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Comparative Analysis of Health Patterns and Gaps due to Environmental Influences in South Korea and North Korea, 2000–2017

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Key Words
Child health; Environmental health; Environmental exposure; Environmental pollution; Environment and public health

Objectives: To conduct a comparative study of children's health in South Korea versus North Korea focusing on air pollution.

Methods: We used annual mortality rate, prevalence, and environmental indicators data from the World Bank and World Health Organizations (WHO). Trend analysis of the two Koreas was conducted to evaluate changes in health status over time. Spearman's correlation analysis was used to find out the correlation between environmental indicators and children's health status.

Results: We found a distinct gap in children's health status between the two Koreas. While North Korea reported a higher death rate of children than South Korea, both showed a decreasing trend with the gap narrowing from 2000 to 2017. The prevalence of overweight and obesity increased and that of thinness decreased in both Koreas. Except $PM_{2.5}$ exposure, South Korea reported higher figures in most indicators of air pollutant emissions (South Korea, mean (SD)=28.3 (2.0); North Korea, mean (SD)=36.5 (2.8), P-value=0.002).

Conclusion: This study empirically discovered the gaps and patterns of children's health between South Korea and North Korea. North Korean children experienced more severe health outcomes than children in South Korea. These findings imply that epigenetic modification caused by environmental stressors affect children's health in the two Koreas despite similar genetic characteristics. Considering the gaps in children's health between the two Koreas, more attention and resources need to be directed towards North Korea because the necessary commodities and services to improve children's health are lacking in North Korea.

Introduction

Children's health is an important theme in public health since its impact covers the life-course from childhood to adulthood. Children have a unique vulnerability to health-related issues and harmful exposures compared to adults [1,2]. Since young children go through rapid growth and development, their metabolism is immature and more vulnerable to environmental stressors [2]. Environmental exposures affect children's health and create a larger burden of diseases, including respiratory diseases (e.g., acute lower respiratory infection [ALRI], pneumonia, and asthma) [1,3,4]. Environmental exposure is known as an important determinant of health in both developed and developing countries, although the patterns of exposure vary [3]. Existing literature discusses the effect of environmental exposure on children's health, which causes a larger burden of diseases [4]. Previous epidemiological studies have reported the association between air pollution exposure and mortality in children under 5 years [5–8]. Health risks caused by air pollution have a great impact in low- and middle-income countries [3,9]. People in wealthier nations may be healthier since economic prosperity allows them to spend more on personal health, leading to better health outcomes [10]. However, economic development has led to a higher level of environmental pollution which damages people's health [11]. We thus argue that environmental exposure is an important determinant of health.

Another body of literature emphasizes the importance of epigenetic modifications caused by environmental stressors such as air pollutants, particulate matter, and metal exposure, thereby affecting children's health [12–14]. Epigenetic change considers genetics as a factor but puts greater emphasis on environmental circumstances that modify one's health [14]. A comparative study of the Republic of Korea (hereafter referred to as South Korea) and the Democratic People's Republic of Korea (hereafter referred to as North Korea) presents a unique opportunity to compare the effects of a shared genetic background versus epigenetic modifications caused by environmental stressors [12,13].

There are few empirical studies on North Korean children's health, despite the ample media reports of widespread malnutrition and infectious diseases. South Korea and North Korea have been isolated from each other due to the politics of the Korean War and the Cold War dynamics on the Korean Peninsula. Such separation from each other while sharing the same ethnicity and early history provides a rich ground for comparative research. However, there are few comparative studies on children's health in these two countries. There are two pertinent points of comparison in this research. First is the impact of the "North Korean Famine (1995–1998)" or "the Arduous March," which has resulted in children's widespread malnutrition and stunting. South Korea did not suffer from famine or malnutrition during the same period. A second point is the remarkably different environmental circumstances due to the different pace and level of economic development.

South Korea and North Korea have been divided since 1945 and their division has solidified after the Korean War in 1950–1953 [15]. Over 7 decades, they have experienced different political regimes and socio-economic development. We assume that the health status of children is conspicuously different between South Korea and North Korea due to socioeconomic, cultural, and environmental factors. Based on this assumption, we hypothesize that harmful environmental circumstances exacerbate the gap in children's health in the two Koreas. Thus, this study aims to analyze the differences in children's health status and the correlation between the environment and children's health in South Korea and North Korea to answer three research questions: (1) How different is the general status of children's health between South Korea and

North Korea, and how has the gap changed over time? (2) What are the disease patterns of children in the two Koreas? and (3) How much do the environmental factors affect children's health in South Korea and North Korea? The comparative analysis will provide interesting findings since many variables have been held constant due to the division. The comparative analysis will help identify the patterns of, and gaps in, children's health in South Korea and North Korea from the perspective of environmental influences on disease patterns across countries of varying levels of economic development.

