

Distribution of The Health Workers in The Tuberculosis Sector, Mongolia: Assessment Results Using the Gini Index

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Abstract:

Background: Mongolia was classified as one of the 30 countries with the highest tuberculosis burden by World Health Organization in 2021 and tuberculosis is the first leading cause of mortality among deaths from all communicable diseases in the country. The number and distribution of health workers to provide tuberculosis healthcare services will play an important role in the fight against tuberculosis. However, there has been no quantitative evaluation of the distribution of tuberculosis health workers in Mongolia. Therefore, this study aimed to examine the distribution of health workers in the tuberculosis sector using the Gini index. The results provide quantifiable information for monitoring resource distribution and serve as a basis for informed decision-making on resource allocation, facilitating targeted interventions and equitable healthcare distribution in Mongolia.

Methods: Data from the National Center for Communicable Diseases and the National Statistical Information Service of Mongolia was obtained and analyzed. The Gini coefficients were calculated to reflect the inequality of distributions.

Results: Total number of health workers in the tuberculosis sector was only 1.29 per 10,000 population. The Gini index values for the distribution of tuberculosis doctors, assistant workers, nurses, and laboratory technicians were at 0.61, 0.67, 0.43, and 0.33 respectively, all showing a range from severe to relative inequality.

Conclusions: Findings showed the number and distribution of tuberculosis health workers were both inadequate and unequal and ring the need for proper health system planning. To plan the tuberculosis control

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and address the high burden of the disease in the country, the human resources situation should be analyzed and handled regularly.

Keywords: Mongolia, Tuberculosis, Health workers, Distribution, Gini index

Background:

According to the World Health Organization (WHO) Global TB Report 2021, which includes data from more than 200 countries, approximately 1.5 million people died from TB in 2020, which increased from 1.4 million reported in 2019. [1] Due to the challenges facing in TB care and services around the world, many people were not diagnosed with TB in 2020, and the number of newly diagnosed TB cases dropped from 7.1 million in 2019 to 5.8 million in 2020. [2] Establishing effective mechanisms for multi-sectoral collaboration, accountability, and program coordination is the key to strengthening health considerations in the work of other sectors.

Mongolia is a landlocked country in East Asia with a population of 3,353,470 people. [3] It is one of the first countries that adopt the Sustainable Development Goals, with the target to end TB and other communicable diseases by the year 2030. Moreover, the Extended plan by Minister of Health of Mongolia established a specific set of activities strengthen detection and stopping TB transmission through successful treatment completion, as well as expanding multi-sectorial collaboration for integrated patient-centered care and services.[4] The goals include an increased TB detection rate of up to 45% and a reduction of TB deaths to 0.65 per 100,000 populations by 2021.[2]

Regardless, TB is still a problem in Mongolia. TB is the sixth leading cause of death and the first leading cause of mortality from all communicable diseases in the country. The Mongolia was classified as one of the 30 countries with the highest TB burden by WHO in 2021.[2] Moreover, Mongolia is listed as the third-highest TB incidence country among 37 countries in the WHO Western Pacific Region. In 2020, the WHO estimated the TB incidence rate of 437 per 100,000 population.[5] Around 4,000 TB cases are reported every year, out of which 10% are pediatric. The TB cases reported among the children indicate that

transmission of TB is very high among the youth in Mongolia. [6]

The provision of TB care and services is approved by Health Ministerial Order and enforced nationwide regardless of the ownership of the hospital. However, lack of diagnostic tools, equipment, infrastructure, and specialized human resources for TB with adequate knowledge and skills are barriers to private hospitals' active participation in TB control_nationwide. As the private clinics are not able to provide TB control, the TB control is mainly carried out in public hospitals in all provinces and districts. [7]

Constraints on human resources for health, including deficits in number, unbalanced distribution, and limited capacity of health workers, have been reported as the main barriers to achieving the global TB control target.[8] Human resource management and planning capacity must be developed and sustained at the national, organizational, program, and individual levels. [9]

Aim:

This study aimed to examine the distribution of the health workers in the tuberculosis sector using the Gini index. The results of this study provide quantifiable information that will be instrumental in monitoring changes in resource distribution. Moreover, the results obtained from this analysis will serve as a valuable basis for informed decision-making regarding resource allocation, allowing for targeted interventions and equitable distribution of healthcare resources to effectively combat tuberculosis and improve overall public health outcomes in Mongolia.

