

## ORIGINAL RESEARCH ARTICLE

# Carbon footprints and health security: A comparative assessment of the Sustainable Development Goals 3 and 13 in East Asian countries

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## Abstract

In East Asia, where several countries are among the top emitters of carbon dioxide globally, the need to address the dual challenges of reducing carbon footprints and ensuring health security is paramount. Against this backdrop, this study used a descriptive analysis to provide a comparative assessment of the carbon footprints and the level of health security in East Asia using secondary data, sourced from the World Development Indicators. The findings from the study show that it is only North Korea that its average carbon footprint of every person is less than 2.3 tons. However, China, Japan, Mongolia and South Korea are currently lagging behind in meeting the SDG 13 target. Meanwhile, North Korea recorded the highest incidence of tuberculosis in the region. Despite the fact that South Korea and Japan were the highest emitter of CO<sub>2</sub>, the duo had the lowest under five mortality, infant mortality, incidence of TB alongside the highest life expectancies which surpassed the regional performance. In view of the above, the policymakers in Asia and the rest of the countries with health insecurity should emulate the policymakers in Japan and South Korea by making adequate investment in health, education, and standard of living of their citizens. (*Afr J Reprod Health 2024; 28 [8]: 99-107*)

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**Keywords:** CO<sub>2</sub>; life expectancy; incidence of TB; infant mortality; under-five mortality

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## Résumé

En Asie de l'Est, où plusieurs pays comptent parmi les plus grands émetteurs de dioxyde de carbone au monde, la nécessité de relever le double défi de réduire l'empreinte carbone et d'assurer la sécurité sanitaire est primordiale. Dans ce contexte, cette étude a utilisé une analyse descriptive pour fournir une évaluation comparative des empreintes carbone et du niveau de sécurité sanitaire en Asie de l'Est à l'aide de données secondaires provenant des indicateurs de développement mondial. Les résultats de l'étude montrent que seule la Corée du Nord a une empreinte carbone moyenne par personne inférieure à 2,3 tonnes. Cependant, la Chine, le Japon, la Mongolie et la Corée du Sud sont actuellement à la traîne dans la réalisation de l'ODD 13. Pendant ce temps, la Corée du Nord a enregistré la plus forte incidence de tuberculose dans la région. Bien que la Corée du Sud et le Japon soient les plus grands émetteurs de CO<sub>2</sub>, ces deux pays ont les taux de mortalité des moins de cinq ans, de mortalité infantile et d'incidence de tuberculose les plus faibles, ainsi que les espérances de vie les plus élevées, dépassant les performances régionales. Compte tenu de ce qui précède, les décideurs politiques d'Asie et du reste des pays souffrant d'insécurité sanitaire devraient imiter les décideurs politiques du Japon et de la Corée du Sud en investissant de manière adéquate dans la santé, l'éducation et le niveau de vie de leurs citoyens. (*Afr J Reprod Health 2024; 28 [8]: 88-107*).

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**Mots-clés:** CO<sub>2</sub> ; espérance de vie; incidence de la tuberculose ; mortalité infantile; mortalité des moins de cinq ans

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## Introduction

In the face of escalating environmental concerns and the imperative to safeguard public health, the intersection of carbon footprints and health security has emerged as a critical focal point for global discourse<sup>1-3</sup>. With the Sustainable Development Goals (SDGs) serving as a blueprint for international action, SDG 3, which aims to ensure healthy lives and promote well-being for all, and SDG 13, which targets urgent climate action, stand out as pivotal

pillars in addressing these interconnected challenges.

