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Original Research Article

National trends in the prevalence of tuberculosis before and during the COVID-19 pandemic, 1998-2021: a nationwide representative study in South Korea

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Abstract

Objective: In this study, we investigate changes in the prevalence of tuberculosis (TB) before and during the COVID-19 pandemic in South Korea, analyzing the effects of age, socioeconomic, and environmental variables on TB trends over a period of 24 years. Investigation into the association between TB and the COVID-19 pandemic can accelerate advances in the prevention and treatment of both diseases.

Methods: This study utilized data from the Korea National Health and Nutrition Examination Survey conducted between 1998 and 2021 by the Korea Disease Control and Prevention Agency. The study population included individuals aged ≥ 5 years, selected to represent a broad spectrum of the South Korean adult population (n=186,561). The data collected encompassed a range of variables, including age, sex, residence, body mass index, education level, income, and other health-related factors potentially influencing TB trends.

Results: A total of 186,561 surveys were included in this study. There was an increase in the trend of TB prevalence before the pandemic (trend in β, 0.124 [95% CI, 0.047-0.201]), which was not apparent during the pandemic. Females saw a significant positive trend in TB prevalence before the pandemic (trend in β, 0.146 [0.055-0.238]), which decreased during the pandemic. Similarly, individuals living in both urban and rural regions (trends in β, 0.104 [0.018-0.189] and 0.239 [0.059-0.420], respectively), those with a high school diploma, middle school, or elementary school education (0.185 [0.056-0.314], 0.239 [0.059-0.420], and 0.740 [0.541-0.939], respectively), and those in the second and lowest income quartiles (0.282 [0.087-0.476] and 0.195 [0.037-0.353], respectively) all showed significant positive trends in TB prevalence before the pandemic, which were no longer apparent after the onset of the pandemic.

Conclusions: There was a sharp decrease in TB prevalence between 2020 and 2021. Differences previously seen between males and females, and those of differing income and education statuses were nullified during and after the pandemic. This highlights the importance of healthcare utilization, timely diagnosis, and effective treatments for diseases that are a significant public health risk.

Keywords: tuberculosis, prevalence, trend, epidemiology, South Korea

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1. Introduction

Tuberculosis (TB) is a bacterial infection caused by *Mycobacterium tuberculosis*.[1] Primarily affecting the respiratory system, this disease has the potential to involve multiple organ systems and can remain inactive in the human body for decades.[2] TB is a global public health issue, especially in resource-poor, lower-income regions of the world.[3] However, South Korea has a disproportionately high TB bu rden amongst higher-income countries.[3] As of 2021, South Korean TB incidence rate has been nearly twice that of the WHO South-East Asia region[4], highlighting the ongoing and significant public health challenge in the country.

During the COVID-19 pandemic, the South Korean government implemented strict public health measures, including vaccinations, lockdowns, social distancing, and mask mandates in order to prevent the spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[5] This led to a notable decrease in the prevalence of other respiratory conditions like asthma and allergic rhinitis.[6] In this context, the similarities between COVID-19 and TB, both affecting the respiratory system and causing immune system dysregulation, especially in co-infected individuals, become particularly relevant.[7-9] These diseases share commonalities in their infection mechanisms, detection methods, and required public health responses.[10] These similarities encourage investigation into the correlation between the two diseases to accelerate advances in prevention and treatment of both TB and COVID-19.[11] Thus, the present study aims to investigate changes in prevalence of TB before and during the COVID-19 pandemic in South Korea, analyzing the effects of age, socioeconomic, and environmental variables on TB trends over a period of 24 years.

2. Methods

2.1 Study Design and Data Source

This study utilized data from the Korea National Health and Nutrition Examination Survey (KNHANES) conducted between 1998 and 2021 by the Korea Disease Control and Prevention Agency (KDCA). A total of 231,264 participants were included in the survey. The survey spanned over 24 years with annual participant numbers varying each year. As illustrated in Fig. 1, 44,703 participants were excluded from the analysis due to incomplete data on essential variables, including age, socioeconomic status, and environmental factors, and weighted values. Therefore, the final study population included 186,561 participants. The number of participants surveyed in each year group was as follows: 96,948 in 1998-2005; 18,519 in 2007–2009; 19,157 in 2010–2012; 16,514 in 2013–2015; 24,433 in 2016–2019; 5,596 in 2020 and 5,394 in 2021.

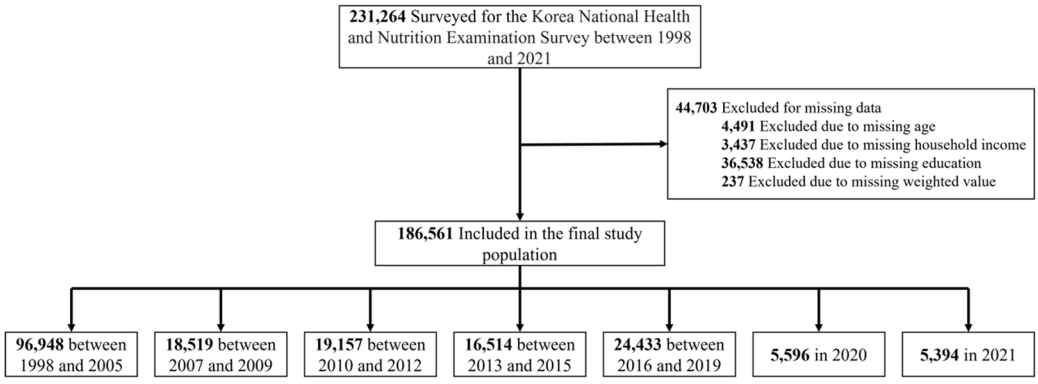

Fig. 1. Study population

The research protocol was approved by the Institutional Review Boards of the KDCA (2007-02CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C, 2012-01EXP-01-2C, 2013-07CON-03-4C, 2013-12EXP-035C) and by the local law of the Act (Article 2, Paragraph 1) and Enforcement Regulation (Article 2, Paragraph 2, item 1) of Bioethics and Safety Act, from Korean government. Written informed consent was obtained from all participants prior to their participation.

2.2 Ascertainment of Tuberculosis

In our study, the dependent variable was the prevalence of TB. Participants reported whether they had been diagnosed with TB, answering the question "Have you ever received a clinical diagnosis of tuberculosis by a medical professional?".[12] To calculate the overall prevalence, we used a weighted average that took into account the proportion of TB cases across different age groups, sex, and socioeconomic statuses on a yearly basis. The prevalence rates were thus adjusted for the population structure in each survey year to reflect a more accurate representation of the disease in the general population.

2.3 Covariates

In our analysis, we incorporated various covariates to create a comprehensive evaluation of factors that could affect the prevalence of TB over time. Covariates included age groups segmented as follows: 5-19, 20-29, 30-39, 40-49, 50-59, 60-69, and above 70 years. Sex was classified into male and female, and the region of residence was divided into urban and rural categories.[13] Household income levels were considered in four quartiles: lowest, second, third, and highest. For education level, participants were grouped into four categories: elementary school or lower, middle school, high school, and college or higher. Additionally, we classified Body Mass Index (BMI) into four groups following the Asian-Pacific guidelines: underweight (BMI less than 18.5 kg/m^2), normal weight (BMI 18.5–22.9 kg/m^2), overweight (BMI 23.0–24.9 kg/m^2), and obese (BMI 25.0 kg/m^2 or above).[14]

2.4 Statistical Analysis

The study analyzed TB prevalence in South Korea using data collected from 186,561 individuals over a 24-year period. The survey data spanned from 1998 to 2021, allowing for a comprehensive investigation of TB trends across different time frames. Data was segmented into periods of 1998-2005, 2007-2009, 2010-2012, 2013-2015, 2016-2019, 2020, and 2021 for detailed analysis.