Methods:

Data Source

In this study, we used data on the population and TB health workers who works for public services in 21 provinces and 9 districts of the capital city Ulaanbaatar, for the year 2020. The number of the

population was obtained from the official report by the government of Mongolia. [10]The number of TB doctors, nurses, laboratory technicians, and assistants was obtained by the TB Surveillance and Research Department of the NCCD.

Definition:

In this study, TB doctors is defined as a doctor who has completed a specialization program for TB with the competence to provide TB care services that meet the needs of the population. A nurse and laboratory technician are both defined as a qualified healthcare worker who has completed a professional program. The nurse works closely with doctors to assess and monitor patients' needs, ensure healthcare is conducted according to the procedures, and perform other related tasks while the laboratory technician designs and executes laboratory testing according to standard procedures for TB care and services. The assistant worker is personnel who supports the daily activities of the TB unit and assists other staff, arranging and cleaning.

Distribution analysis:

There are multiple methods to measure inequality, such as the Gini index, Range ratio, The McLoone index, Theil T, the decile ratio, the Robin Hood index, and the Atkinson index. [11, 12] In this study, we use the Gini index considering it allows direct comparison between units with different size populations, is attractive intuitive interpretation, it sufficiently simple that it can be compared across countries and be easily interpreted, and has a transfer principle. The Gini index was introduced by Corrado Gini back in 1912 to measure the equality of values. [13]The Gini index is a commonly used tool for evaluating the distribution of resources, including medical and health resources. It provides a quantitative measure of inequality or concentration in the distribution of these resources among different regions or countries. When applied to the evaluation of medical and health resources, the Gini index can help assess the fairness and equity of resource allocation, identify areas of imbalances, and guide policy interventions to address disparities. [14–16]

It has been used to study several aspects of health inequalities and is often cited in many studies.[16–19]

We determined the value of the Gini index by calculating the gap between the equality line and the Lorenz curve using the R concentration ratio formula as follows:

$$R = \frac{\sum_{i=1}^s (i_{i-1} + i_i - 1) f_i x_i}{(n - 1) A_n} - 1$$

R represents a numerical value that is the extent of inequality or concentration in the distribution of health workers per population across different provinces. A higher Gini index indicates greater inequality, while a lower index suggests a more even distribution of health workers. The numerator of the formula involves calculating the sum of products. The symbol \sum represents the summation, indicating that the subsequent expression will be summed over a range. For each province, you take the sum of the number of health workers in the current province (i_{i-1}) and the number of health workers in the previous province (i_i). This sum is then multiplied by a weighting factor (f_i) associated with that province. Finally, multiply this product by a specific term or value (x_i) associated with that province. This process is repeated for all provinces, and the results are summed up. The denominator of the formula consists of two terms. The first term is $(n-1)$, where n represents the total number of provinces or regions included in the analysis. It serves as a constant value that remains the same throughout the calculation for consistency. The second term, A_n , is a variable associated with that specific value. The numerator result is divided by the product of the denominator terms, and 1 is subtracted from this quotient. We undertake a calculation of the ratio of TB health workers to the population, subsequently arranging the provinces in ascending order based on the magnitude of this ratio, from those with the lowest number of TB health workers to those with the highest. The equality line represents perfect equality, while the Lorenz curve is a nonlinear mathematical model obtained by sorting the ratio of cumulative health care resources to the population of every province.[20] It represented the distribution of health care resources. We processed the Gini calculation using Microsoft excel. The Gini indexes ranged between 0 and 1, with 0 representing perfect equality and 1 representing perfect inequality. Further, we interpret the

distribution as follows: a Gini index less than 0.2 demonstrates absolute equality, 0.2 – 0.3 relative equality, 0.3 – 0.4 inequality, 0.4 – 0.5 large

inequality, and above 0.5 expresses severe inequality.[21]