A comparative study of children's health in South Korea versus North Korea is important for three reasons. First, it can provide a rich comparative analysis of the effect of the environment on children's health with many important health factors held constant. Second, this study will help delineate how a developed, as opposed to a developing, country's environmental factors change as a result of economic progress. Finally, it can contribute as a preparatory study to the understanding of children's health status of the two Koreas to prevent and minimize social disturbances that can be caused by reunification.

Method

1. Data source

We used estimated data for North Korea since the country does not provide official statistics on environmental and health measurements. We utilized data provided by international organizations (for details of data source, see the appendix [Table S1]). The collected (ecological) data are from 2000 to 2017 and included two strands of indicators: (1) environmental indicators and (2) children's health status (mortality rate, prevalence). The collected data were published by the World Bank and the World Health Organization (WHO) [16,17]. Environmental indicators include fine particulate matter ($PM_{2.5}$) exposure and air pollutant emissions, including gas emissions and fossil fuels. In the supplementary material, we provide annual population characteristics and medical and nutritional status collected from the United Nations Children's Fund (UNICEF), Energy Information Administration (EIA), World Bank, Organisation for Economic Co-operation and Development (OECD), and Korea Statistical Information Service. We categorized the indicators of children's health status into four categories: reproductive health, respiratory disease, chronic disease, and nutritional disease.

2. Air pollution indicators

The annual mean $PM_{2.5}$ concentration estimates were derived from the Global Burden of Disease study [18–20]. These data are estimates of the population-weighted average exposure and a general air quality indication to inform cross-country comparisons of health risks. The population estimation data are based on the Gridded Population of the World by NASA Socioeconomic Data and Applications Center (version 4). The detailed description of the exposure estimates is based on previous studies of global estimates of air pollution and environmental risks [18–20]. The emission data include carbon dioxide (CO_2), nitrous oxide (N_2O), methane, and fossil fuel information.

3. Outcome indicators

Children's health indicators consist of two types: (1) annual children's mortality rate (infant, stillbirth, neonatal, under-five, ALRI), congenital anomalies, prematurity, birth asphyxia, diarrheal disease, meningitis/encephalitis, sepsis and other infections) and (2) prevalence (anemia, overweight, obesity, thinness). Infant mortality, stillbirth, and neonatal mortality were calculated as deaths per 1,000 live births (0–4 years old). Mortality of under–five, ALRI, congenital anomalies, prematurity, birth asphyxia, diarrheal disease, meningitis/encephalitis, sepsis and other infections was calculated as deaths per 1,000 children (0–4 years old). We used data on the prevalence of anemia in children under 5 years of age and that of overweight, obesity, and thinness in children 5–9 years of age. Here, overweight is defined as the Body Mass Index (BMI) exceeding +1 SD above the median, obesity as the BMI exceeding +2 SD above the median, and thinness means as a BMI is below median -2 SD.

4. Statistical analysis

We performed two analyses to examine how South Korea and North Korea are differently situated after the "North Korean Famine" in terms of air pollution and health status. First, we compared descriptive statistics for South Korea and North Korea. Second, we performed trend analysis to observe how children's health status in South Korea and North Korea has changed over time.

As the children's health indicator data were estimated annually, we focused on observing the changes per year. Overall, we considered three methods for trend analysis of children's health status: (1) Sen's slope, (2) Mann-Kendall trend test, and (3) linear regression. The first two methods are used to analyze the trends for non-parametric data. If the beta coefficient is greater than zero ($\beta > 0$), the data are considered to show a positive trend. When there are many missing values, the Mann-Kendall trend test can be used as a way to adjust missing data. This method validates significance by using Kendall's correlation coefficient.

We analyzed the correlation coefficient between environmental indicators and children's health status. Since our data spans from 2000 to 2017, the number of pair samples for health status is 18. As the sample number is too small to assume a specific distribution, we utilized Spearman's correlation based on the non-parametric method.

5. Sensitivity analysis

The sources of data in this study are international organizations. Since the data we use are secondary, a direct comparison between the two Koreas is limited. Thus, we cross-checked our results with the data reported by the OECD and the South Korean government (Statistics Korea) for sensitivity analysis [21,22]. This study also extracted North Korean data from the South Korean database (Statistics Korea).

Results

Over a total span of 18 years (2000–2017), we found a distinct gap between South Korea and North Korea in two domains: (1) children's health status (mortality rate, prevalence) and (2) environmental indicators. Differences were observed despite similar demographic trends from 2000 to 2018 – growing population, increase in life expectancy, decrease in total fertility rate, and aging (Table 1).