East Asia, characterized by rapid economic growth and urbanization, faces a unique set of environmental and health challenges amidst its burgeoning development<sup>4</sup>. The region's carbon footprint, propelled by industrialization and urban expansion, casts a looming shadow over public health outcomes, exacerbating air pollution, compromising water quality, and altering ecosystems. Concurrently, the region grapples with

the pressing need to fortify health security systems against a backdrop of evolving climate patterns, emerging infectious diseases, and the compounding effects of environmental degradation<sup>4,5</sup>

The Sustainable Development Goals 3 and 13 in East Asia present a complex landscape where economic growth, environmental sustainability, and public health intersect. In East Asia, countries like China, Japan, South Korea, and others have experienced rapid industrialization and urbanization, leading to significant carbon emissions and environmental degradation. This has resulted in air pollution, water contamination, deforestation, and other environmental issues that directly impact public health<sup>4</sup>. The carbon footprints, defined as the total amount of greenhouse gases emitted directly or indirectly by human activities, is a key driver of climate change. High levels of carbon emissions not only contribute to global warming but also have significant implications for public health<sup>6,7,8</sup>. According to the World Health Organization (WHO)<sup>9</sup>, climate change is expected to exacerbate health risks, including heat-related illnesses, vector-borne diseases, and food insecurity, particularly in vulnerable populations.

In East Asia, where several countries are among the top emitters of carbon dioxide globally, the need to address the dual challenges of reducing carbon footprint and ensuring health security is paramount. A comparative assessment of SDGs 3 and 13 in the context of East Asia can provide valuable insights into the trade-offs or synergies between environmental sustainability and public health in the region, which has hitherto been excluded from the extant literature. Thus, this study aims to provide a comparative assessment of the carbon footprints and health security –life expectancy, under-five mortality, incidence of tuberculosis, infant mortality, and human capital development in East Asian countries.

### **Literature review**

Iqbal *et al.*<sup>10</sup> investigated the connection between green and climatic factors and lifespan longevity in developing Asian nations, including Bangladesh, China, India, Malaysia, the Republic of Korea, Singapore, and Thailand from 2000 to 2019. The

study stressed that the effects of expanding green footprints and warming weather in developing Asian nations pose a threat to the lifespan of humans. Polcynet *al.*<sup>11</sup> evaluated the effects of wealth, population density, greenhouse gases released, power usage, and investment in health care in 46 Asian countries between 1997 and 2019. The study employed the inter autoregressive distributive lag (CS-ARDL) approach. Long-term results showed that greenhouse gases had negative effects on the well-being of individuals in Asian nations. Raihanet *al.*<sup>12</sup> examined the effects of economic growth, the use of fossil fuels, the implementation of green power sources, and health care costs in relation to Malaysia's greenhouse gases releases between 1990 and 2021. The study employed the autoregressive distributed lag (ARDL) technique to investigate both the immediate and long-term outcomes. The data revealed that increasing economic growth and the use of fossil fuels are linked to rising greenhouse gas. By contrast, persistent reductions in greenhouse gases are associated with the usage of green power and medical spending.

Juhuaet *al.*<sup>13</sup> evaluated the factors that influence health care expenditure amidst growing population, biodiversity, economic growth, and greenhouse gases using quarterly data spanning 2000 to 2018. To determine the long-term impact factors, the study used a new dual adjustment technique. The results using the dual adjustment strategy confirmed the co-integration of each factor. Additionally, the research used dynamic ordinary least square (DOLS) and fully modified ordinary least square (FMOLS) estimation methods. The outcomes showed that while renewable resource purchase in China reduces medical spending, economic expansion, growing population, and greenhouse gases enhance it.

Alharthi and Hanif<sup>14</sup> investigated the role of energy types and environmental quality on human health in twenty developing Asian countries, using a panel dataset of twenty-three years (1995–2018). Having used the autoregressive-Distributed lag (ARDL) technique of econometric, the study confirmed that dirty energy, carbon emission, and the process of natural resource exhaustion had a significant impact in enhancing health risks the Asia region. In contrast, the per capita income growth and

clean energy usage contributed significantly to human health improvement.

## Methods

In this study, a comparative analysis approach was used to investigate the impact of carbon emissions on health security in five East Asia countries, namely China, Japan, Mongolia, North Korea and South Korea. Data from 2000 to 2021, extracted from World Development Indicators, published by the World Bank<sup>15</sup> were used to conduct a comparative analysis among these countries. It is important to stress that East Asian countries were the focus of this study because these countries are among the top emitters of carbon dioxide globally, the need to address the dual challenges of reducing carbon footprint and ensuring health security is paramount in order to provide valuable insights into the trade-offs or synergies between environmental sustainability and public health in the region. However, the scope of 2000 to 2021 was chosen as a result of availability of data that are relevant to the study.