To ensure accuracy in our estimates, we employed linear and logistic regression models, supplemented by weighted complex sampling methods. This approach helped us to generate weighted odds ratios (wOR) along with their corresponding 95% confidence intervals (CI).[15] Additionally, the beta (β) coefficient was assessed to observe the change in TB prevalence throughout the study period.[15] Our risk factor analysis included the following variables: age, sex, education, residential area, income, and BMI, which were consistent across all regression models.[16, 17] We transformed categorical variables into binary variables, allowing us to understand the unique impact of each factor and identify groups particularly vulnerable to TB during different periods. Furthermore, the analysis focused on identifying variations in TB prevalence trends before the pandemic (1998–2019) and during the pandemic (2020–2021), as denoted by the β difference (β_{diff}).[18] All statistical analyses were performed using appropriate software tools, SAS software (version 9.4; SAS Institute, Cary, NC, USA), with a two-sided test.[19] A p-value <0.05 was considered statistically significant ensuring robust and significant findings.[20] Through this comprehensive methodological approach, our study aimed to provide a detailed understanding of the TB prevalence in South Korea, particularly in the context of the COVID-19 pandemic.

3. Results

Table 1 presents the baseline characteristics of the study population stratified by age in both crude and weighted rates. From 1998 to 2021, we included 186,561 participants with the following age distribution: 5-19 years (16.64% [95% CI, 16.47 to 16.80]); 20-29 years (12.99% [95% CI, 12.83 to 13.14]); 30-39 years (17.60% [95% CI, 17.43 to 17.78]); 40-49 years (17.36% [95% CI, 17.19 to 17.53]); 50-59 years (14.47% [95% CI, 14.31 to 14.63]); 60-69 years (12.75% [95% CI, 12.60 to 12.90]); and ≥70 years (8.20% [95% CI, 8.08 to 8.33]). The sex distribution was 46.33% male (95% CI, 46.10 to 46.55) and 53.67% female (95% CI, 53.45 to 53.90).

Table 1. Baseline characteristics of Koreans in crude and weighted rates, based on data collected from the KNHANES between 1998 and 2021 (n=186,561)

	Total	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021
Overall, n	186,561	96,948	18,519	19,157	16,514	24,433	5,596	5,394
	Crude rate (95% CI)							
Age, years, (95% CI)								
5-19	16.64 (16.47 to 16.80)	22.19 (21.93 to 22.45)	12.51 (12.03 to 12.98)	11.24 (10.80 to 11.69)	11.30 (10.82 to 11.78)	9.23 (8.87 to 9.60)	8.68 (7.95 to 9.42)	8.29 (7.55 to 9.02)

Table 1. Continued

	Total	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021
20-29	12.99 (12.83 to 13.14)	15.13 (14.90 to 15.35)	11.06 (10.61 to 11.51)	9.78 (9.36 to 10.20)	10.32 (9.85 to 10.78)	10.67 (10.28 to 11.06)	12.83 (11.95 to 13.71)	11.27 (10.43 to 12.12)
30-39	17.60 (17.43 to 17.78)	19.22 (18.98 to 19.47)	18.49 (17.94 to 19.05)	17.12 (16.59 to 17.66)	15.07 (14.53 to 15.62)	14.95 (14.50 to 15.40)	13.08 (12.20 to 13.96)	11.55 (10.70 to 12.40)
40-49	17.36 (17.19 to 17.53)	17.57 (17.33 to 17.81)	17.97 (17.42 to 18.52)	16.39 (15.86 to 16.91)	16.76 (16.19 to 17.33)	17.57 (17.10 to 18.05)	16.33 (15.36 to 17.30)	16.87 (15.87 to 17.87)
50-59	14.47 (14.31 to 14.63)	11.70 (11.50 to 11.90)	15.21 (14.69 to 15.73)	17.65 (17.11 to 18.19)	18.26 (17.67 to 18.85)	18.25 (17.76 to 18.73)	18.07 (17.06 to 19.07)	17.91 (16.89 to 18.93)
60-69	12.75 (12.60 to 12.90)	9.4 (9.29 to 9.66)	14.51 (14.00 to 15.02)	15.74 (15.22 to 16.25)	16.16 (15.60 to 16.72)	16.90 (16.43 to 17.37)	18.75 (17.72 to 19.77)	19.50 (18.45 to 20.56)
≥70	8.20 (8.08 to 8.33)	4.72 (4.59 to 4.85)	10.25 (9.81 to 10.69)	12.07 (11.61 to 12.54)	12.12 (11.63 to 12.62)	12.43 (12.02 to 12.84)	12.26 (11.40 to 13.12)	14.61 (13.67 to 15.55)
Sex, (95% CI)								
Male	46.33 (46.10 to 46.55)	48.34 (48.02 to 48.65)	43.83 (43.11 to 44.54)	43.75 (43.05 to 44.45)	43.49 (42.73 to 44.25)	44.55 (43.93 to 45.18)	46.02 (44.71 to 47.32)	44.92 (43.59 to 46.25)
Female	53.67 (53.45 to 53.90)	51.66 (51.35 to 51.98)	56.17 (55.46 to 56.89)	56.25 (55.55 to 56.95)	56.51 (55.75 to 57.27)	55.45 (54.82 to 56.07)	53.99 (52.68 to 55.29)	55.08 (53.75 to 56.41)
Region of residence, (95% CI)								
Urban	77.66 (77.48 to 77.85)	75.59 (75.32 to 75.86)	74.77 (74.14 to 75.39)	80.18 (79.62 to 80.75)	81.72 (81.14 to 82.31)	82.31 (81.84 to 82.79)	80.86 (79.83 to 81.89)	79.11 (78.02 to 80.19)
Rural	22.34 (22.15 to 22.52)	24.41 (24.14 to 24.68)	25.23 (24.61 to 25.86)	19.82 (19.25 to 20.38)	18.28 (17.69 to 18.86)	17.69 (17.21 to 18.16)	19.14 (18.11 to 20.17)	20.89 (19.81 to 21.98)
BMI* group, (95% CI)								
Underweight (<18.5kg/m^2)	4.57 (4.47 to 4.66)	3.09 (2.98 to 3.20)	7.14 (6.77 to 7.52)	6.69 (6.33 to 7.04)	6.08 (5.72 to 6.44)	5.42 (5.14 to 5.70)	5.24 (4.65 to 5.82)	5.47 (4.86 to 6.08)
Normal weight (18.5-22.9 kg/m^2)	24.55 (24.35 to 24.74)	10.65 (10.46 to 10.85)	40.37 (39.67 to 41.08)	40.93 (40.23 to 41.63)	40.36 (39.61 to 41.11)	39.18 (38.57 to 39.80)	35.47 (34.22 to 36.73)	35.74 (34.46 to 37.02)
Overweight (23-24.9 kg/m^2)	13.34 (13.18 to 13.49)	5.19 (5.05 to 5.33)	22.50 (21.90 to 23.10)	22.00 (21.42 to 22.59)	22.53 (21.90 to 23.17)	21.88 (21.36 to 22.40)	21.73 (20.65 to 22.81)	21.99 (20.88 to 23.09)