The time-plots show the trends in children's annual mortality and prevalence in South Korea and North Korea, respectively (Figs. 1, 2). The results of the trend analysis are presented in the appendix (Table S2). Child mortality rates in South Korea and North Korea are decreasing, except for prematurity. While North Korea reported a higher death rate of children than South Korea, the gaps in children's mortality and their health status in both Koreas narrowed from 2000 to 2017

Table 1. Demographic characteristics of South Korea and North Korea

Year	Population (1,000 people)		Life expectancy (yr)						Total fertility rate (births per 1,000 women)	
	South Korea	North Korea	South Korea			North Korea			South Korea	North Korea
			Total	Male	Female	Total	Male	Female		
2000	47,008	22,702	76.0	72.3	79.7	65.3	61.2	69.0	1.48	1.99
2001	47,370	22,902	76.5	72.9	80.1	66.1	62.1	69.7	1.31	1.99
2002	47,645	23,088	76.8	73.4	80.3	66.9	63.0	70.4	1.18	1.99
2003	47,892	23,254	77.3	73.8	80.8	67.6	63.8	71.0	1.19	1.99
2004	48,083	23,411	77.8	74.3	81.2	68.1	64.3	71.5	1.16	1.98
2005	48,185	23,561	78.2	74.9	81.6	68.4	64.7	71.7	1.09	1.98
2006	48,438	23,707	78.8	75.4	82.1	68.5	64.8	71.8	1.13	1.97
2007	48,684	23,849	79.2	75.9	82.5	68.7	65.0	72.0	1.26	1.96
2008	49,055	23,934	79.6	76.2	83.0	68.9	65.3	72.2	1.19	1.95
2009	49,308	24,062	80.0	76.7	83.4	69.2	65.6	72.5	1.15	1.94
2010	49,554	24,187	80.2	76.8	83.6	69.6	66.0	72.9	1.23	1.94
2011	49,937	24,308	80.6	77.3	84.0	70.0	66.4	73.3	1.24	1.93
2012	50,200	24,427	80.9	77.6	84.2	70.5	66.8	73.8	1.30	1.93
2013	50,429	24,545	81.4	78.1	84.6	70.9	67.2	74.2	1.18	1.93
2014	50,747	24,662	81.8	78.6	85.0	71.2	67.6	74.5	1.21	1.93
2015	51,015	24,779	82.1	79.0	85.2	71.5	67.8	74.9	1.24	1.92
2016	51,218	24,897	82.4	79.3	85.4	71.7	68.1	75.1	1.17	1.92
2017	51,362	25,014	82.7	79.7	85.7	71.9	68.3	75.3	1.05	1.91
Average (SD)	49,229.4 (1,394.1)	23,960.5 (702.7)	79.6 (2.1)	76.2 (2.3)	82.9 (2.0)	69.2 (1.9)	65.4 (2.1)	72.5 (1.9)	1.2 (0.1)	2.0 (0.0)
Sen's slope (95% CI)	260.3 (253, 272.9)	125.3 (120.0, 134.7)	0.4 (0.4, 0.4)	0.4 (0.4, 0.4)	0.4 (0.3, 0.4)	0.3 (0.3, 0.4)	0.4 (0.3, 0.4)	0.3 (0.3, 0.4)	0.00 (–0.02, 0.01)	0.00 (–0.01, –0.00)
Mann-Kendall statistics	5.8 (P–value <0.001)	5.8 (P–value <0.001)	5.8 (P–value <0.001)	5.8 (P–value <0.001)	5.8 (P–value <0.001)	5.8 (P–value <0.001)	5.8 (P–value <0.001)	5.8 (P–value <0.001)	–0.8 (P–value: 0.425)	–5.3 (P–value: <0.001)
β (Slope) (95% CI)*	260.6 (252.5, 268.7)	131.2 (125.9, 136.5)	0.4 (0.4, 0.4)	0.4 (0.4, 0.4)	0.4 (0.3, 0.4)	0.4 (0.3, 0.4)	0.4 (0.3, 0.4)	0.3 (0.3, 0.4)	0.01 (–0.02, 0.00)	0.00 (–0.01, 0.00)

*The slope coefficient for simple linear regression.

(Fig. 1). In particular, North Korean children recorded a sharp decline in mortality rate indicators, especially after 2005.