Table 1. Number of TB health workers per population

No	Areas	Populations	Number of TB doctors	Number of TB doctor per 10,000 population	Number of nurses	Number of nurses per 10,000 population	Number of laboratory technicians	Number of laboratory technician per 10,000 population	Number of assistant workers	Number of assistant workers per 10,000 population	Total number of health workers in TB sector	Total number of health workers in TB sector per 10,000 population
1	Arkhangai Province	94,088	2	0.21	5	0.53	1	0.11	1	0.11	9	0.96
2	Bayan-Ulgii Province	110,597	3	0.27	8	0.72	1	0.09	5	0.45	17	1.54
3	Bayankhongor Province	88,955	2	0.22	6	0.67	1	0.11	2	0.22	11	1.24
4	Bulgan Province	61,955	3	0.48	5	0.81	1	0.16	2	0.32	11	1.78
5	Gobi-Altai Province	57,674	2	0.35	6	1.04	1	0.17	1	0.17	10	1.73
6	Gobisumber Province	17,965	1	0.56	1	0.56	1	0.56	1	0.56	4	2.23
7	Darkhan-Uul Province	106,909	5	0.47	13	1.22	2	0.19	4	0.37	24	2.24
8	Dornogobi Province	71,207	4	0.56	1	0.14	1	0.14	0	0.00	6	0.84
9	Dornod Province	83,087	4	0.48	10	1.20	2	0.24	3	0.36	19	2.29
10	Dundgobi Province	46,981	1	0.21	6	1.28	1	0.21	4	0.85	12	2.55
11	Zavkhan Province	72,763	1	0.14	2	0.27	1	0.14	1	0.14	5	0.69
12	Orkhon Province	107,765	3	0.28	6	0.56	1	0.09	2	0.19	12	1.11
13	Uvurkhangai Province	115,732	1	0.09	6	0.52	1	0.09	1	0.09	9	0.78
14	Umnugobi Province	70,371	1	0.14	1	0.14	1	0.14	0	0.00	3	0.43
15	Sukhbaatar Province	63,822	2	0.31	5	0.78	1	0.16	3	0.47	11	1.72
16	Selenge Province	109,285	5	0.46	11	1.01	2	0.18	7	0.64	25	2.29
17	Tuv Province	93,162	5	0.54	9	0.97	1	0.11	6	0.64	21	2.25
18	Uvs Province	83,524	2	0.24	6	0.72	1	0.12	2	0.24	11	1.32
19	Khovd Province	90,533	4	0.44	7	0.77	2	0.22	1	0.11	14	1.55
20	Khuvsgul Province	135,705	2	0.15	7	0.52	1	0.07	1	0.07	11	0.81
21	Khentii Province	78,172	2	0.26	8	1.02	2	0.26	0	0.00	12	1.54
22	Baganuur district	29,324	1	0.34	0	0.00	1	0.34	0	0.00	2	0.68
23	Bayangol district	231,517	6	0.26	4	0.17	1	0.04	0	0.00	11	0.48
24	Bayanzurkh district	367,679	7	0.19	6	0.16	2	0.05	1	0.03	16	0.44
25	Nalaikh district	38,690	2	0.52	6	1.55	1	0.26	5	1.29	14	3.62
26	Songinokhairkhan district	335,703	5	0.15	5	0.15	2	0.06	0	0.00	12	0.36
27	Sukhbaatardistrict	144,616	3	0.21	3	0.21	1	0.07	0	0.00	7	0.48
28	Khan-uul district	195,927	4	0.20	2	0.10	1	0.05	1	0.05	8	0.41
29	Chingeltei district	151,203	3	0.20	2	0.13	1	0.07	1	0.07	7	0.46
30	Bagakhangai district	4,463	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	National average			0.30		0.60		0.15		0.25		1.29
	Mongolia	3,259,374	86		157		36		55		334	