Table 1. Continued

	Total	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021
Obese (≥ 25.0 kg/m^2)	18.52 (18.35 to 18.70)	6.31 (6.16 to 6.47)	29.53 (28.87 to 30.18)	30.01 (29.36 to 30.66)	30.94 (30.23 to 31.64)	33.27 (32.68 to 33.86)	36.74 (35.48 to 38.00)	35.65 (34.37 to 36.93)
Unknown	39.03 (38.81 to 39.25)	74.75 (74.48 to 75.03)	0.45 (0.36 to 0.55)	0.37 (0.28 to 0.46)	0.09 (0.04 to 0.14)	0.25 (0.19 to 0.31)	0.82 (0.59 to 1.06)	1.15 (0.87 to 1.43)
Education, (95% CI)								
Elementary school or lower education	23.35 (23.16 to 23.55)	27.97 (27.69 to 28.26)	23.54 (22.93 to 24.15)	20.71 (20.14 to 21.29)	18.41 (17.82 to 19.01)	14.93 (14.48 to 15.37)	12.26 (11.40 to 13.12)	13.83 (12.91 to 14.75)
Middle school	14.72 (14.55 to 14.88)	14.94 (14.72 to 15.17)	16.10 (15.57 to 16.63)	15.36 (14.85 to 15.87)	14.59 (14.06 to 15.13)	13.26 (12.84 to 13.69)	12.79 (11.92 to 13.67)	12.57 (11.68 to 13.45)
High school	31.74 (31.53 to 31.95)	33.71 (33.41 to 34.01)	30.48 (29.82 to 31.15)	29.56 (28.91 to 30.21)	29.99 (29.29 to 30.69)	28.87 (28.30 to 29.43)	29.07 (27.88 to 30.26)	29.40 (28.19 to 30.62)
College or higher education	30.19 (29.99 to 30.40)	23.37 (23.11 to 23.64)	29.88 (29.22 to 30.54)	34.36 (33.69 to 35.04)	37.00 (36.26 to 37.74)	42.95 (42.33 to 43.57)	45.87 (44.57 to 47.18)	44.20 (42.87 to 45.52)
Smoking status, (95% CI)								
Smoker	12.52 (12.37 to 12.67)	7.67 (7.51 to 7.84)	19.82 (19.25 to 20.40)	18.65 (18.10 to 19.20)	17.09 (16.51 to 17.66)	16.88 (16.41 to 17.35)	16.14 (15.17 to 17.10)	15.29 (14.33 to 16.26)
Ex-smoker	10.34 (10.20 to 10.48)	2.71 (2.61 to 2.81)	16.85 (16.31 to 17.39)	18.00 (17.45 to 18.54)	17.66 (17.08 to 18.24)	19.69 (19.20 to 20.19)	21.30 (20.23 to 22.37)	21.84 (20.74 to 22.94)
Non-smoker	37.83 (37.61 to 38.05)	15.19 (14.96 to 15.42)	57.00 (56.29 to 57.71)	63.35 (62.67 to 64.03)	65.25 (64.53 to 65.98)	63.43 (62.82 to 64.03)	62.56 (61.29 to 63.83)	62.87 (61.58 to 64.16)
Unknown	39.30 (39.08 to 39.52)	74.42 (74.15 to 74.70)	6.32 (5.97 to 6.67)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)
Alcohol consumption, (95% CI)								
Non-drinker	14.67 (14.51 to 14.83)	11.95 (11.74 to 12.15)	19.94 (19.36 to 20.51)	19.42 (18.86 to 19.98)	18.23 (17.64 to 18.82)	15.06 (14.61 to 15.51)	15.14 (14.20 to 16.07)	15.63 (14.66 to 16.60)
1–5 days/month	34.66 (34.45 to 34.88)	8.56 (8.39 to 8.74)	60.65 (59.95 to 61.35)	61.65 (60.97 to 62.34)	62.60 (61.86 to 63.34)	64.32 (63.72 to 64.92)	65.64 (64.39 to 66.88)	66.67 (65.41 to 67.92)
6-30days/month	11.98 (11.84 to 12.13)	5.06 (4.93 to 5.20)	19.37 (18.81 to 19.94)	18.93 (18.37 to 19.48)	19.17 (18.57 to 19.77)	20.62 (20.12 to 21.13)	19.23 (18.20 to 20.26)	17.70 (16.69 to 18.72)

Table 1. Continued

	Total	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021
Unknown	38.68 (38.46 to 38.90)	74.42 (74.15 to 74.70)	0.04 (0.01 to 0.07)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)
Household Income, (95% CI)								
Lowest quartile	19.03 (18.86 to 19.21)	20.55 (20.30 to 20.81)	19.48 (18.91 to 20.05)	17.86 (17.32 to 18.41)	17.19 (16.61 to 17.76)	16.49 (16.02 to 16.96)	14.76 (13.83 to 15.69)	16.02 (15.04 to 17.00)
Second quartile	25.09 (24.89 to 25.28)	25.09 (24.81 to 25.36)	24.86 (24.24 to 25.48)	25.83 (25.21 to 26.45)	25.65 (24.98 to 26.32)	24.86 (24.32 to 25.40)	23.86 (22.74 to 24.97)	23.82 (22.69 to 24.96)
Third quartile	27.90 (27.70 to 28.10)	27.68 (27.40 to 27.96)	27.60 (26.96 to 28.25)	27.98 (27.35 to 28.62)	28.30 (27.61 to 28.98)	28.03 (27.47 to 28.60)	29.63 (28.43 to 30.82)	28.92 (27.71 to 30.13)
Highest quartile	27.98 (27.77 to 28.18)	26.68 (26.40 to 26.96)	28.05 (27.41 to 28.70)	28.32 (27.69 to 28.96)	28.87 (28.18 to 29.56)	30.62 (30.04 to 31.20)	31.75 (30.54 to 32.97)	31.24 (30.00 to 32.48)
				Weighted rate (95% CI)				
Age (years), weighted % (95% CI)								
5-19	14.16 (13.92 to 14.41)	21.29 (20.86 to 21.72)	12.87 (12.24 to 13.50)	12.71 (11.95 to 13.46)	11.85 (11.21 to 12.48)	9.78 (9.28 to 10.29)	9.01 (7.91 to 10.10)	8.54 (7.40 to 9.67)
20-29	16.17 (15.84 to 16.50)	16.43 (15.96 to 16.91)	17.11 (16.10 to 18.12)	16.11 (15.10 to 17.11)	15.88 (15.00 to 16.76)	15.67 (14.87 to 16.46)	15.90 (14.41 to 17.40)	15.57 (13.77 to 17.36)
30-39	18.39 (18.03 to 18.76)	19.76 (19.21 to 20.30)	20.09 (18.98 to 21.21)	18.85 (17.85 to 19.86)	17.54 (16.50 to 18.58)	16.77 (15.87 to 17.68)	16.17 (14.30 to 18.04)	15.80 (14.13 to 17.48)
40-49	18.98 (18.69 to 19.27)	18.42 (18.02 to 18.82)	20.21 (19.38 to 21.05)	19.64 (18.79 to 20.48)	18.95 (18.17 to 19.72)	18.93 (18.23 to 19.63)	18.42 (16.84 to 20.01)	18.14 (16.59 to 19.70)
50-59	15.58 (15.31 to 15.84)	11.22 (10.88 to 11.57)	14.66 (13.96 to 15.36)	16.44 (15.67 to 17.21)	17.90 (17.09 to 18.70)	18.72 (18.05 to 19.38)	19.13 (17.74 to 20.52)	18.48 (16.99 to 19.98)
60-69	10.41 (10.19 to 10.63)	8.46 (8.15 to 8.77)	9.18 (8.66 to 9.70)	9.58 (9.03 to 10.13)	10.62 (10.01 to 11.22)	12.43 (11.81 to 13.05)	14.13 (12.72 to 15.53)	15.22 (13.84 to 16.60)
≥70	6.31 (6.14 to 6.48)	4.42 (4.19 to 4.65)	5.88 (5.44 to 6.32)	6.68 (6.21 to 7.16)	7.28 (6.77 to 7.79)	7.70 (7.23 to 8.17)	7.25 (6.15 to 8.35)	8.26 (7.16 to 9.35)
Sex, weighted % (95% CI)								