The prevalence of overweight and obesity has increased and that of thinness decreased in both Koreas (Fig. 2). While South Korean children showed an increasing prevalence of anemia, North Korean children decreased and then increased again in North Korean children after 2009. For North Korean children under the age of 5 years who had anemia, a U–shaped pattern was observed since it decreased in the early 2000s and then increased after 2008 (Fig. 2).

We discovered differences in environmental indicators between the two Koreas. Except for $PM_{2.5}$ exposure, South Korea recorded much higher figures than North Korea in most indicators of air pollutant emissions such as CO_2, N_2O, and methane emissions (Table 2 and Fig. S1). An interesting finding is that $PM_{2.5}$ concentration estimates were higher in North Korea than in

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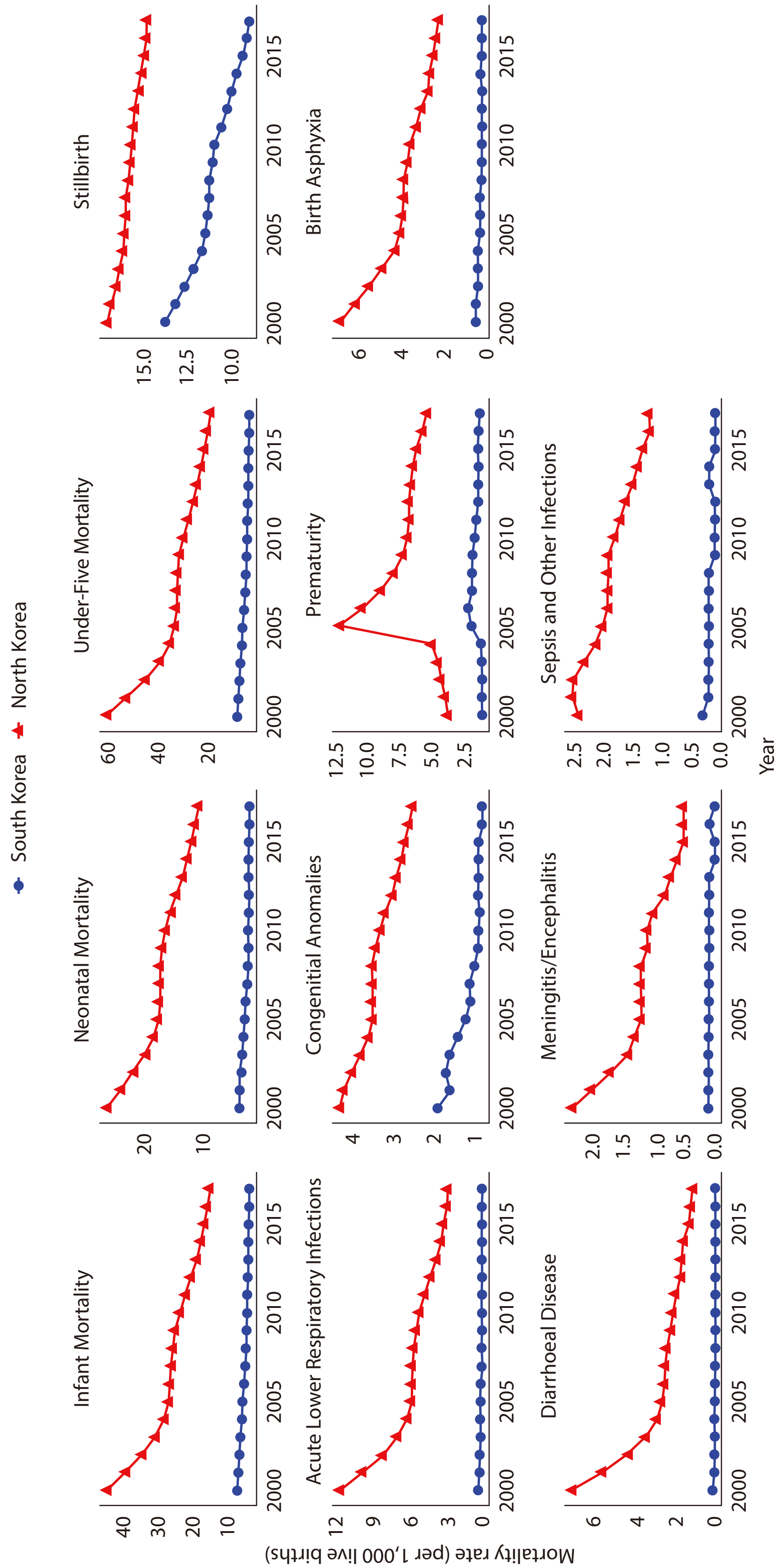

Fig. 1. Trends in children's health (mortality) in South Korea and North Korea. The red line stands for children's health status (mortality, per 1,000 live births) in North Korea and the blue line for South Korea.