Results

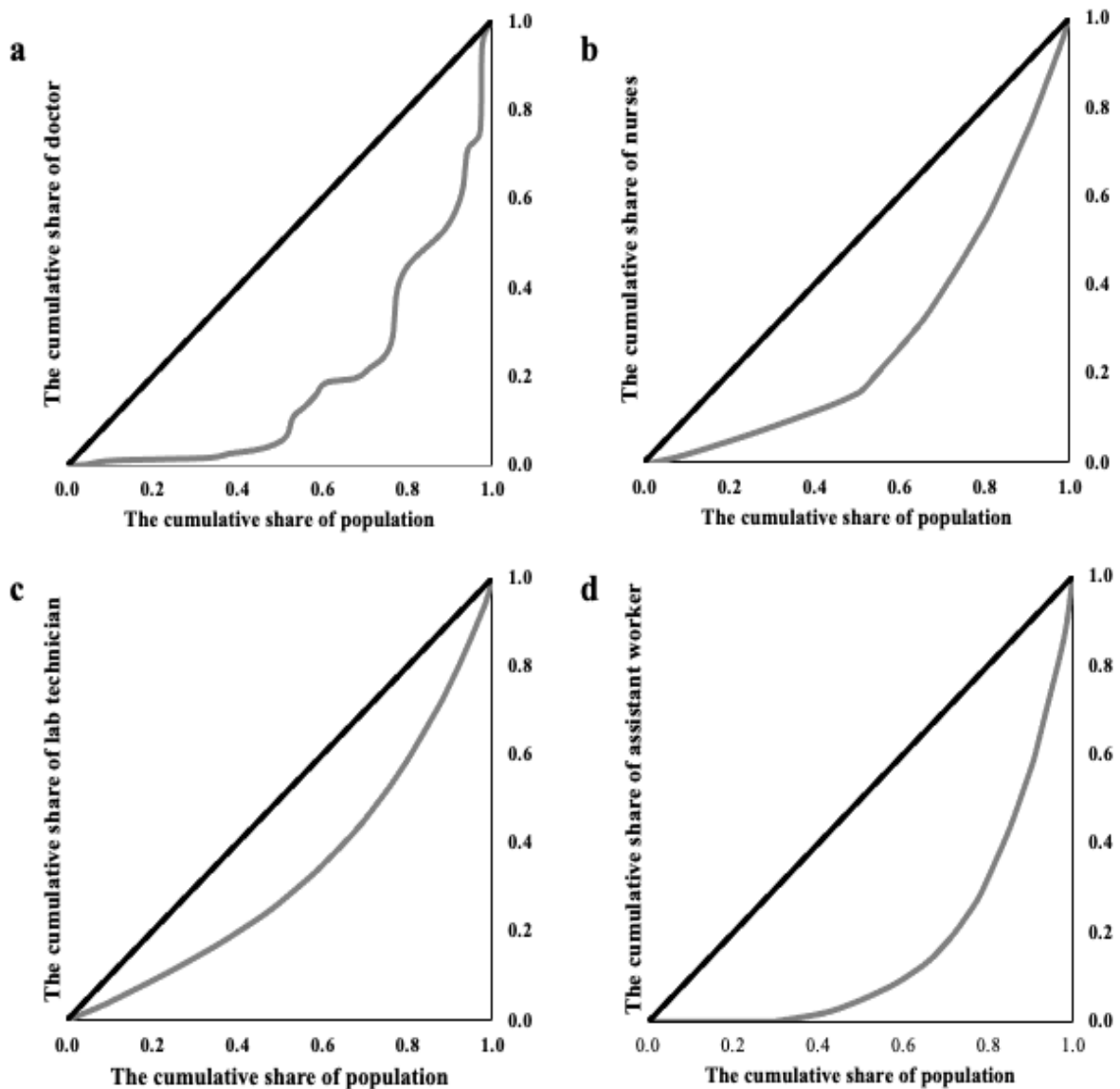
Table 1 showed the total number of TB health workers and their number per 10,000 population by provinces and districts. In 2020, the number of doctors, nurses, laboratory technicians, and assistant workers in the sector was 86, 157, 36, and 55, respectively. However, some areas where provinces of Dornogobi, Umnugobi, and Khentii, and districts of Bayangol, Songinokhairkhan, and Sukhbaatar do not have assistant workers for TB care. Baganuur district only has one TB doctor, one laboratory technician, and does not have any nurse or assistant worker. The worst condition is in the Bagakhangai district, where there are no TB doctors, nurses, laboratory technicians, or assistant workers.

The national average for the number of TB doctors, nurses, laboratory technicians, and assistant workers per 10,000 population was 0.30, 0.60, 0.15, and 0.25 respectively. The total number of health workers in the TB sector was merely 1.29 per 10,000 population.

[Insert Table 1 here]

The Lorenz curves depicting the distribution of the TB health workers per share of the population are shown in Figure 1. The area between the Lorenz curve and equality line indicated the gap between perfectly equal distribution and the real distribution. From the figure, we can see that large gaps appear in the assessment of TB doctors (Figure 1a) and assistant workers (Figure 1d).

