted composite sampling analysis was carried out using linear and logistic regression models.[5, 6] To analyze prevalence trends before and during the COVID-19 pandemic, we employed an weighted linear regression model to obtain a β coefficient with a 95% confidence interval (CI). Specifically, we defined the start of the pandemic period based on the notification to the WHO China Country Office of 44 cases of pneumonia of unknown cause in Wuhan, China, between 31 December 2019 and 3 January 2020.[9] The βdiff was analyzed to indicate the distinction between the pre-pandemic (1998–2020) and pandemic periods (2020 and 2021).[5, 6] Those with a two-sided P-value less than 0.05 were included. Statistical analyses were conducted using SAS version 9.4 (SAS Institute; Cary, NC, USA).[10]

**Results**

General attributes are illustrated in Table S1, which shows the baseline participants of this study. From the total participants (mean age 47.80 [standard deviation, 16.49] years), 66,177(49.3%) were male, and 80,087(50.7%) were female. Figure 1 and Table 1 show a significant AR prevalence was increased in pre-pandemic (5.84% [95% CI, 5.57 to 6.10] in 1998-2005; 7.65% [7.24 to 8.06] in 2016-2019), which slightly decreased during the pandemic (8.69% [7.78 to 9.60] in 2020; 8.99% [8.07 to 9.91] in 2021). At Figure 1 and Table 2 shows the prevalence of CRS increased at years 1998-2020 (1.84% [1.70 to 1.97] in 1998-2005; 3.34% [3.08 to 3.60] in 2016-2019), with a slight decrease during the pandemic (4.06% [3.40 to 4.71] in 2020; 3.70% [3.18 to 4.23] in 2021). Through this large-scale, longitudinal, and representative study, from 1998 to 2021, this study observed the prevalence of AR and CRS across 24-year from 1998 to 2022, analyzing both the differences before and during the COVID-19 pandemic by the KNHANES data (Table 1, 2). This is necessary to understand the long-term effects of the previous pandemic period on these health conditions. Tables 1 and 2 present the trends in prevalence of various factors relevant to our study, both before and during the pandemic. These factors include age, sex, region of residence, educational background, household income, smoking status, and asthma prevalence rates. Moreover, the tables highlight the differences observed in these factors between the pre-pandemic and pandemic periods. Table S2 shows that the overall ratio of OR for AR or CRS was not associated with any socioeconomic factors during the pandemic, suggesting there is no COVID-19 related vulnerable association between any socioeconomic factors and AR or CRS in South Korea.

**Discussion**

Our study, conducted over 24 years from 1998 to 2021, investigated the effects of the COVID-19 pandemic on AR and CRS, particularly regarding the prevalence and risk factors associated with these conditions. The longitudinal nature of this research, coupled with the large sample size and representative data of the Korean population, has allowed us to perform a comprehensive investigation of age-stratified trends in AR and CRS. As the first study to specifically investigate the relationship between COVID-19 pandemic and AR and CRS, our research makes a pioneering contribution to the existing body of literature.

Despite these strengths, our study has several limitations. The presence of AR and CRS in elderly individuals could lead to recall bias, and changes in diagnostic tools and criteria over time may have resulted in under-diagnosed or over-diagnosed allergic diseases. Moreover, many Koreans are unfamiliar with accurate medical terms for specific diseases and often mistakenly refer to common illnesses such as the common cold as allergic rhinitis. By acknowledging these limitations, we were able to refine our methodology and increase the rigor of our analysis, ultimately drawing more reliable conclusions and providing valuable insights into the effects of COVID-19 on AR and CRS. Furthermore, these limitations set the stage for future research to build upon and further explore the intricate relationship between these conditions and the COVID-19 pandemic.

**A****cknowledgement**

None

###### Statement of Ethics

This study protocol was reviewed and approved by Korea Disease Control and Prevention Agency (KDCA) and Institutional Review Board of Kyung Hee University, approval number [KHUH 2022-06-042]. This research adhered to the ethical guidelines established by relevant national and institutional review boards for human research and followed the 1975 Helsinki Declaration, as amended in 2008.

**Conflict of Interest Statement**

The authors have no conflicts of interest to declare.