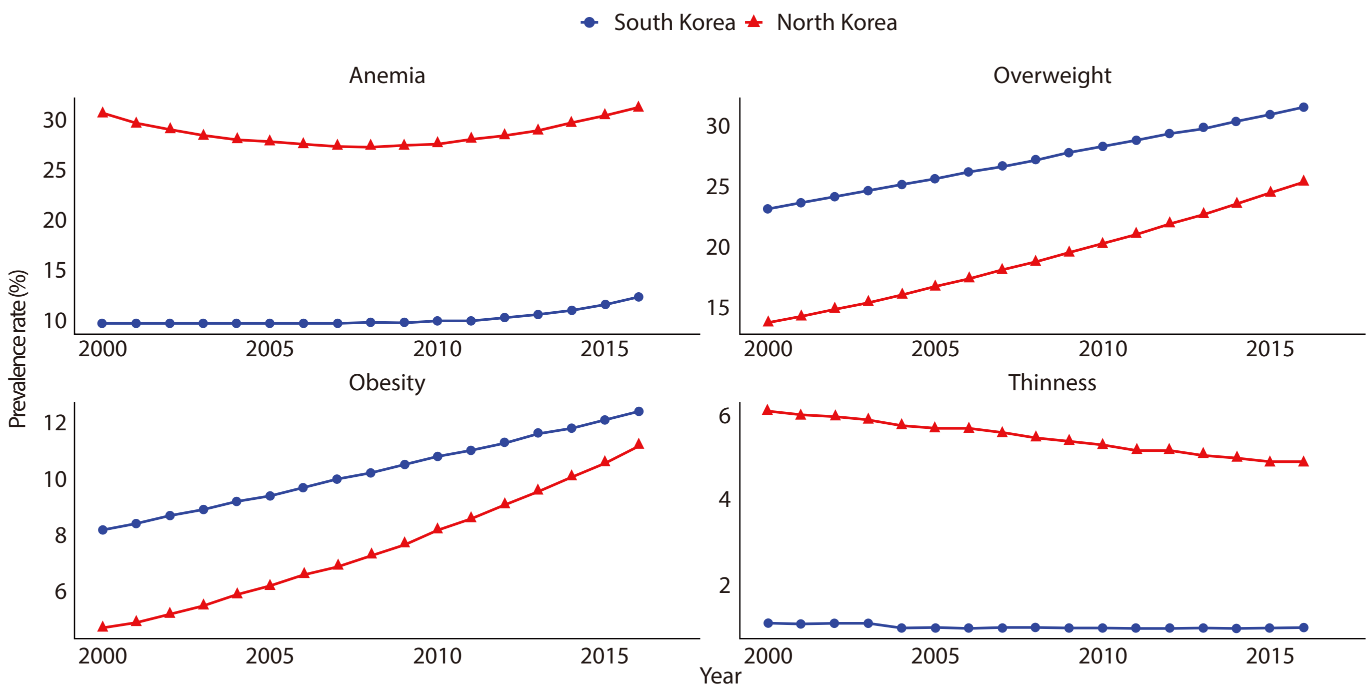

Fig. 2. Trends in children's health (prevalence) in South Korea and North Korea. The red line stands for children's health status (prevalence, %) in North Korea and the blue line for South Korea.

South Korea. North Korea is faced with the danger of high $PM_{2.5}$ concentration which is known to increase the risk of children's ALRI.

Given the differences in environmental indicators between South Korea and North Korea, we examined the association between the environment and children's health. $PM_{2.5}$ showed a positive relationship with infant and child mortality indicators and a negative relationship with the prevalence of anemia, overweight, and obesity in the two Koreas (Fig. 3). In the Poisson regression model, North Korea's $PM_{2.5}$ exposure concentrations were related to infant mortality (% increase: 9.07, 95% confidence interval [CI]: 3.06, 15.44), neonatal mortality (% increase: 7.50, 95% CI: 0.52, 14.97), and under-five mortality (% increase: 8.67, 95% CI: 3.44, 14.17). Meanwhile, the correlation of CO_2, N_2O, and fossil fuel emissions with health effects varied between the two Koreas. It is positive in North Korea, while South Korea has a negative or no correlation.

Discussion

There is a large gap in children's health status between South Korea and North Korea. Children living in North Korea experienced more severe health outcomes than those in South Korea. The death rate of prematurity, congenital anomalies, and birth asphyxia is higher in North Korea, which indicates that newborns in North Korea are more susceptible to these diseases than their South Korean counterparts. This trend has continued albeit with a decreasing rate over time. The time-plot of infant mortality rate during the North Korean famine is provided in the supplementary appendix (Figs. S2 and S3).