Table 1. Continued

	Total	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021
Male	49.97 (49.72 to 50.21)	49.61 (49.31 to 49.91)	50.32 (49.63 to 51.00)	50.19 (49.46 to 50.92)	49.49 (48.74 to 50.24)	50.13 (49.51 to 50.76)	50.71 (49.61 to 51.82)	50.50 (49.17 to 51.84)
Female	50.03 (49.79 to 50.28)	50.39 (50.09 to 50.69)	49.68 (49.00 to 50.37)	49.81 (49.08 to 50.54)	50.51 (49.76 to 51.26)	49.87 (49.24 to 50.49)	49.29 (48.18 to 50.39)	49.50 (48.16 to 50.83)
Region of residence, weighted % (95% CI)								
Urban	83.05 (82.09 to 84.01)	82.40 (81.59 to 83.21)	81.26 (78.17 to 84.36)	80.70 (77.44 to 83.97)	83.37 (80.49 to 86.25)	85.55 (83.15 to 87.95)	85.45 (80.38 to 90.51)	84.88 (79.96 to 89.80)
Rural	16.95 (15.99 to 17.91)	17.60 (16.79 to 18.41)	18.74 (15.64 to 21.83)	19.30 (16.03 to 22.56)	16.63 (13.75 to 19.51)	14.45 (12.05 to 16.85)	14.55 (9.49 to 19.62)	15.12 (10.20 to 20.04)
BMI* group, weighted % (95% CI)								
Underweight (<18.5kg/m^2)	5.40 (5.22 to 5.57)	3.12 (2.80 to 3.44)	7.32 (6.81 to 7.83)	7.00 (6.55 to 7.46)	6.41 (5.92 to 6.90)	5.59 (5.22 to 5.96)	5.31 (4.50 to 6.11)	5.82 (4.89 to 6.75)
Normal weight (18.5-22.9 kg/m^2)	30.74 (30.34 to 31.15)	9.23 (8.39 to 10.07)	40.49 (39.65 to 41.33)	41.08 (40.13 to 42.02)	41.01 (40.13 to 41.88)	39.33 (38.57 to 40.09)	34.91 (33.29 to 36.53)	36.27 (34.63 to 37.91)
Overweight (23-24.9 kg/m^2)	16.71 (16.44 to 16.99)	4.85 (4.40 to 5.30)	22.22 (21.54 to 22.90)	21.34 (20.61 to 22.07)	21.93 (21.18 to 22.69)	21.46 (20.85 to 22.07)	21.91 (20.71 to 23.12)	20.84 (19.43 to 22.25)
Obese (≥ 25.0 kg/m^2)	24.31 (23.97 to 24.65)	6.06 (5.50 to 6.63)	29.49 (28.66 to 30.31)	30.15 (29.27 to 31.04)	30.54 (29.68 to 31.40)	33.34 (32.55 to 34.14)	37.14 (35.52 to 38.76)	36.13 (34.34 to 37.91)
Unknown	22.84 (22.14 to 23.54)	76.73 (74.68 to 78.78)	0.48 (0.31 to 0.66)	0.42 (0.29 to 0.55)	0.12 (0.04 to 0.19)	0.28 (0.19 to 0.36)	0.73 (0.47 to 0.99)	0.95 (0.63 to 1.27)
Education, weighted % (95% CI)								
Elementary school or lower education	16.05 (15.75 to 16.35)	24.51 (24.00 to 25.02)	16.12 (15.26 to 16.98)	14.75 (13.90 to 15.59)	12.94 (12.16 to 13.73)	10.37 (9.74 to 10.99)	8.13 (6.91 to 9.35)	8.79 (7.50 to 10.08)
Middle school	12.73 (12.52 to 12.95)	13.84 (13.50 to 14.17)	14.53 (13.89 to 15.18)	13.81 (13.21 to 14.40)	12.28 (11.71 to 12.86)	10.90 (10.40 to 11.40)	9.99 (8.92 to 11.07)	9.84 (8.82 to 10.85)
High school	32.05 (31.68 to 32.42)	34.03 (33.49 to 34.57)	33.05 (32.03 to 34.07)	32.39 (31.33 to 33.46)	31.22 (30.16 to 32.29)	29.74 (28.85 to 30.62)	30.18 (28.27 to 32.08)	30.25 (28.38 to 32.12)

Table 1. Continued

	Total	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021
College or higher education	39.17 (38.65 to 39.70)	27.63 (26.90 to 28.35)	36.29 (34.90 to 37.69)	39.05 (37.64 to 40.47)	43.55 (42.16 to 44.94)	49.00 (47.69 to 50.31)	51.70 (48.71 to 54.69)	51.12 (48.38 to 53.86)
Smoking status, weighted % (95% CI)								
Smoker	17.17 (16.83 to 17.51)	7.35 (6.68 to 8.02)	24.02 (23.22 to 24.81)	23.76 (22.89 to 24.64)	20.66 (19.80 to 21.52)	19.80 (19.06 to 20.54)	18.32 (16.88 to 19.76)	17.45 (15.99 to 18.91)
Ex-smoker	14.24 (14.00 to 14.48)	3.16 (2.83 to 3.50)	17.33 (16.72 to 17.95)	17.44 (16.77 to 18.10)	17.68 (16.99 to 18.37)	19.86 (19.29 to 20.43)	22.12 (20.96 to 23.28)	22.89 (21.54 to 24.24)
Non-smoker	45.96 (45.42 to 46.51)	15.45 (14.10 to 16.79)	51.74 (50.72 to 52.77)	58.80 (57.91 to 59.69)	61.66 (60.78 to 62.54)	60.34 (59.59 to 61.09)	59.56 (57.97 to 61.15)	59.66 (57.85 to 61.48)
Unknown	22.63 (21.88 to 23.38)	74.05 (71.80 to 76.29)	6.91 (6.16 to 7.65)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)
Alcohol consumption, weighted % (95% CI)								
Non-drinker	14.29 (13.89 to 14.69)	12.88 (11.74 to 14.02)	16.92 (16.22 to 17.62)	16.38 (15.66 to 17.11)	15.50 (14.81 to 16.20)	13.05 (12.52 to 13.58)	12.70 (11.49 to 13.91)	13.06 (11.76 to 14.37)
1-5 days/month	47.77 (47.32 to 48.23)	8.97 (8.14 to 9.80)	61.89 (60.95 to 62.83)	62.36 (61.42 to 63.31)	63.55 (62.61 to 64.48)	65.05 (64.32 to 65.78)	66.35 (64.85 to 67.86)	67.99 (66.51 to 69.47)
6-30days/month	16.16 (15.88 to 16.44)	4.10 (3.69 to 4.51)	21.15 (20.37 to 21.94)	21.25 (20.48 to 22.02)	20.95 (20.14 to 21.75)	21.90 (21.26 to 22.53)	20.95 (19.58 to 22.32)	18.95 (17.61 to 20.29)
Unknown	21.78 (21.03 to 22.53)	74.05 (71.80 to 76.29)	0.04 (0.00 to 0.07)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)	0.00 (0.00 to 0.00)
Income, weighted % (95% CI)								
Lowest quartile	15.70 (15.29 to 16.10)	19.46 (18.65 to 20.28)	15.23 (14.15 to 16.30)	15.23 (14.17 to 16.30)	14.04 (13.00 to 15.07)	13.79 (12.91 to 14.67)	12.11 (10.14 to 14.07)	11.70 (9.90 to 13.50)
Second quartile	25.14 (24.67 to 25.61)	25.60 (24.83 to 26.38)	24.87 (23.57 to 26.18)	27.55 (26.16 to 28.93)	25.11 (23.75 to 26.47)	24.16 (23.11 to 25.21)	22.18 (19.88 to 24.47)	22.91 (20.64 to 25.17)
Third quartile	29.14 (28.67 to 29.60)	27.46 (26.73 to 28.19)	29.48 (28.16 to 30.80)	29.35 (28.09 to 30.61)	30.14 (28.73 to 31.55)	29.61 (28.55 to 30.68)	30.82 (28.59 to 33.06)	31.21 (28.95 to 33.48)

Table 1. Continued

	Total	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021
Highest quartile	30.03 (29.38 to 30.68)	27.47 (26.41 to 28.54)	30.42 (28.51 to 32.33)	27.87 (26.35 to 29.39)	30.71 (28.90 to 32.52)	32.44 (30.89 to 33.99)	34.89 (31.38 to 38.41)	34.18 (30.33 to 38.03)

Abbreviations: n, number; BMI, body mass index; CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey.

*According to the Asian-Pacific guidelines, the BMI is divided into four groups: underweight (<18.5 kg/m^2), normal (18.5-22.9 kg/m^2), overweight (23–24.9 kg/m^2), and obese (≥25 kg/m^2).