**Funding Sources**

The funders had no role in study design, data collection, data analysis, and reporting of this study.

**Author Contribution**

Dr Dong Keon Yon had full access to all the data used in the study and took responsibility for the integrity of the data and accuracy of the data analysis. All authors approved the final version of the manuscript before submission. *Study concept and design*: Hojae Lee and Dong Keon Yon; *Acquisition, analysis, or interpretation of data*: Hojae Lee and Dong Keon Yon; *Drafting of the manuscript*: Hojae Lee and Dong Keon Yon; *Critical revision of the manuscript for important intellectual content*: Hojae Lee, Jaeyu Park, Myeongcheol Lee, Hyeon Jin Kim, Minji Kim, Rosie Kwon, Seung Won Lee, Ai Koyanagi, Lee Smith, Min Seo Kim, Sang Youl Rhee, Joong Ki Cho, Sunyoung Kim, Masoud Rahmati, Dong Keon Yon; *Statistical analysis*: Hojae Lee and Dong Keon Yon; *Study supervision*: Sunyoung Kim, Masoud Rahmati, and Dong Keon Yon. Dong Keon Yon supervised the study and is the guarantor for this study. The corresponding author attests that all listed authors meet the authorship criteria and that authors meeting the criteria have not been omitted.‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬‬

**Data Availability Statement**

Data are publicly available on legal and ethical grounds from the Korea Disease Control and Prevention Agency as open data (https://knhanes.kdca.go.kr/knhanes/eng/index.do). Further inquiries including study protocol and statistical code can be directed to the corresponding author, DKY (email: yonkkang@gmail.com).

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**Figure legends**

**Figure 1.** 24-year trends in the weighted prevalence of AR and CRS in South Korea, 1998–2021. Abbreviation, AR, allergic rhinitis; CRS, chronic rhinosinusitis.