While South Korea recorded higher figures in air pollutant emissions such as CO_2, N_2O, and methane than North Korea, $PM_{2.5}$ concentration estimates are higher in North Korea (Table 2). Although both Koreas are affected by air pollution, including fine particulate matters and dust

Table 2. Comparison of environmental indicators in South Korea and North Korea

	South Korea			North Korea			P–value
	n	Mean	SD	n	Mean	SD	
Environmental indicator							
$PM_{2.5}$ (μg/m³)	10	28.3	2	10	36.5	2.8	0.002
CO_2 emissions (metric tons per capita)	17	10.6	1	17	2.3	0.9	<0.001
N_2O emissions (thousand metric tons of CO_2 equivalent)	13	14,338.0	1,996.8	13	3,286.2	74.8	<0.001
Methane emissions (kt of CO_2 equivalent)	13	31,680.5	703.4	13	18,390.4	671.1	<0.001
Fossil fuel (% of total)	16	82.4	1.2	15	79.5	13.1	0.421

P-value by Wilcoxon's sign rank test.

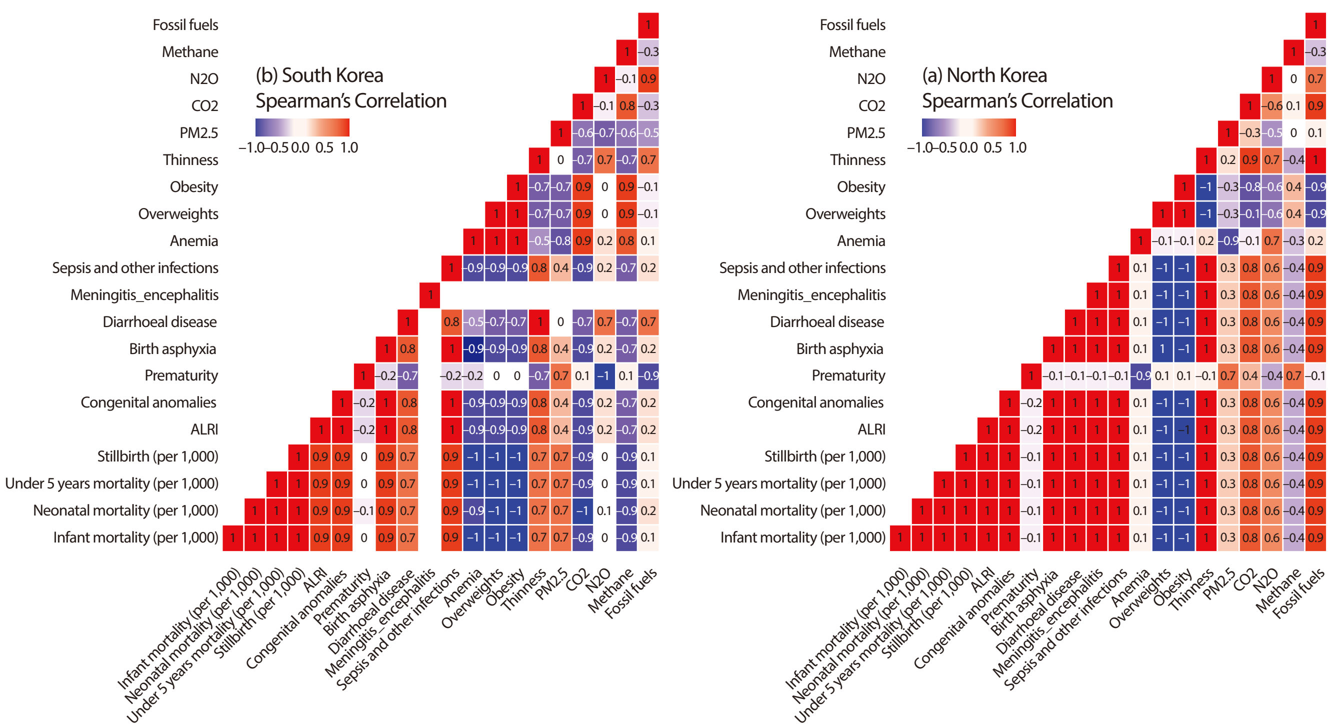

Fig. 3. Correlation between air pollution exposure and children's health in South Korea and North Korea.

flying from China, North Korea showed a higher rate of $PM_{2.5}$ concentration estimates than South Korea. We speculate that North Korea's use of cooking and heating fuel with low combustion rate and low thermal efficiency, as well as low-quality coal, has resulted in a higher exposure to $PM_{2.5}$ (Fig. S4). North Korea's use of ineffective domestic fuel is likely to release particulate matter and increase the level of $PM_{2.5}$ concentration over that in South Korea [23]. Fossil fuels, particularly coal and heavy oil, in thermal power plants, industrial boilers, kilns, motor cars, and households are the major pollutants in the largest city of North Korea (Pyongyang) and in nearby industrial districts [24].