### Estimation procedures

In adopting relevant variables to assess the nexus between carbon emissions and health security in East Asia, the study took an insight from the extant literature such as Iqbal *et al.*<sup>10</sup>, Alharthi and Hanif<sup>14</sup>, Afolayan and Aderemi<sup>16</sup>, Lawalet *et al.*<sup>17</sup>, Opeleet *et al.*<sup>18</sup>,

Osabohienet *et al.*<sup>19</sup>, Zhouet *et al.*<sup>20</sup> and Olayemiet *et al.*<sup>21</sup>. Therefore, this study utilized CO<sub>2</sub> emissions as a proxy for carbon footprints. Whereas, life expectancy, the incidence of TB, under five mortality, infant mortality and human capital development index were employed as proxies for health security. Consequently, due to the nature of this study, the preferred method of estimation to drive the investigation of comparative analysis as the use of graphs and descriptive statistics. These techniques provide a comprehensive analysis to enable the robust understanding of the subject matter of this study. Table 1

### Data analysis

Due to the nature of this study, the preferred method of data analysis employed in this study is the use of graphs and descriptive statistics. The use of graph provided a historical perspective in assessing and identifying patterns, trends, or changes in data over the years. In this study, trend analysis was achieved with the aid of bar graph which shows the pictorial representation of the variables over the periods of the analysis. This method provides a comprehensive analysis to enable the robust understanding of the subject matter of this study. Similarly, the descriptive statistics explains distribution and patterns of the variables under investigation by the mean value which was estimated by adding all the data from 2000 to 2021 and divided by the number of the observations, which is 22.

**Table 1:** Measurement of variables

In table 1, the operational definitions of various variables in the study are discussed as follows

Abbreviation	Variable	Operational Definition
LEP	Life expectancy.	Life expectancy at birth (years)
CE	Carbon emissions.	CO <sub>2</sub> emissions (metric tons per capita). This is an average household carbon footprint.
HDI	Human development index	Composite index to measure human welfare in three basic aspects of human development: health, knowledge, and standard of living.
IT	Incidence of tuberculosis	Incidence of tuberculosis (per 100,000 people)
IM	Infant mortality	Infant mortality rate (per 1, 000 live births)
UF	Under five	Under five mortality rate (per 1, 000 live births)

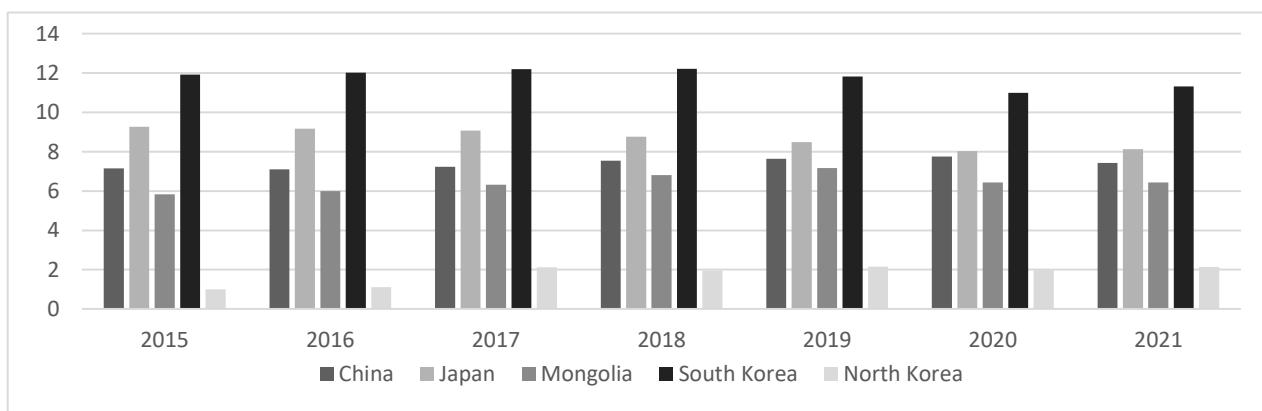
**Ethical consideration**

The data in the WDI were obtained using appropriate ethical procedures and guidelines. Consequently, further ethical issues were minimal. The data were completely anonymized, while the data was already freely available to the general public. Hence, further ethical clearance was not obtained for this study.