Table 2 illustrates the national trends and weighted prevalence of TB before (1998-2019) and during (2020-2021) the COVID-19 pandemic. Overall, there was an increase in the trend of TB prevalence before the pandemic (trend in β, 0.124 [95% CI, 0.047 to 0.201]), which was no longer apparent during the pandemic. Individuals 20-29 years saw a significant decrease in TB prevalence trends during the pandemic, especially compared to the pre-pandemic (trends in β, -0.501 [95% CI, -0.735 to -0.267] and -0.45 [-0.72 to -0.17], respectively). Females saw a significant positive trend in TB prevalence before the pandemic (trend in β, 0.146 [95% CI, 0.055 to 0.238]), which decreased during the pandemic. Similarly, individuals living in both urban and rural regions (trends in β, 0.104 [95% CI, 0.018 to 0.189] and 0.239 [0.059 to 0.420], respectively), those with a high school diploma, middle school, or elementary school education (trends in β, 0.185 [95% CI, 0.056 to 0.314], 0.239 [0.059 to 0.420], and 0.740 [0.541 to 0.939], respectively), and those in the second and lowest income quartiles (trends in β, 0.282 [95% CI, 0.087 to 0.476] and 0.195 [0.037 to 0.353], respectively) all showed significant positive trends in TB prevalence before the pandemic, which were no longer apparent after the onset of the pandemic.

Table 2. National trends of the prevalence of tuberculosis and β-coefficients of odds ratios before and during the COVID-19 pandemic in Koreans aged over 5, weighted % (95% CI), data was collected 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)	βdiff between 1998-2019 and 2021 (95% CI)
	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021			
Overall	1.34 (1.24 to 1.45)	4.85 (4.48 to 5.22)	3.69 (3.36 to 4.02)	3.30 (2.95 to 3.65)	3.03 (2.78 to 3.27)	3.17 (2.65 to 3.68)	2.73 (2.25 to 3.22)	0.124 (0.047 to 0.201)	-0.147 (-0.418 to 0.124)	-0.27 (-0.55 to 0.01)
Age group										
5-19	0.06 (0.02 to 0.11)	0.64 (0.25 to 1.03)	0.09 (0.00 to 0.25)	0.06 (0.00 to 0.19)	0.10 (0.00 to 0.30)	NA	NA	-0.035 (-0.082 to 0.013)	-0.052 (-0.153 to 0.049)	-0.02 (-0.13 to 0.09)

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)	βdiff between 1998-2019 and 2021 (95% CI)
	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021			
20-29	0.73 (0.52 to 0.94)	1.95 (1.24 to 2.65)	1.56 (0.86 to 2.25)	1.12 (0.54 to 1.69)	1.00 (0.53 to 1.47)	1.05 (0.03 to 2.07)	NA	-0.052 (-0.196 to 0.093)	-0.501 (-0.735 to -0.267)	-0.45 (-0.72 to -0.17)
30-39	1.43 (1.18 to 1.68)	4.24 (3.52 to 4.96)	2.87 (2.16 to 3.58)	2.32 (1.65 to 2.99)	1.55 (1.10 to 1.99)	1.22 (0.36 to 2.07)	0.81 (0.07 to 1.54)	-0.204 (-0.353 to -0.056)	-0.369 (-0.794 to 0.056)	-0.16 (-0.61 to 0.29)
40-49	1.48 (1.24 to 1.72)	5.27 (4.40 to 6.14)	4.11 (3.26 to 4.96)	3.32 (2.56 to 4.08)	2.95 (2.38 to 3.51)	2.73 (1.43 to 4.03)	1.95 (0.98 to 2.93)	0.008 (-0.173 to 0.189)	-0.494 (-1.050 to 0.061)	-0.50 (-1.09 to 0.08)
50-59	2.37 (1.97 to 2.77)	7.63 (6.49 to 8.78)	5.82 (4.87 to 6.78)	5.51 (4.50 to 6.51)	4.32 (3.64 to 5.01)	5.01 (3.42 to 6.61)	5.71 (3.85 to 7.56)	-0.093 (-0.341 to 0.156)	0.691 (-0.316 to 1.697)	0.78 (-0.25 to 1.82)
60-69	2.92 (2.42 to 3.42)	9.25 (7.91 to 10.59)	6.42 (5.39 to 7.45)	6.21 (5.15 to 7.27)	5.63 (4.83 to 6.42)	5.98 (4.25 to 7.71)	4.59 (3.14 to 6.03)	0.043 (-0.232 to 0.318)	-0.552 (-1.389 to 0.285)	-0.60 (-1.48 to 0.29)
≥70	3.20 (2.51 to 3.89)	9.38 (7.86 to 10.90)	7.64 (6.30 to 8.99)	5.92 (4.78 to 7.06)	6.95 (5.85 to 8.05)	6.83 (4.23 to 9.43)	6.06 (4.05 to 8.07)	0.127 (-0.240 to 0.493)	-0.450 (-1.598 to 0.697)	-0.58 (-1.78 to 0.63)
Sex										
Male	1.67 (1.50 to 1.84)	5.96 (5.39 to 6.54)	4.37 (3.84 to 4.90)	3.93 (3.41 to 4.45)	3.56 (3.19 to 3.94)	3.88 (3.09 to 4.66)	3.08 (2.31 to 3.85)	0.101 (-0.017 to 0.220)	-0.245 (-0.667 to 0.177)	-0.35 (-0.78 to 0.09)
Female	1.02 (0.90 to 1.15)	3.73 (3.30 to 4.16)	3.00 (2.62 to 3.39)	2.67 (2.26 to 3.09)	2.49 (2.19 to 2.79)	2.44 (1.68 to 3.19)	2.39 (1.80 to 2.98)	0.146 (0.055 to 0.238)	-0.052 (-0.380 to 0.276)	-0.20 (-0.54 to 0.14)
Region of residence										
Urban	1.31 (1.19 to 1.43)	4.86 (4.43 to 5.28)	3.81 (3.43 to 4.20)	3.14 (2.75 to 3.54)	2.98 (2.72 to 3.25)	3.17 (2.58 to 3.76)	2.77 (2.22 to 3.32)	0.104 (0.018 to 0.189)	-0.107 (-0.411 to 0.198)	-0.21 (-0.53 to 0.11)
Rural	1.51 (1.24 to 1.79)	4.83 (4.11 to 5.54)	3.18 (2.56 to 3.80)	4.06 (3.31 to 4.81)	3.30 (2.68 to 3.91)	3.12 (2.36 to 3.88)	2.54 (1.73 to 3.34)	0.239 (0.059 to 0.420)	-0.381 (-0.897 to 0.135)	-0.62 (-1.17 to -0.07)
Education										
Elementary school or lower education	1.41 (1.21 to 1.61)	6.67 (5.82 to 7.51)	5.07 (4.24 to 5.90)	4.48 (3.60 to 5.36)	5.42 (4.52 to 6.31)	6.35 (3.78 to 8.92)	4.06 (1.83 to 6.29)	0.740 (0.541 to 0.939)	-0.642 (-1.808 to 0.525)	-1.38 (-2.56 to -0.20)
Middle school	1.35 (1.08 to 1.62)	5.38 (4.44 to 6.32)	3.57 (2.74 to 4.41)	3.74 (2.90 to 4.59)	3.45 (2.71 to 4.19)	3.66 (2.12 to 5.20)	2.63 (1.30 to 3.97)	0.211 (0.001 to 0.421)	-0.400 (-1.154 to 0.353)	-0.61 (-1.39 to 0.17)