We also found a gap in prevalence indicators between the two Koreas. The prevalence of anemia, overweight, obesity, and thinness is lagged for estimation, and North Korean children are faced with a greater danger of anemia and thinness while those in South Korea experience a higher prevalence of overweight and obesity. More interestingly, the prevalence of overweight and obesity is increasing and that of thinness is decreasing in both Koreas. This trend in prevalence indicators is probably caused by nutritional factors rather than air pollution. The previous study on North Korean refugee children residing in South Korea showed that the gap in growth (height and weight) and obesity rates between South Korean and North Korean children was narrowed after consuming sufficient food [25]. The nutritional status of South Korean and North Korean is provided in the appendix (Table S3 and Fig. S5). It implies that poor nutritional intake in North Korea has led to the children's malnutrition causing anemia and thinness, while the higher prevalence of overweight and obesity in South Korea is most likely caused by a Westernized dietary pattern, which contains high amounts of saturated fatty acids and energy-dense foods that are poor in micronutrients.

The differences in environmental indicators such as air pollutant emissions between South Korea and North Korea created gaps in the children's health status. The higher emissions of environmental pollutants, including $PM_{2.5}$, serve as a trigger for increasing the incidence of respiratory diseases (ALRI, pneumonia, and asthma) [4]. This relationship was supported by another study showing that long-term exposure to ambient fine particulate matter ($PM_{2.5}$) is inversely associated with lung function in children, adolescents, and young adults [26]. In addition to air pollutants, lead is more noxious to children than adults [27]. In particular, anemia is observed in young children who have lead poisoning [27]. Iron deficiency anemia is a risk factor for lead toxicity, as it not only promotes pica behavior but also increases the absorption of lead from the gastrointestinal tract [28]. Lead exposure and nutritional deficiencies, which are prevalent in North Korea, put children in danger of growth retardation and behavioral challenges. For instance, the active use of inefficient cooking and heating fuel such as a tire close to the furnace increases the level of lead exposure among North Korean children. North Korean children have a higher risk of respiratory infections caused by indoor air pollution from low-quality fuels.

Further, this study found an interesting pattern in diseases between South Korea and North Korea. The two Koreas have been isolated from each other since 1945, sharing the same ethnicity and similar genetic characteristics (Fig. S6). The different environmental circumstances for over 7 decades since the division have led to very different disease characteristics. North Korean children suffer from infectious diseases such as parasite infection, tuberculosis, lower respiratory tract infections, acute infectious diarrhea, malaria, meningitis, and sepsis. Infectious diseases are prevalent in North Korea due to poor conditions – pollution of drinking water (Figs. S7 and S8), weak management of vaccination, and unavailability of antibiotics. In contrast, pediatric allergic, autoimmune, and metabolic diseases are prevalent among South Korean children. The so-called "hygiene hypothesis" explains this by assuming that microbes such as bacteria stimulate the immune response and the too-clean environmental and hygienic conditions decrease immunity so that people can be more susceptible to allergies and autoimmune diseases [29,30]. As immune polarization caused by different environmental stressors exists in South Korea and North Korea, the disease patterns are different [14,31,32]. The disease pattern of North Korean children is similar to that of developing countries, whereas the disease pattern of South Korean children is similar to that of developed countries, as illustrated in the appendix based on the mortality rate and prevalence of each disease (Figs. S9–S12).

This study offers two key contributions. First, the study examines the gap in children's health between South Korea and North Korea, explores the association between the environment and children's health, and finds the disease patterns of South Korea and North Korea to be similar to the differences found between developed and developing countries. While there have been few studies comparing the children's health status between South Korea and North Korea, this study empirically highlighted the differences and patterns of children's health, which helps to fill the lacunae in the children's health studies. Second, this study is meaningful in that it compared children's health status and environmental circumstances between South Korea and North Korea after the two were forcibly divided in 1945 and further distanced by a war between the two in 1950¬–1953. The two countries in the Korean Peninsula provide an interesting test-bed for a rich comparative analysis as a social experiment to examine how South Korea and North Korea have evolved for over 7 decades since the division in terms of the environment and children's health.