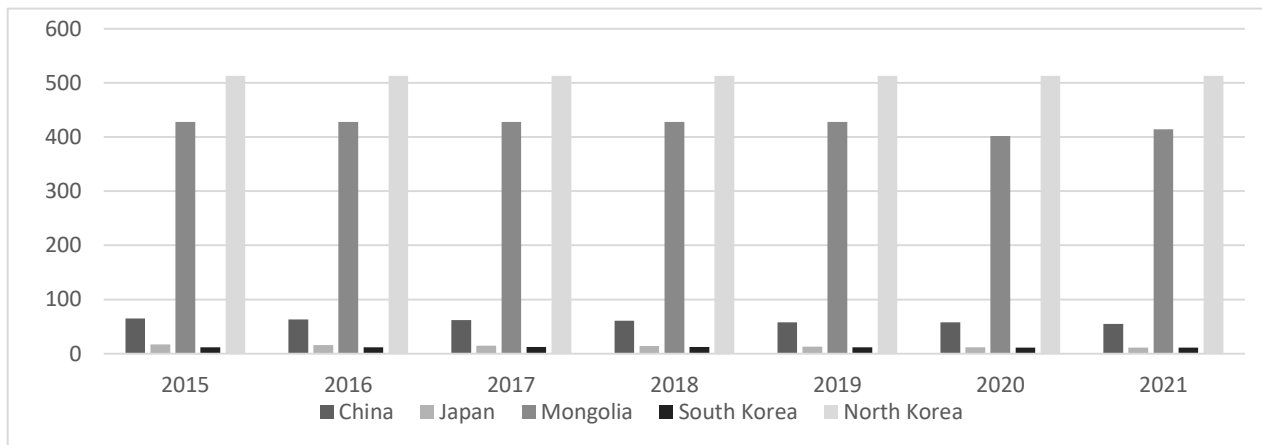
**Results**

The Figure 1 shows a comparison of the carbon footprints in China, Japan, Mongolia, South Korea and North Korea within the periods of 2015 and 2021. The chart reveals that South Korea consistently had the highest carbon footprints among

the countries studied between the periods of 2015 to 2021. This was followed by Japan and China respectively. Although there was no significant reduction in carbon footprints in Japan from 2015 to 2018, but in 2019 and 2020, the country recorded a noticeable reduction in carbon footprints before it slightly rose in 2021. Meanwhile, in the case of China, carbon footprints consistently rose from 2017 to 2020 before it marginally dropped in 2021. Although Mongolia emitted the second least carbon footprint among the selected country, yet, its emission rose steadily and consistently from 2015 to 2019 before it slightly declined in 2020. However, North Korea recorded the least carbon footprint among the five selected countries in the East Asia.



**Figure 1:** Carbon footprints (metric tons per capita) in East Asia



**Figure 2:** Incidence of tuberculosis (per 100,000 people) in East Asia

Figure 2 shows a comparison of the incidence of tuberculosis in China, Japan, Mongolia, South Korea and North Korea within the periods of 2015 and 2021. It is important to state that North Korea recorded the highest incidence of tuberculosis in the region during the period of the study without any improvement. This was followed by Mongolia, although, this country witnessed a slight decline in incidence of tuberculosis in 2020. China had the third highest incidence of tuberculosis among the selected countries, though its cases were relatively low compared to North Korea and Mongolia. Similarly, the incidence of tuberculosis continuously declined in China from 2015 to 2021. Meanwhile, South Korea and Japan had the least and the second least incidence of tuberculosis respectively in East Asia. These two countries maintained constituent reductions in the incidence of tuberculosis from 2015 to 2021.