**Table 1.** The national trend of the prevalence of AR and β-coefficients and odds ratios before and during COVID-19 pandemic, weighted% (95% CI), in the KNHANES.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Period | Pre-pandemic | | | | Pandemic | | Trend of the pre-pandemic era, β (95% CI) | Trend of the pandemic era, β (95% CI) | Trend difference, βdiff (95% CI) |
| Year | 1998–2005 | 2007–2009 | 2013–2015 | 2016–2019 | 2020 | 2021 |
| AR, weighted % (95% CI) | | | | | | | | | |
| Overall | 5.84 (5.57 to 6.10) | 4.65 (4.27 to 5.03) | 6.39 (5.96 to 6.82) | 7.65 (7.24 to 8.06) | 8.69 (7.78 to 9.60) | 8.99 (8.07 to 9.91) | **0.009 (0.007 to 0.011)** | 0.003 (-0.010 to 0.016) | -0.006 (-0.019 to 0.007) |
| Age, weighted % (95% CI) | | | | | | | | | |
| 19–59 | 6.60 (6.29 to 6.90) | 5.06 (4.62 to 5.51) | 7.09 (6.57 to 7.61) | 8.55 (8.05 to 9.06) | 10.11 (8.97 to 11.25) | 10.08 (8.90 to 11.27) | **0.036 (0.032 to 0.040)** | -0.007 (-0.037 to 0.024) | **-0.043 (-0.073 to -0.012)** |
| ≥ 60 | 2.33 (2.02 to 2.63) | 2.87 (2.29 to 3.45) | 3.94 (3.37 to 4.50) | 4.95 (4.41 to 5.48) | 4.98 (3.93 to 6.02) | 6.30 (5.12 to 7.48) | **0.013 (0.010 to 0.016)** | 0.018 (-0.004 to 0.040) | 0.005 (-0.017 to 0.027) |
| Sex, weighted % (95% CI) | | | | | | | | | |
| Male | 5.05 (4.70 to 5.39) | 2.40 (1.97 to 2.82) | 3.58 (3.05 to 4.11) | 4.71 (4.24 to 5.18) | 5.26 (4.29 to 6.22) | 6.36 (5.22 to 7.50) | **0.003 (0.000 to 0.005)** | 0.011 (-0.004 to 0.026) | 0.008 (-0.007 to 0.023) |
| Female | 6.58 (6.22 to 6.93) | 6.86 (6.21 to 7.51) | 9.14 (8.49 to 9.80) | 10.57 (9.91 to 11.22) | 12.10 (10.65 to 13.55) | 11.60 (10.27 to 12.93) | **0.028 (0.024 to 0.032)** | -0.010 (-0.038 to 0.019) | **-0.038 (-0.066 to -0.010)** |
| Region of residence, weighted % (95% CI) | | | | | | | | | |
| Urban | 6.33 (6.02 to 6.63) | 4.90 (4.46 to 5.34) | 6.84 (6.35 to 7.33) | 7.74 (7.29 to 8.18) | 9.04 (8.02 to 10.06) | 9.46 (8.44 to 10.48) | **0.027 (0.024 to 0.030)** | 0.004 (-0.020 to 0.029) | -0.022 (-0.047 to 0.002) |
| Rural | 3.74 (3.25 to 4.23) | 3.60 (2.87 to 4.34) | 4.29 (3.46 to 5.12) | 7.18 (6.06 to 8.30) | 6.77 (4.99 to 8.55) | 6.52 (4.57 to 8.47) | **0.022 (0.016 to 0.028)** | -0.010 (-0.055 to 0.034) | -0.033 (-0.077 to 0.012) |
| Education background, weighted % (95% CI) | | | | | | | | | |
| High school or lower | 4.71 (4.44 to 4.97) | 3.96 (3.54 to 4.38) | 4.95 (4.51 to 5.39) | 6.31 (5.85 to 6.77) | 7.09 (6.10 to 8.08) | 7.53 (6.46 to 8.60) | **0.020 (0.017 to 0.023)** | 0.006 (-0.019 to 0.030) | -0.014 (-0.039 to 0.011) |
| College or higher | 8.20 (7.64 to 8.75) | 6.26 (5.44 to 7.09) | 9.33 (8.41 to 10.24) | 9.65 (8.94 to 10.35) | 11.13 (9.55 to 12.71) | 11.05 (9.52 to 12.58) | **0.037 (0.031 to 0.043)** | -0.013 (-0.053 to 0.027) | -0.050 (-0.091 to -0.009) |
| Household income, weighted % (95% CI) | | | | | | | | | |
| Low income (quartile 1 and 2) | 4.73 (4.40 to 5.05) | 4.34 (3.78 to 4.90) | 5.56 (4.95 to 6.18) | 7.06 (6.43 to 7.69) | 7.33 (6.10 to 8.55) | 8.21 (6.82 to 9.59) | **0.020 (0.016 to 0.023)** | 0.009 (-0.019 to 0.037) | -0.010 (-0.039 to 0.018) |
| High income (quartile 3 and 4) | 6.78 (6.39 to 7.17) | 4.87 (4.34 to 5.39) | 6.95 (6.36 to 7.53) | 8.05 (7.51 to 8.58) | 9.50 (8.23 to 10.77) | 9.44 (8.16 to 10.72) | **0.031 (0.027 to 0.036)** | -0.005 (-0.038 to 0.028) | **-0.036 (-0.069 to -0.003)** |
| Smoking status, weighted % (95% CI) | | | | | | | | | |
| Non- or ex-smoker | 5.96 (5.68 to 6.24) | 5.81 (5.31 to 6.30) | 7.37 (6.85 to 7.89) | 8.75 (8.27 to 9.24) | 9.69 (8.64 to 10.74) | 9.62 (8.59 to 10.65) | **0.009 (0.005 to 0.013)** | 0.000 (-0.026 to 0.026) | **-0.027 (-0.053 to -0.001)** |
| Smoker | 4.57 (3.83 to 5.31) | 1.51 (1.07 to 1.95) | 2.81 (2.11 to 3.51) | 3.54 (2.94 to 4.14) | 4.51 (2.94 to 6.08) | 6.16 (4.17 to 8.14) | **0.025 (0.020 to 0.030)** | 0.031 (-0.042 to 0.103) | 0.004 (-0.069 to 0.078) |
| Asthma prevalence rates, weighted % (95% CI) | | | | | | | | | |
| Absence | 5.75 (5.48 to 6.01) | 4.44 (4.07 to 4.81) | 6.03 (5.60 to 6.46) | 7.25 (6.85 to 7.66) | 8.30 (7.39 to 9.21) | 8.45 (7.50 to 9.40) | **0.025 (0.022 to 0.028)** | -0.001 (-0.023 to 0.022) | **-0.025 (-0.048 to -0.003)** |
| Presence | 10.62 (8.38 to 12.85) | 12.07 (8.55 to 15.59) | 19.23 (14.93 to 23.52) | 21.19 (17.83 to 24.56) | 21.61 (14.34 to 28.87) | 26.57 (17.94 to 35.20) | **0.067 (0.043 to 0.091)** | 0.024 (-0.131 to 0.178) | -0.044 (-0.200 to 0.112) |