Our findings should be interpreted, however, in light of data limitations. First, official data on North Korean health, environment, or nutrition are not available. Therefore, we used data collected from multiple international organizations including the World Bank and WHO. Second, we cannot determine a direct relationship between air pollution exposure and health effects in South Korea and North Korea due to data constraints. To overcome this, we conducted comparative and trend analyses. The differences in mortality and morbidity of children in the two Koreas might be caused by socioeconomic and cultural factors, as well as environmental factors. Thus, it would be necessary to secure national data for precise research to improve North Korean children's health. Therefore, more reliable data sources representing a larger sample or that enable longitudinal studies such as cohort studies are needed. Third, it is difficult to access prevalence indicators since their availability is limited compared to mortality indicators. Lastly, the dataset does not consider regional disparities within North Korea. It would be important to identify regional differences to help reduce the health status gaps among different regions.

Considering the patterns and gaps in children's health between South Korea and North Korea, more attention and resources need to be directed towards North Korea. The current health status of North Korean children needs intensive international development cooperation because the necessary commodities and services to improve the health of children are lacking in North Korea (Fig. S13). Although the governments of South Korea and North Korea have not had a Summit since 2018, there is hope that future official summits between South Korea and North Korea, and with other countries including the US could open doors for cooperation and unification. Should North Korea become open to international development cooperation, South Korea can play an important role in assisting North Korea although its assistance cannot be counted toward foreign aid as the two do not recognize each other as separate countries. Nevertheless, South Korea's shared ethnicity, language, culture, and geographical proximity would be very useful to assist the international efforts for development cooperation in North Korea.

These findings imply that epigenetic modification resulting from environmental stressors has had an impact on children's health in South Korea and North Korea despite sharing similar genetic backgrounds. After the division of the Korean Peninsula, different environmental circumstances modified children's health in the two Koreas, with genetics held constant. Considering the effect of epigenetic modification caused by environmental factors, it would be vital to develop a strategy for improving public health, especially targeting North Korean children if and when unification occurs. In particular, there is a danger that infectious diseases can spread quickly in South Korea and North Korea since people across the Korean Peninsula have not been exposed to each other for a long time. It is likely that infectious diseases such as measles, tuberculosis, malaria, and parasite infection, which are common in North Korea, can spread to

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South Korea, while other infectious diseases and socially driven illnesses from South Korea can spread to North Korea [33]. As South Korea established a relatively stronger health infrastructure than North Korea (Table S4), advances in the health care system can contribute to reducing the mortality rate. Thus, access to optimal management and referral systems at the primary care level, stable supply of nutrients, and removing economic barriers in North Korea would be crucial. Based on the children's disease patterns of South Korea and North Korea found in this study, it is projected that infectious diseases will become more prevalent if we do not have preventive measures. Given the significant differences in children's health between South Korea and North Korea which have persisted for more than 7 decades, it is imperative to bridge this gap.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Ethics Approval and Consent to Participate

Not applicable.

Supplementary Materials

Supplementary materials are available from: https://doi.org/10.12771/emj.2022.e14.

Supplementary Table S1. Description of data characteristics

Supplementary Table S2. The analysis of children's health indicators in South Korea and North Korea from 2000 to 2017
Supplementary Table S3. The daily nutrition per person in South Korea and North Korea from 1990 to 2017
Supplementary Table S4. The number of doctors in South Korea and North Korea

Supplementary Fig. S1. The average annual concentration of $PM_{2.5}$ in South Korea and North Korea from 2015 to 2019.
Supplementary Fig. S2. The estimation of birth losses and excess deaths during the North Korean famine from 1994 to 2005.
Supplementary Fig. S3. The time–plot of annual infant mortality rates in South Korea and North Korea from 1990 to 2019.
Supplementary Fig. S4. Coal consumption in South Korea and North Korea from 2000 to 2017.
Supplementary Fig. S5. The undernourished population of South Korea and North Korea.
Supplementary Fig. S6. Major historical events in the Korean Peninsula from 1970 to 2020.
Supplementary Fig. S7. Quality of source drinking water in North Korea in 2017.
Supplementary Fig. S8. Quality of household drinking water in North Korea in 2017.
Supplementary Fig. S9. Disease pattern of North Korea with developing countries (mortality rate per 1,000 live births).
Supplementary Fig. S10. Disease pattern of North Korea with developing countries (prevalence (%)).
Supplementary Fig. S11. Disease pattern of South Korea with developed countries (mortality rate per 1,000 live births).
Supplementary Fig. S12. Disease pattern of South Korea with developed countries (prevalence (%)).
Supplementary Fig. S13. History of health and medical care policy in North Korea from 1970 to 2020.

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