Figure 3 shows a comparison of infant mortality rates in China, Japan, Mongolia, South Korea and North Korea during the periods of 2015 and 2021. It is evident that Mongolia had the highest infant mortality rate during the period, although this country witnessed a continuous decline in infant mortality rate from 2015 to 2021. Similarly, North Korea occupied the position as the country with the second highest infant mortality rate in the East Asia. From 2015 to 2021, North Korea experienced a slight decline in infant mortality rate. Meanwhile, in 2015, China had the third position highest infant mortality rate with 8 infant deaths per 1,000 live births. The country maintained this position through the period of the analysis, though, the incidence of infant deaths per 1,000 live births reduced to 5 in 2021. Consequently, Japan recorded the lowest incidence of infant mortality rate which is closely followed by South Korea.

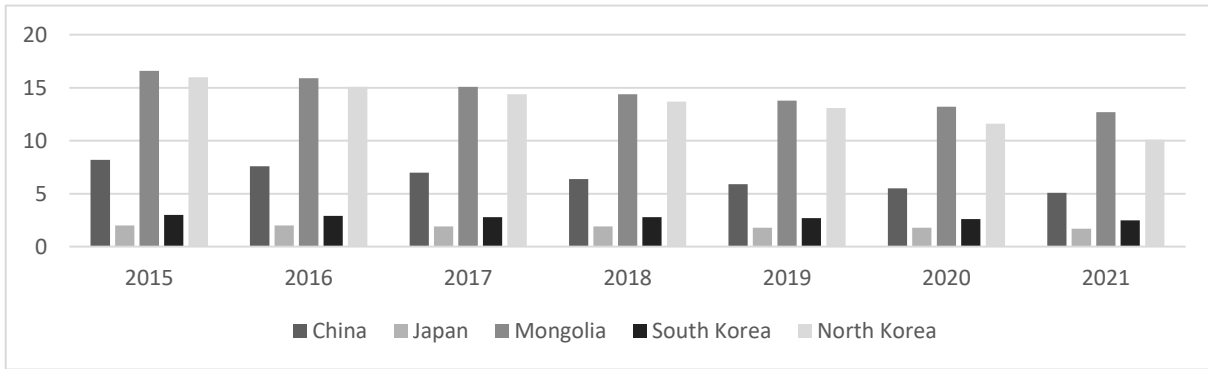
Figure 4 shows a comparison of under-five mortality rates in China, Japan, Mongolia, South Korea, and North Korea between 2015 and 2021. The data show that Japan recorded the lowest under five mortalities, closely followed by South Korea. Under five mortality was relatively low in these two countries compared to the rest of the countries in East Asia. North Korea witnessed the highest incidence of under-five mortality with 21 under five deaths per 1, 000 live births in 2015. This figure

consistently declined annually to 15 under five deaths per 1, 000 live births in 2021. The country with second highest incidence of under five deaths was Mongolia with 19 per 1000 under five deaths in 2015. This figure reduced annually until it reached 14 under five deaths per 1, 000 live births in 2021. Furthermore, China had the third highest incidence of under-five mortality in the sub region with 10 cases of under five deaths per 1, 000 live births in 2015. The country's cases of under five deaths reduced gradually each year with the record of 6 under five deaths per 1, 000 live births in 2021.