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)	βdiff between 1998-2019 and 2021 (95% CI)
	1998-2005	2007-2009	2010-2012	2013-2015	2016-2019	2020	2021			
High school	1.26 (1.07 to 1.44)	4.43 (3.82 to 5.05)	3.28 (2.70 to 3.86)	3.65 (3.08 to 4.22)	2.74 (2.31 to 3.16)	3.74 (2.70 to 4.78)	2.69 (1.79 to 3.58)	0.185 (0.056 to 0.314)	-0.031 (-0.535 to 0.473)	-0.22 (-0.74 to 0.30)
College or higher education	1.39 (1.18 to 1.60)	4.22 (3.64 to 4.79)	3.55 (3.00 to 4.11)	2.57 (2.11 to 3.02)	2.60 (2.27 to 2.94)	2.23 (1.60 to 2.87)	2.56 (1.88 to 3.23)	-0.069 (-0.193 to 0.055)	-0.022 (-0.394 to 0.351)	0.05 (-0.35 to 0.44)
Household income										
Lowest quartile	1.93 (1.66 to 2.20)	6.39 (5.36 to 7.41)	5.04 (4.14 to 5.95)	4.10 (3.25 to 4.96)	4.28 (3.58 to 4.97)	3.68 (2.28 to 5.08)	4.02 (2.55 to 5.49)	0.282 (0.087 to 0.476)	-0.138 (-0.928 to 0.652)	-0.42 (-1.23 to 0.39)
Second quartile	1.37 (1.16 to 1.58)	4.89 (4.13 to 5.65)	3.64 (3.02 to 4.27)	3.42 (2.71 to 4.13)	3.29 (2.79 to 3.80)	3.59 (2.60 to 4.57)	2.60 (1.64 to 3.56)	0.195 (0.037 to 0.353)	-0.344 (-0.882 to 0.194)	-0.54 (-1.10 to 0.02)
Third quartile	1.09 (0.90 to 1.28)	4.79 (4.17 to 5.40)	3.37 (2.73 to 4.01)	2.95 (2.43 to 3.48)	2.79 (2.32 to 3.27)	2.91 (1.83 to 4.00)	2.28 (1.49 to 3.07)	0.075 (-0.065 to 0.215)	-0.260 (-0.720 to 0.200)	-0.33 (-0.82 to 0.15)
Highest quartile	1.16 (0.97 to 1.35)	4.12 (3.50 to 4.73)	3.34 (2.74 to 3.94)	3.16 (2.49 to 3.83)	2.52 (2.12 to 2.91)	2.94 (2.19 to 3.69)	2.80 (1.91 to 3.69)	0.087 (-0.048 to 0.222)	0.140 (-0.351 to 0.630)	0.05 (-0.46 to 0.56)

Abbreviations: CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey;
The numbers in bold indicate a significant difference (p<0.05).

Fig. 2 provides a visual presentation of the data shown in Table 2. Overall, there was a slight increase in TB prevalence early in the pandemic, but there was a sharp decrease between 2020 and 2021. Males before the pandemic were at higher risk of TB infection than females; however, those differences waned during the pandemic as indicated by the overlapping 95% confidence intervals. Similarly, while those with lower education and income levels had significantly higher prevalence of TB, those differences ceased to exist during the pandemic.

Table 3 presents the weighted odds ratios of each group between the years 1998-2021. Table 4 presents the differences in those odds ratios overall (1998-2021), between the pre-pandemic (1998-2019) and during the pandemic (2020-2021). Older age was associated with a higher risk of TB infection. The region of residence did not affect the risk of TB infection. Those with lower education levels (elementary and middle school or lower) and lower income have a higher risk of TB infection compared to those with a high school and college degree or higher income level. Only those with an elementary school education or lower saw a significant increase in odds of TB infection during the pandemic as compared to the pre-pandemic (wOR, 1.519 [95% CI, 1.053 to 2.192]).

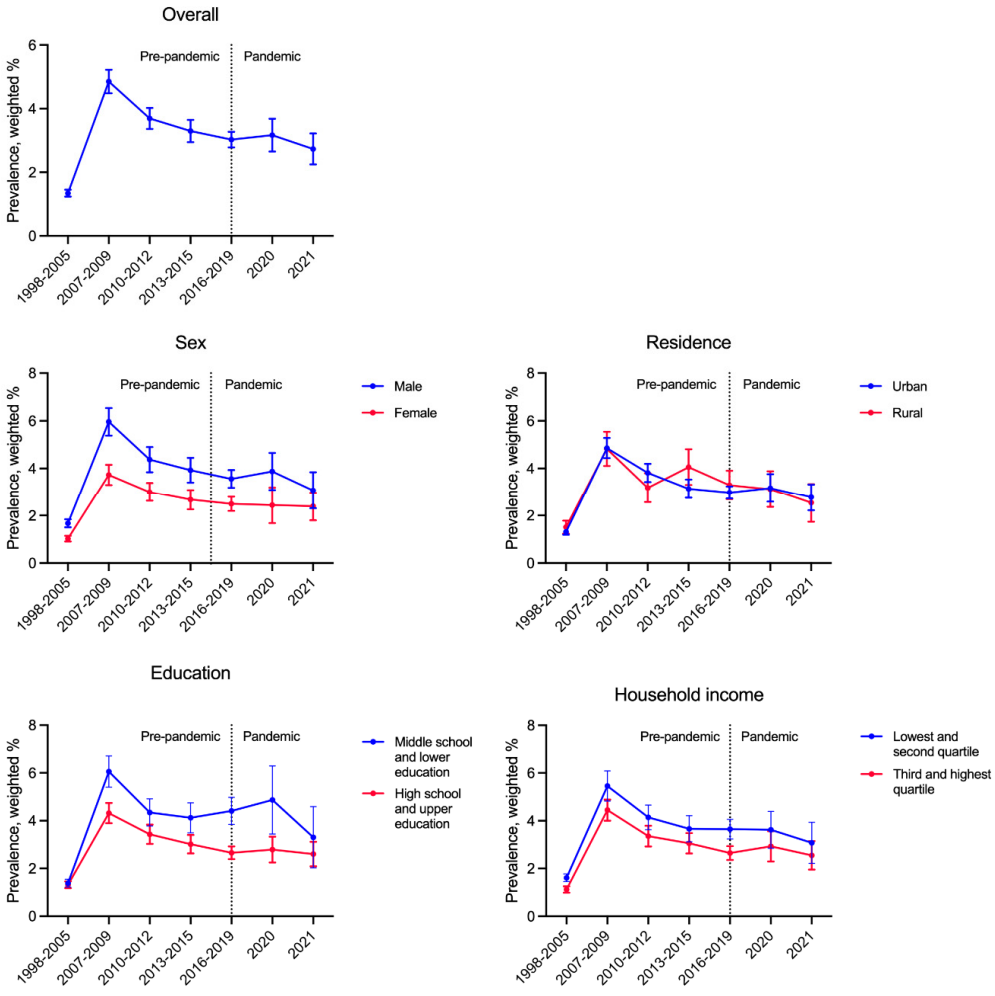

Fig. 2. Nationwide trend in tuberculosis prevalence over 24 years (1998–2021) among 186,561 Korean adults, 1998–2021.

Table 3. Weighted odds ratio of before and during the pandemic, weighted % (95% CI), data was collected from the KNHANES

	2007-2009 versus 1998–2005 (reference)	*P*-value	2010-2012 versus 2007-2009 (reference)	*P*-value	2013-2015 versus 2010-2012 (reference)	*P* -value	2016-2019 versus 2013-2015 (reference)	*P* -value	2020 versus 2016-2019 (reference)	*P* -value	2021 versus 2020 (reference)	*P*-value
Overall	3.74 (3.34 to 4.20)	<.0001	0.75 (0.67 to 0.85)	<.0001	0.89 (0.77 to 1.03)	0.109	0.92 (0.80 to 1.05)	0.212	1.05 (0.87 to 1.26)	0.621	0.86 (0.67 to 1.10)	0.225
Age group												
5-19	9.94 (3.76 to 26.33)	<0.001	0.13 (0.02 to 1.04)	0.055	0.74 (0.05 to 11.93)	0.831	1.61 (0.10 to 25.84)	0.736	NA	NA	NA	NA
20-29	2.69 (1.68 to 4.29)	<0.001	0.80 (0.45 to 1.43)	0.443	0.71 (0.36 to 1.43)	0.339	0.90 (0.44 to 1.81)	0.760	1.05 (0.36 to 3.08)	0.926	NA	NA