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

\*Numbers in bold indicate a significant difference (P < 0.05).

**Table 2.** The national trend of the prevalence of CRS and β-coefficients and odds ratios before and during COVID-19 pandemic, weighted% (95% CI), in the KNHANES.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Period | Pre-Pandemic | | | | Pandemic | | Trend of the pre-pandemic era, β (95% CI) | Trend of the pandemic era, β (95% CI) | Trend difference, βdiff (95% CI) |
| Year | 1998–2005 | 2007–2009 | 2013–2015 | 2016–2019 | 2020 | 2021 |
| CRS, weighted % (95% CI) | | | | | | | | | |
| Overall | 1.84 (1.70 to 1.97) | 1.99 (1.74 to 2.23) | 0.99 (0.78 to 1.21) | 3.34 (3.08 to 3.60) | 4.06 (3.40 to 4.71) | 3.70 (3.18 to 4.23) | **0.006 (0.005 to 0.008)** | -0.004 (-0.012 to 0.005) | **-0.010 (-0.019 to -0.001)** |
| Age, weighted % (95% CI) | | | | | | | | | |
| 19–59 | 1.88 (1.72 to 2.03) | 1.88 (1.59 to 2.16) | 0.92 (0.70 to 1.15) | 3.39 (3.07 to 3.72) | 4.49 (3.63 to 5.36) | 3.65 (2.97 to 4.33) | **0.017 (0.014 to 0.020)** | -0.019 (-0.041 to 0.003) | **-0.036 (-0.058 to -0.014)** |
| ≥ 60 | 1.64 (1.37 to 1.91) | 2.47 (1.95 to 2.99) | 1.24 (0.86 to 1.62) | 3.20 (2.78 to 3.61) | 2.92 (2.19 to 3.66) | 3.83 (2.97 to 4.69) | **0.007 (0.005 to 0.009)** | 0.012 (-0.003 to 0.028) | 0.005 (-0.011 to 0.021) |
| Sex, weighted % (95% CI) | | | | | | | | | |
| Male | 1.98 (1.77 to 2.19) | 1.35 (1.05 to 1.65) | 0.61 (0.39 to 0.83) | 2.31 (1.97 to 2.65) | 3.20 (2.43 to 3.98) | 3.04 (2.15 to 3.92) | **0.014 (0.010 to 0.017)** | -0.007 (-0.035 to 0.020) | -0.021(-0.049 to 0.007) |
| Female | 1.70 (1.53 to 1.87) | 2.61 (2.24 to 2.99) | 1.37 (1.05 to 1.69) | 4.37 (3.97 to 4.78) | 4.91 (3.99 to 5.83) | 4.36 (3.57 to 5.16) | **0.014 (0.011 to 0.017)** | -0.009 (-0.026 to 0.009) | **-0.023 (-0.041 to -0.005)** |
| Region of residence, weighted % (95% CI) | | | | | | | | | |
| Urban | 1.92 (1.76 to 2.08) | 1.91 (1.65 to 2.18) | 1.04 (0.80 to 1.28) | 3.38 (3.09 to 3.66) | 4.09 (3.37 to 4.81) | 3.81 (3.20 to 4.41) | **0.014 (0.012 to 0.017)** | -0.007 (-0.024 to 0.011) | **-0.021 (-0.038 to -0.003)** |
| Rural | 1.48 (1.23 to 1.73) | 2.29 (1.71 to 2.87) | 0.79 (0.37 to 1.21) | 3.17 (2.52 to 3.83) | 3.87 (2.35 to 5.40) | 3.17 (2.20 to 4.14) | **0.012 (0.007 to 0.017)** | -0.015 (-0.046 to 0.017) | -0.027 (-0.058 to 0.005) |