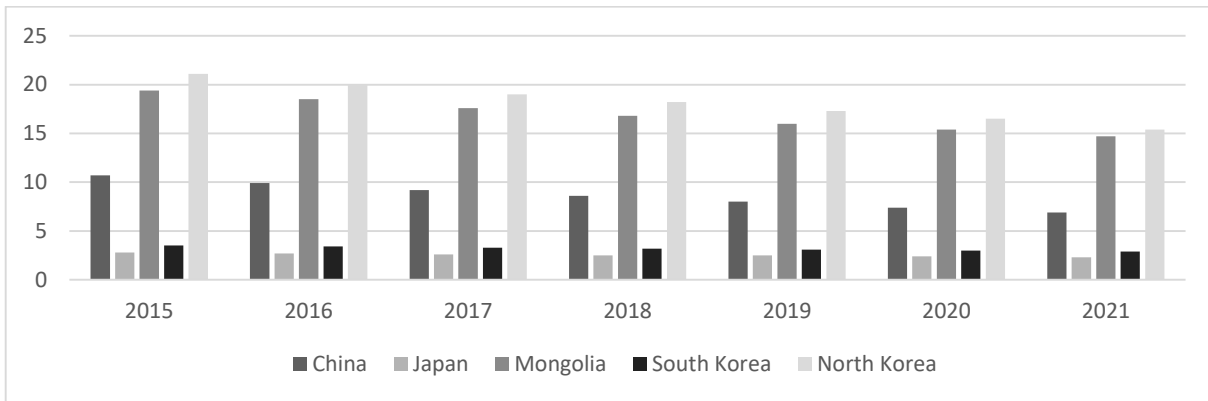
Figure 5 shows the comparison of life expectancy in China, Japan, Mongolia, South Korea and North Korea during the periods, 2015 and 2021. The data show that Japan had the highest life expectancy of 83 years in 2015, which improved to 84 years in 2021. This was closely followed by South Korea with 82 years in 2015, ending with 83 years in 2021. Similarly, China came in the third place with a life expectancy of 76 years in 2015 after which it improved to 78 years in 2021. However, the countries with the lowest life expectancies in East Asia were Mongolia and North Korea with 69 years and 72 years in 2015 respectively. Meanwhile, by 2021, the life expectancy in these two countries improved to 70 years and 73 years respectively. Figure 6

Human capital development, HDI used a composite index to measure human welfare in three basic aspects of human development: health, knowledge, and standard of living. This indicator was used in Figure 6 to show the comparison of human security in China, Japan, Mongolia and South Korea within the periods of 2015 and 2021. North Korea was omitted in this analysis due to the paucity of data. Japan and South Korea had high HDI through the periods of analysis. Whereas, China had relatively lower HDI compared to Japan and South Korea, but marginally higher level than Mongolia.

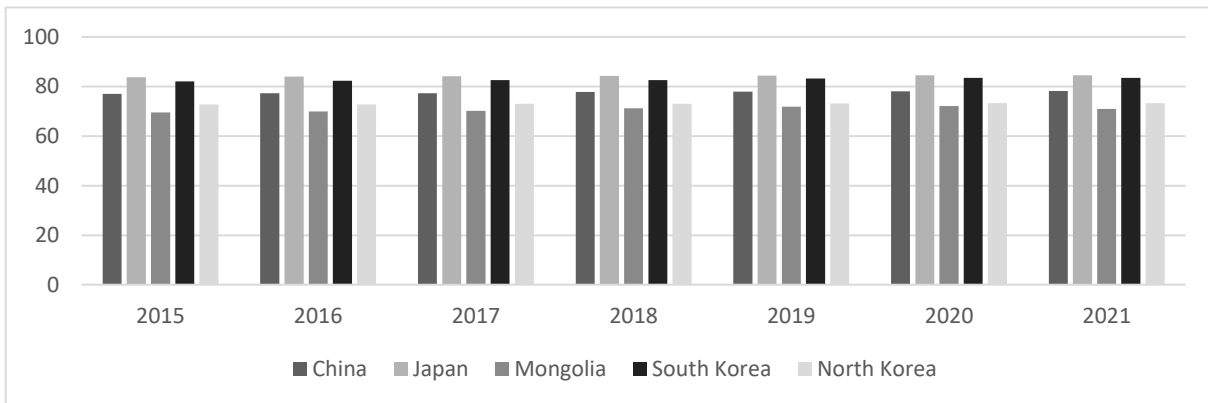
In Table 2, in terms of both regional and countrywide performances, efforts have been made to summarise the descriptive statistics of all the indicators employed to proxy carbon footprint and health security in East Asia thus; firstly, in terms of sub regional analysis, from 2000 to 2021, on the average basis, carbon footprints had 6.7 metric tons per capita in East Asia. However, South Korea and