Table 3. Continued

	2007-2009 versus 1998–2005 (reference)	*P* - value	2010-2012 versus 2007-2009 (reference)	*P* - value	2013-2015 versus 2010-2012 (reference)	*P* - value	2016-2019 versus 2013-2015 (reference)	*P* - value	2020 versus 2016-2019 (reference)	*P* - value	2021 versus 2020 (reference)	*P* - value
30-39	3.06 (2.38 to 3.93)	<0.001	0.67 (0.49 to 0.91)	0.010	0.81 (0.55 to 1.19)	0.276	0.66 (0.44 to 1.00)	0.052	0.78 (0.37 to 1.67)	0.528	0.66 (0.21 to 2.10)	0.482
40-49	3.69 (2.91 to 4.69)	<0.001	0.77 (0.59 to 1.02)	0.065	0.80 (0.58 to 1.10)	0.172	0.89 (0.65 to 1.20)	0.436	0.92 (0.55 to 1.56)	0.769	0.71 (0.35 to 1.43)	0.337
50-59	3.40 (2.69 to 4.31)	<0.001	0.75 (0.59 to 0.95)	0.017	0.94 (0.73 to 1.22)	0.657	0.78 (0.60 to 1.00)	0.049	1.17 (0.81 to 1.69)	0.412	1.15 (0.70 to 1.87)	0.582
60-69	3.39 (2.67 to 4.30)	<0.001	0.67 (0.53 to 0.85)	0.001	0.97 (0.75 to 1.24)	0.777	0.90 (0.71 to 1.14)	0.384	1.07 (0.76 to 1.50)	0.707	0.76 (0.48 to 1.18)	0.219
≥70	3.13 (2.35 to 4.17)	<0.001	0.80 (0.62 to 1.04)	0.093	0.76 (0.58 to 1.01)	0.055	1.19 (0.91 to 1.55)	0.207	0.98 (0.64 to 1.51)	0.931	0.88 (0.52 to 1.50)	0.639
Sex												
Male	3.73 (3.23 to 4.31)	<0.001	0.72 (0.61 to 0.85)	<0.001	0.90 (0.74 to 1.08)	0.243	0.90 (0.76 to 1.08)	0.251	1.09 (0.87 to 1.38)	0.461	0.79 (0.57 to 1.09)	0.152
Female	3.75 (3.16 to 4.44)	<0.001	0.80 (0.67 to 0.96)	0.014	0.89 (0.72 to 1.09)	0.254	0.93 (0.76 to 1.14)	0.480	0.98 (0.70 to 1.37)	0.893	0.98 (0.66 to 1.46)	0.919
Region of residence												
Urban	3.85 (3.39 to 4.38)	<0.001	0.78 (0.68 to 0.89)	<.0001	0.82 (0.69 to 0.97)	0.018	0.95 (0.81 to 1.11)	0.499	1.07 (0.87 to 1.31)	0.545	0.87 (0.66 to 1.14)	0.316
Rural	3.30 (2.60 to 4.21)	<0.001	0.65 (0.50 to 0.84)	0.001	1.29 (0.97 to 1.70)	0.076	0.81 (0.61 to 1.06)	0.120	0.95 (0.69 to 1.30)	0.732	0.81 (0.53 to 1.22)	0.310
Education												
Elementary school or lower education	5.00 (4.11 to 6.08)	<0.001	0.75 (0.60 to 0.93)	0.009	0.88 (0.67 to 1.15)	0.342	1.22 (0.93 to 1.60)	0.146	1.18 (0.75 to 1.88)	0.473	0.62 (0.30 to 1.29)	0.202
Middle school	4.17 (3.17 to 5.48)	<0.001	0.65 (0.48 to 0.88)	0.006	1.05 (0.75 to 1.47)	0.777	0.92 (0.67 to 1.27)	0.608	1.06 (0.66 to 1.72)	0.804	0.71 (0.37 to 1.39)	0.318
High school	3.64 (2.96 to 4.48)	<0.001	0.73 (0.58 to 0.92)	0.009	1.12 (0.87 to 1.42)	0.378	0.74 (0.59 to 0.93)	0.010	1.38 (1.00 to 1.91)	0.052	0.71 (0.45 to 1.12)	0.139
College or higher education	3.12 (2.53 to 3.84)	<0.001	0.84 (0.67 to 1.04)	0.107	0.72 (0.56 to 0.91)	0.007	1.02 (0.81 to 1.27)	0.892	0.85 (0.62 to 1.18)	0.335	1.15 (0.77 to 1.70)	0.494

Table 3. Continued

	2007-2009 versus 1998–2005 (reference)	*P* - value	2010-2012 versus 2007-2009 (reference)	*P* - value	2013-2015 versus 2010-2012 (reference)	*P* - value	2016-2019 versus 2013-2015 (reference)	*P* - value	2020 versus 2016-2019 (reference)	*P* - value	2021 versus 2020 (reference)	*P* - value
Household income												
Lowest quartile	3.46 (2.77 to 4.32)	<0.001	0.78 (0.60 to 1.01)	0.055	0.81 (0.60 to 1.07)	0.140	1.04 (0.79 to 1.38)	0.759	0.86 (0.56 to 1.30)	0.464	1.10 (0.64 to 1.88)	0.736
Second quartile	3.71 (2.96 to 4.64)	<0.001	0.74 (0.58 to 0.94)	0.013	0.94 (0.71 to 1.24)	0.648	0.96 (0.74 to 1.26)	0.770	1.09 (0.79 to 1.52)	0.595	0.72 (0.44 to 1.16)	0.173
Third quartile	4.58 (3.67 to 5.71)	<0.001	0.69 (0.55 to 0.88)	0.003	0.87 (0.67 to 1.14)	0.320	0.94 (0.73 to 1.22)	0.658	1.05 (0.69 to 1.57)	0.834	0.78 (0.47 to 1.30)	0.335
Highest quartile	3.66 (2.92 to 4.59)	<0.001	0.81 (0.63 to 1.03)	0.079	0.94 (0.71 to 1.26)	0.694	0.79 (0.60 to 1.04)	0.089	1.18 (0.86 to 1.60)	0.303	0.95 (0.63 to 1.44)	0.812

Abbreviations: CI, confidence interval; KNHANES, Korea National Health and Nutrition Examination Survey.
The numbers in bold indicate a significant difference ($p<0.05$).

Table 4. Difference between pre-pandemic and during pandemic by the ratio of ORs on tuberculosis, weighted % (95% CI), data was collected from the KNHANES

Variables		Overall (1998–2021)		Pre-pandemic era (1998–2019)		During pandemic era (2020–2021)		Ratio of ORs (95% CI), pre-pandemic (reference) versus during pandemic	
		Weighted OR (95% CI)	*P*-value	Weighted OR (95% CI)	*P*-value	Weighted OR (95% CI)	*P*-value	Weighted OR (95% CI)	*P*-value
Age (years)	20-29 (ref)	1.00		1.00		1.00		1.00	
	5-19	0.12 (0.07 to 0.20)	<0.001	0.12 (0.07 to 0.20)	<0.001	NA		NA	
	30-39	1.97 (1.60 to 2.43)	<0.001	1.96 (1.59 to 2.42)	<0.001	1.90 (0.62 to 5.79)	0.261	0.967 (0.310 to 3.012)	0.954
	40-49	2.84 (2.32 to 3.48)	<0.001	2.76 (2.25 to 3.39)	<0.001	4.44 (1.59 to 12.36)	0.005	1.606 (0.565 to 4.567)	0.374
	50-59	4.61 (3.79 to 5.61)	<0.001	4.32 (3.54 to 5.27)	<0.001	10.37 (3.80 to 28.31)	<0.001	2.402 (0.863 to 6.687)	0.093
	60-69	5.32 (4.38 to 6.46)	<0.001	5.08 (4.16 to 6.19)	<0.001	10.42 (3.97 to 27.35)	<0.001	2.052 (0.766 to 5.498)	0.153
	≥70	6.10 (5.01 to 7.43)	<0.001	5.78 (4.73 to 7.05)	<0.001	12.65 (4.58 to 34.89)	<0.001	2.190 (0.779 to 6.160)	0.137
Sex	Female (ref)	1.00		1.00		1.00		1.00	
	Male	1.53 (1.43 to 1.64)	<0.001	1.53 (1.42 to 1.65)	<0.001	1.51 (1.17 to 1.96)	0.002	0.987 (0.755 to 1.290)	0.924