| Education background, weighted % (95% CI) | | | | | | | | | |
| High school or lower | 1.66 (1.50 to 1.81) | 1.99 (1.72 to 2.27) | 0.75 (0.54 to 0.95) | 2.80 (2.49 to 3.11) | 3.51 (2.73 to 4.29) | 2.80 (2.23 to 3.38) | **0.010 (0.008 to 0.013)** | -0.013 (-0.029 to 0.004) | **-0.023 (-0.040 to -0.006)** |
| College or more | 2.21 (1.94 to 2.48) | 1.97 (1.54 to 2.41) | 1.50 (1.09 to 1.90) | 4.16 (3.68 to 4.63) | 4.89 (3.78 to 6.00) | 4.98 (3.99 to 5.97) | **0.020 (0.016 to 0.024)** | -0.003(-0.032 to 0.026) | -0.023 (-0.052 to 0.006) |
| Household income, weighted % (95% CI) | | | | | | | | | |
| Low income (quartile 1 and 2) | 2.01 (1.79 to 2.22) | 2.25 (1.86 to 2.65) | 1.05 (0.71 to 1.40) | 3.33 (2.94 to 3.73) | 3.84 (2.95 to 4.73) | 3.40 (2.60 to 4.20) | **0.01 (0.008 to 0.013)** | -0.009 (-0.027 to 0.010) | **-0.019 (-0.038 to -0.001)** |
| High income (quartile 3, 4) | 1.69 (1.51 to 1.87) | 1.80 (1.47 to 2.12) | 0.95 (0.70 to 1.20) | 3.35 (3.01 to 3.69) | 4.19 (3.30 to 5.08) | 3.88 (3.17 to 4.59) | **0.017 (0.013 to 0.020)** | -0.008 (-0.030 to 0.014) | **-0.024 (-0.046 to -0.002)** |
| Smoke, weighted % (95% CI) | | | | | | | | | |
| Non- or ex-smoker | 1.78 (1.64 to 1.92) | 2.35 (2.04 to 2.66) | 1.17 (0.91 to 1.42) | 3.88 (3.56 to 4.20) | 4.43 (3.68 to 5.18) | 4.07 (3.48 to 4.67) | **0.006 (0.003 to 0.009)** | 0.002 (-0.016 to 0.020) | -0.011 (-0.029 to 0.007) |
| Smoker | 2.43 (1.92 to 2.94) | 1.00 (0.64 to 1.36) | 0.37 (0.10 to 0.64) | 1.36 (0.97 to 1.74) | 2.51 (1.38 to 3.65) | 2.04 (0.97 to 3.11) | **0.016 (0.012 to 0.020)** | -0.024 (-0.071 to 0.024) | -0.037 (-0.084 to 0.011) |
| Asthma prevalence rates, weighted % (95% CI) | | | | | | | | | |
| Absence | 1.76 (1.63 to 1.89) | 1.94 (1.70 to 2.18) | 0.93 (0.73 to 1.14) | 3.22 (2.95 to 3.49) | 3.79 (3.15 to 4.44) | 3.52 (3.00 to 4.04) | **0.013 (0.011 to 0.015)** | -0.006 (-0.022 to 0.009) | **-0.019(-0.035 to -0.004)** |
| Presence | 5.90 (4.27 to 7.52) | 3.71 (1.97 to 5.46) | 3.19 (1.41 to 4.97) | 7.61 (5.40 to 9.82) | 12.80 (6.47 to 19.14) | 9.68 (5.20 to 14.17) | **0.038 (0.018 to 0.059)** | -0.072 (-0.187 to 0.043) | -0.111 (-0.227 to 0.006) |

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

\*Numbers in bold indicate a significant difference (P < 0.05).

A graph of the average of the pandemic

Description automatically generated with medium confidence