**Figure 3:** Infant mortality rate (per 1, 000 live births)



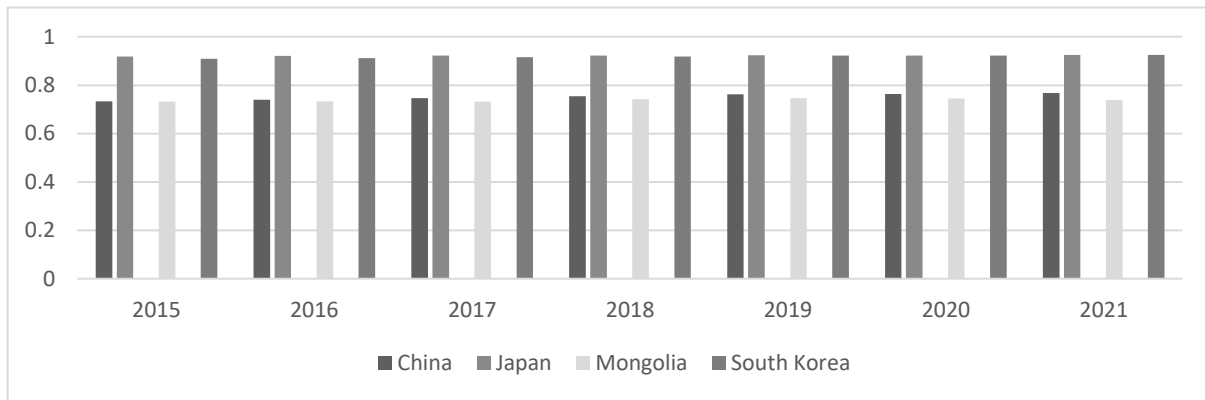
**Figure 4:** Under five mortality rate (per 1, 000 live births)



**Figure 5:** Life Expectancy at birth, total (years)

Japan had carbon footprints of 10.9 metric tons per capita and 9.1 metric tons per capita respectively. The average carbon footprints in these two countries were higher than the average carbon footprints in the East Asia sub region. Similarly, the average life expectancy in East Asia was 75 years. By contrast,

Japan and South Korea have life expectancies that surpassed the regional performance. Further results show that the average under-five mortality in East Asia was 17 deaths per 1,000 live births, which was similar to the situation report of China. Mongolia and North Korea had average values of under-five



**Figure 6:** Human Capital Development

**Table 2:** Mean value of the study’s variables between 2000 and 2021

Country/Region	Observations	CO <sub>2</sub>	Life exp	Under 5 mortality	Incidence of TB	Infant mortality
East Asia	110	6.722085	75.20449	17.11818	223.4545	13.60636
China	22	5.838085	75.56768	17.63182	77.81818	14.05455
Japan	22	9.174474	82.96263	3.236364	20.86364	2.372727
Mongolia	22	5.347625	67.46791	30.73636	426.1818	25.10455
North Korea	22	2.263521	69.85873	29.45000	513.0000	22.60909
South Korea	22	10.98672	80.16552	4.536364	79.40909	3.890909

mortality of 30 deaths and 29 deaths per 1,000 live births respectively. Meanwhile, Japan and South Korea recorded 3 deaths and 4 deaths per 1,000 live births simultaneously as average values of under-five mortality.

In the same vein, on an average basis, among every 100,000 people, East Asia registered 223 cases of tuberculosis; whereas, North Korea had 513 cases; Mongolia had 426 cases; South Korea and China had cases of 79 and 77 respectively. However, Japan was only the country with the least incidence of TB, which its average cases was 20. Also, the mean value of infant mortality in East Asia was 13 deaths per 1,000 live births. Whereas, Mongolia and North Korea had average values of infant mortality as 25 deaths and 22 deaths per 1,000 live births simultaneously. China recorded an average value of 14 infant deaths, South Korea 4 deaths and Japan 2 deaths per 1,000 live births.