Figure 1. Lorenz curves of TB health workers



Gini calculation showed that the distribution of TB doctors and assistant workers was severely unequal with Gini index values of 0.61 and 0.67, respectively (Table 2). Table 2 also showed that the

Gini index of nurses' distribution was 0.43, showing large inequality. The distribution of laboratory technicians was also considered unequal with a Gini index of 0.33.

Table 2. The Gini indexes of TB health workers

TB health workers	Gini index value	Interpretation
Doctors	0.61	Severe inequality
Nurses	0.43	Large inequality
Laboratory technicians	0.33	Inequality
Assistant workers	0.67	Severe inequality

Discussion:

Current situation:

A previous study found that Mongolia is close to the ideal point in terms of both numbers and adequate distribution of human resources per 10,000 population, with an average of 69.4 doctors and nurses. [14] Our study showed that the total number of TB doctors and nurses for TB care was calculated less than 1 (0.9) per 10,000 population which only accounts for 1.2% of the total doctors and nurses in the country compared to the study. According to the Mongolian National Standard (MNS 5095:2017) for the General Hospital, 1 TB doctor and 1-2 nurses for every 50 patients (5-year average), and at least 1 epidemiologist and 1 health social worker shall work in the TB unit. General hospitals are considered public services and supported through a national health insurance fund. [22] However, high TB prevalence areas namely Darkhan-Uul province, Songinokhairkhan, Bayanzurkh, and Chingeltei districts which have insufficient TB doctors, while Bayan-Ulgii, Bulgan, Dornogobi, Tuv, and Khovd provinces have adequate numbers according to this standard. There are a sufficient number of nurses only in four provinces; Bayan-Ulgii, Khovd, Bayankhongor, and Dornod, while the other 17 provinces have an insufficient number of nurses. Also, there are no full-time nurses in TB units of Zavkhan and Uvs provinces.[23]

A previous study in the United Kingdom stated that a TB control program depends on adequate numbers of specialist TB nurses for early detection and case-holding.[24] In 2021, the number of TB health workers in Mongolia has increased to a total of 572 people (including prison hospital and NCCD) as a result of efforts from governmental and international organizations.[23]

In terms of the Gini index, it provides a numerical measure that enables evidence-based decision-making and resource allocation to achieve more equitable and effective healthcare systems at both national and global scales. [25] Within a country, the Gini index can be used to analyze the distribution of medical and health resources across different regions or provinces. High Gini index values indicate a more unequal distribution, highlighting regions that may be underserved or lacking resources.[15] Our study showed that the distribution of TB health workers is unequal with Gini ranging between 0.33 – 0.67. The previous study of distribution for all doctors and nurses showed a more equal distribution than our results that Gini indexes with 0.18 for doctors and 0.07 for nurses in the country. [14] Unequal distribution of existing human resources might be one of the reasons resulting in the worst TB indicators which may impact all cascades from case detection to control after the TB treatment. TB high incidence in districts of Ulaanbaatar city and provinces connected especially trans-Siberian railway

especially needed more attention and human resources to accessibility and delivery of TB care on time.

At the global level, the Gini index helps assess the distribution of health workers and related research across countries. [25–27] For instance, the Gini index for physicians per population in Japan and Poland was 0.17 and 0.30, respectively while the Gini index for general practitioners in Turkey and Britain was similar at 0.09 and 0.08. [26, 28, 29] The study for TB human resources also used Gini indexes, but it was limited due to the possible scarcity of TB doctors in some countries. Nevertheless, countries with more equal distribution of doctors had fewer TB incidences, ranging from 6 to 20 per 100, 000. [5] Therefore, take an action for the significant shortage or concentration of healthcare professionals might help for the health outcome. Further, the number and equality in distribution of health workers namely nurses, laboratory technicians, and assistant workers in the TB sector are equally significant to the service delivery and specific strategies to attract the workers into the communicable diseases sector are crucial especially in the high TB-burden countries like Mongolia.

Socioeconomic circumstances:

Mongolia is classified as a lower middle-income country and has a high of 0.73 human development index. [30] The government of Mongolia provides free healthcare for TB care and services; however, some essential diagnostic tests cannot be done in rural because of a lack of necessary equipment or human resources. Therefore, it leads to a substantial burden for low-income rural populations seeking better services in urban areas. [7] Therewith, according to a study, 46% of TB patients are unemployed and 70% live below the poverty line. [31]

On the other hand, insufficient social protection and low salaries make it unable to attract and keep health workers who need them in rural. [14, 32–34] However, many efforts have been made to support the financial stability of human resources.