Table 4. Continued

Variables		Overall (1998–2021)		Pre-pandemic era (1998–2019)		During pandemic era (2020–2021)		Ratio of ORs (95% CI), pre-pandemic (reference) versus during pandemic	
		Weighted OR (95% CI)	*P*-value	Weighted OR (95% CI)	*P*-value	Weighted OR (95% CI)	*P*-value	Weighted OR (95% CI)	*P*-value
Region of residence	Rural (ref)	1.00		1.00		1.00		1.00	
	Urban	0.95 (0.87 to 1.03)	0.226	0.94 (0.86 to 1.03)	0.193	1.02 (0.80 to 1.30)	0.867	1.086 (0.837 to 1.410)	0.535
Education level	College or higher education (ref)	1.00		1.00		1.00		1.00	
	Elementary school or lower education	1.40 (1.27 to 1.53)	<0.001	1.35 (1.23 to 1.49)	<0.001	2.05 (1.44 to 2.92)	<0.001	1.519 (1.053 to 2.192)	0.025
	Middle school	1.18 (1.06 to 1.32)	0.003	1.17 (1.04 to 1.31)	0.010	1.33 (0.93 to 1.90)	0.116	1.141 (0.783 to 1.662)	0.492
	High school	1.04 (0.95 to 1.14)	0.348	1.01 (0.92 to 1.11)	0.791	1.35 (1.00 to 1.83)	0.051	1.334 (0.971 to 1.832)	0.075
Household income	Highest quartile (ref)	1.00		1.00		1.00		1.00	
	Lowest quartile	1.50 (1.35 to 1.66)	<0.001	1.51 (1.36 to 1.69)	<0.001	1.37 (1.01 to 1.87)	0.045	0.906 (0.653 to 1.257)	0.554
	Second quartile	1.16 (1.05 to 1.29)	0.005	1.17 (1.05 to 1.31)	0.005	1.10 (0.82 to 1.47)	0.546	0.936 (0.683 to 1.282)	0.680
	Third quartile	1.02 (0.92 to 1.14)	0.683	1.04 (0.93 to 1.16)	0.521	0.91 (0.65 to 1.28)	0.599	0.881 (0.619 to 1.254)	0.482

Abbreviations: KNHANES, Korea National Health and Nutrition Examination Survey; CI, confidence interval; OR, odds ratio;
The numbers in bold indicate a significant difference ($p<0.05$).

4. Discussion

4.1 Key results

This study analyzed the trends in TB 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 TB prevalence trends and associated factors in the Korean population, including the COVID-19 pandemic. Overall, there was an increase in the trend of TB prevalence before the pandemic, which plateaued after the pandemic. There was a sharp decrease in TB prevalence between 2020 and 2021. Males before the pandemic were at higher risk of TB infection than females; however, those differences waned during the pandemic, as indicated by the overlapping 95% confidence intervals. Similarly, while those with lower education and income levels had a significantly higher prevalence of TB compared to those with higher education levels and incomes, those differences ceased to exist during the pandemic.

4.2 Comparison with previous studies

The results of this study are consistent with previous studies done in other countries. During the COVID-19 pandemic, TB case detection in countries including China, the Philippines, Indonesia, India and others decreased significantly between 2019 and 2020, during the COVID-19 pandemic.[21, 22] However, many of these studies focused on reporting aggregate numbers of diagnosed cases and treatments. TB and COVID-19 are highly influenced by socioeconomic factors, which are covered thoroughly by this study for the South Korean population.

4.3 Global epidemiology and mechanism

The observed decrease in TB prevalence in South Korea during the pandemic could be attributed to the reduction of healthcare utilization that was seen worldwide due to the pandemic.[23] Not unlike other countries, South Korea's healthcare utilization significantly decreased in early 2020 during the COVID-19 pandemic.[24] TB is considered a legal communicable disease in South Korea, making it mandatory to report diagnosed TB in South Korea. From 2020 to 2021, there was a significant reduction in reported cases.[11] This reduction in healthcare utilization accompanied by the decrease in reported TB is consistent with our findings of decreased TB prevalence between 2020 and 2021.

Interestingly, according to the Korean public-private mix monitoring database, there were no significant changes in TB testing; however, treatment success rates decreased from 2019 to early 2020.[25] It is concerning that South Koreans were not being treated as successfully post-diagnosis; perhaps current treatment regimens were less effective (such as in cases of multidrug-resistant [MDR]-TB) or complicated by COVID-19 co-infection.[26]

TB and COVID-19 have been recently referred to as another "cursed duet" and individuals should be given special attention if co-infected.[27] TB is a risk factor for COVID-19 and preventative measures should not be neglected.[28] MDR-TB remains a growing public health concern in South Korea. In anticipation of an MDR-TB resurgence after COVID-19, new treatments and more rigorous prevention regimens have been suggested.[29]

Though it is difficult to establish causation, the temporary decreasing trends in TB prevalence observed are likely related to decreased healthcare utilization trends, mask usage, and social distancing. With the reestablishment of the status quo, usual healthcare services, and returning utilization, we may see TB prevalence trends return to pre-pandemic levels or even higher with the potential worsening of MDR-TB.[30] Moving forward, it would be informative to combine data from both private and public sectors regarding TB incidence and prevalence. Once more data from the post-pandemic period is available, analysis of combined databases would provide further insight into trends of TB prevalence in South Korea.

4.4 Policy implications

This study found that prior to the COVID-19 pandemic, males, lower education, and lower income individuals had higher odds of developing a TB infection. With the disruption of healthcare utilization and resources, these differences lessened. However, with the return to normalcy post-pandemic, we may see the reemergence of these trends. Increased public health

education and prophylactic testing in these more vulnerable communities may serve as a starting point to push towards health equity with regards to TB.[31]

The impact of COVID-19 has only emphasized the need to push for quick and novel translational TB research. Especially with the existing problem and possible post-COVID-19 surge of MDR-TB in South Korea, improved testing, more effective treatment and management, and public health education and awareness are all necessary to provide proper TB management in the community.[25, 29]

4.5 Strengths and limitations

Limitations of this study lie in the inherent characteristics of the KNHANES database. There is a lack of data on infants of 0-5 years, though this could provide increased insight into the prevalence of TB in infants, especially in Korea where latent TB is a growing issue. Due to the nature of self-report, recall bias is also introduced. The KNHANES provides minimal data on the TB status of participants. We cannot differentiate between active or latent TB or assess if the TB was new-onset or diagnosed previously. We also cannot fully establish an association between COVID-19 measures and TB 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, it cannot be used to generalize global trends. Nonetheless, this study is an insightful addition to similar previous studies from other countries; together, these studies can help understand the global trends of TB. The data ranges from 1998 to 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 TB prevalence trends. Despite these limitations, the strength of this study lies in its large sample size, which is representative of the Korean population. Stratification of the population allows for clear observation of the nuances between different socioeconomic and age groups before and during the pandemic.

5. Conclusion

This study provides valuable insights into the long-term trends and associated factors influencing TB prevalence in South Korea over a 24-year period, particularly in the context of the COVID-19 pandemic. Prior to the pandemic, there was an increasing trend in TB prevalence, which diminished during the pandemic. Notably, a sharp decrease in TB prevalence was observed between 2020 and 2021. This highlights the significance of TB and COVID-19 sharing commonalities in affecting the respiratory system and altering the immune response. By analyzing a large and representative sample of the Korean population from KNHANES, the research offers a detailed picture of TB dynamics across various socioeconomic and age groups. The findings underscore the complex interplay between infectious diseases and public health measures. Moreover, this contributes significantly to the understanding of the impact of the COVID-19 pandemic on TB management and prevention policies domestically, offering profound insights into the future public health implications.

Capsule Summary

This study highlights the importance of healthcare utilization, timely diagnosis, and effective treatments for tuberoculosis that are a significant public health risk.

Ethical statement

The research protocol was approved by the Institutional Review Boards of the KDCA (2007-02CON-04-P, 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C, 2011-02CON-06-C, 2012-01EXP-01-2C, 2013-07CON-03-4C, 2013-12EXP-035C) and by the local law of the Act (Article 2, Paragraph 1) and Enforcement Regulation (Article 2, Paragraph 2, item 1) of Bioethics and Safety Act, from Korean government. Written informed consent was obtained from all participants prior to their participation.

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: JP and AN; Acquisition, analysis, or interpretation of data: JP and AN; Drafting of the manuscript: JP and AN; Critical revision of the manuscript for important intellectual content: all authors; Statistical analysis: JP and AN; Study supervision: SHC. SHC is guarantor for this study. JP and AN contributed equally as first authors. 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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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.

Provenance and peer review

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