## Discussion

In assessing the level of carbon footprint in each of the selected countries in East Asia, the results of this

study indicate that North Korea recorded the least carbon footprints among the selected countries in the East Asia. This situation report shows that it was only North Korea that its average carbon footprints per person was less than 2.3 tons of CO<sub>2</sub>. This implies that the average carbon footprints in North Korea is in tandem with the SDG 13 target. Therefore, North Korea has been adjudged to meet the SDG 13 goal. However, this country had the worst indicators of health security in East Asia. This shows that carbon footprints might not be a risk factor militating against health security in the country. As such, other factors like poverty, deprivation, malnutrition and lack of sufficient health facilities might be the major sponsors of poor performances of health security in North Korea. Therefore, the policymakers in this country should employ a holistic approach in revamping the country’s health sector in order to improve the health security of the citizens of the country. By contrast, China, Japan, Mongolia and South Korea currently lag behind in meeting the SDG 13 target. As such, policymakers in these countries need to embark on measures to ensure the reduction of CO<sub>2</sub> emissions

metric tons per capita to at least 2.3 tons if these countries are desirous to meet the SDG 13 by 2030.

When it comes to the incidence of tuberculosis, North Korea recorded the highest incidence of tuberculosis in the region, without any improvement. This was followed by Mongolia, although this country witnessed a slight decline in incidence of tuberculosis in 2020. However, China had the third highest incidence of tuberculosis among the selected countries, although its cases were relatively low compared to North Korea and Mongolia. Similarly, the incidence of tuberculosis continuously declined in China from 2015 to 2021. Meanwhile, South Korea and Japan had the least and the second least incidence of tuberculosis respectively in East Asia. These two countries maintained constituent reductions in the incidences of tuberculosis from 2015 to 2021. It is worthy of note that the incidence of tuberculosis in South Korea and Japan suggests that these countries were in tune with the SDG targets of 80% reduction in incidence rate of tuberculosis compared with the level of 2015. As such, policymakers in the rest of the East Asia should be committed to ending the incidence of tuberculosis epidemic in their respective countries through massive investment in health facilities.

In the same vein, Japan recorded the lowest under five mortality which was closely followed by South Korea. These two countries had low levels of under-five mortality when compared to North Korea, Mongolia and China. This shows that SDG 3 target of reducing under-5 mortality to at least as low as 25 per 1,000 live birth had been met in all the countries in East Asia. The policymakers in East Asia should ensure that they maintain this achievement till 2030 and beyond.

Furthermore, currently, Japan has the highest life expectancy in the region of 84 years, which is closely followed by South Korea with 83 years. Similarly, China came in third place with a life expectancy of 78 years. The countries in the low spectrum of life expectancy in East Asia are Mongolia and North Korea with 70 years and 73 years concurrently. This is an indication that the SDG 3 target- healthy lives and well-being for all at all ages are being adequately promoted in East Asia.

Another strategic indicator of health security is human capital development which uses a multidimensional approach to measure the welfare of human beings in three basic aspects of human development: health, knowledge, and standard of living. It was evident from the study that the level of human capital development in Japan and South Korea are extremely high. This is a reflection of an adequate investment in health, education and standard of living of the citizenry in these countries. In view of the above, the policymakers in Asia and the rest of the countries with low HDI should emulate the policymakers in Japan and South Korea by making an adequate investment in health, education and standard of living of their citizens.

### **Study strengths and limitations**

This study's strengths lie in its clear research question, comprehensive descriptive analysis and emergence of the new empirical evidence in the study. Primarily, this study is limited based on its scope, as the study focuses on only five strategic countries in East Asia, namely China, Japan, Mongolia, North Korea and South Korea. Further studies could therefore be carried out on the entire Asian countries to provide a wider policy implication for the entire continent.

### **Conclusion**

This study therefore concludes that on an average basis, North Korea recorded the least carbon footprints among the selected countries in the East Asia. This situation report shows that it is only the North Korea that its average carbon footprint is in tandem with SDG 13 - CO<sub>2</sub> of every person less than 2.3 tons. However, China, Japan, Mongolia and South Korea are currently lagging behind in meeting the SDG 13 target. Meanwhile, North Korea recorded the highest incidence of tuberculosis in the region, without any improvement. South Korea and Japan have the least and the second least incidence of tuberculosis respectively in East Asia. In the same vein, Japan recorded the lowest under five mortality which is closely followed by South Korea. These two countries have an extreme low level of under-



five mortality when comparing to North Korea, Mongolia and China. Though, North Korea has the biggest.

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