For instance, all specialists in TB units and inpatient TB clinics receive an additional 30% incentive calculated on the base salary for the duration of the position in terms of Government Resolution No 382 for attracting and retaining human resources for TB since 2018. This has been providing a significant contribution to attracting health workers to the sector. [30] In addition, the Global Fund has been providing the technical and financial support through AIDS and TB projects in Mongolia since 2003 to support the implementation of national programs and strategies to prevent and combat TB, and AIDS. The fund is contributing to the human resources issues by providing scholarships for doctors who enrolled in the 9 months of short-term training of the TB residency program started in 2018 and 25 (89.3%) out of all 28 doctors who graduated between 2018 – 2020 are working in the TB sector. In 2020 – 2021, 22 doctors received the same scholarship for the TB residency program, and the financial aid from the fund will end in 2023. [6] Based on the experiences of other countries public-private partnerships can be helpful as additional support from local areas in the country. [7] Private hospitals are rapidly increasing both in urban and rural areas, however, only slight engagement for TB diagnosis is reported and it can be strengthened through long-term government policy with the captivation of private clinics and extensive training. [35, 36] Further, more opportunities offered in urban environments for career development, networking, and socializing have great significance on both professional and personal levels for health workers. [32, 34] A clear career pathway and special rewards might be helpful retention of existing health workers and attract new staff in rural Mongolia. [14] In particular, creating conditions for human resources to work sustainably will play an important role in the fight against TB. [4] In addition, holistic approaches to public health interventions like advocacy, communication, and prevention of TB are needed as a priority in Mongolia. [7] WHO reported that for every USD 1 invested for TB, USD 43 is refunded as the benefits of a healthy functioning society. [37]

Geographic features:

The country's sparsely populated areas impose substantial challenges in providing TB care and services in rural areas.[14, 17] The long distances mean that a facility-based treatment support model is likely not to work well. Therefore, better documentation of how the different support models perform in terms of outcomes is also required.[7] Previous studies recommended that mobile clinics might be suitable to geographic features since nomadic people who live through animal husbandry usually do not move to urban settings. [14]

Conclusion:

Our findings showed the distribution of TB health workers was unequal, especially the distributions of TB doctors and assistant workers which were considered severely unequal. Health system planning especially in respiratory infections like TB should be controlled based on the epidemiological and human resources shift in the sector. Our study can be a basis of evidence for the inequality of health workers for TB care and future policy actions to end TB.

Limitations of the study

This study had several limitations that should be considered. We were unable to analyze dynamic changes in the distribution of all TB doctors, nurses, and other personnel because of the scarcity of available data and literature. In addition, our study is an ecological study with provinces as the point of analysis; thus, it was not possible to analyze the basic information of the respondents.

Abbreviations:

WHO: World Health Organization;

TB: Tuberculosis;

DR-TB: Drug-resistant tuberculosis;

COVID-19: Coronavirus disease;

NCCD: National Center of Communicable Diseases

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Authors' contributions:

OE designed and coordinated the study, analyzed the results, and drafted the manuscript. SAP contributed analysis of the results and the drafting of the manuscript. AD and BJ contributed to the interpretation of data and drafting of the manuscript. BL participated and completed the data collection and validation. AP and KH participated in the drafting of the manuscript. BTs drafting and revising the manuscript critically. AT completed the illustration and critical revision. All authors read and approved the final manuscript.

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Availability of data and materials:

The original datasets from NCCD and NSO used during the current study are available from the corresponding author upon reasonable request.

https://www.1212.mn/en/statistic/statcate/573051/table-view/DT_NS0_0300_071V

Declarations:

We confirm that all the methods were carried out in accordance with relevant guidelines and regulations.

Ethics approval and consent to participate

Secondary data obtained from the NSO is anonymous with no identifying information, and publicly available online. Data from the NCCD do not involve any experiments of any form with human subjects and are anonymous. We obtained approval from NCCD in accordance with the data sharing rule and regulations and confirm that all the methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication:

Not applicable.

Competing interests:

The authors declare no conflict of interest.

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