

Air Pollution as a Slow-Onset Disaster in Ulaanbaatar

Oyuntuya Bayanjargal¹

¹Faculty of Arts, University of Groningen, Groningen, The Netherlands

Submitted: October 26, 2019

Revised: November 18, 2019

Accepted: December 6, 2019

Corresponding Author

Oyuntuya Bayanjargal, MA
Zalaatiin am 4-2, Bayanzurkh
district, Ulaanbaatar, Mongolia
Tel: +976 9947-1365
E-mail: Oyu9jargal@gmail.com

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/bync/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited. Copyright© 2019 Mongolian National University of Medical Sciences

Objectives: This research aimed to better understand how exposure to high levels of winter air pollution may be affecting the health of children living in areas where housing is predominantly ger type traditional homes and houses compared to those living in areas where housing is predominantly apartments in Ulaanbaatar. The objective of the research was to study the differences in health and missed school days in children from these areas. **Methods:** Data were gathered from 36 childcare centers (kindergartens), schools and primary centers and interviews conducted among 148 individuals in three districts of Ulaanbaatar namely Chingeltei, Songinokhairkhan and Khan-uul. The study was performed between October 1, 2015 and December 31, 2015. **Results:** This study revealed that at the beginning of the study, the rate of children reported to be sick was about the same for both ger and apartment district primary schools, however by the end of the study the number of children reported sick each day living in predominantly gers and cabins was more than reported in apartment districts, that is, about 4 per 10,000 in apartment districts vs about 7 per 10,000 in ger districts. At the end of the study, rates of sickness reported was 5 to 6 times higher in children in childcare centers compared to children attending in primary schools regardless of where they lived. **Conclusion:** This study suggests that air pollution is not only affecting children's health, but also affecting their education in Ulaanbaatar.

Keywords: Air Pollution, Ulaanbaatar, Children's Health

Introduction

The World Health Organization (WHO) estimated that in 2012 around 7 million people died from chronic air pollution and constant exposure to toxic air [1]. The majority of these deaths (88%) occurred in low and middle-income countries [2,3]. In Southeast Asia and the Western Pacific regions, 3.3 million deaths were attributed to outdoor air pollution. In children, acute respiratory infection (ARI) is the one of the most common causes

of illness and a major cause of childhood mortality around the world. Approximately 3-5 million children deaths have been attributed to ARI annually, of which 75% were because of air polluted related pneumonia [4].

Air pollution in Mongolia's capital of Ulaanbaatar has reached critical levels with little optimism that the situation will improve in the near to mid-term future. A large portion of the urban population of just over one million people live in what are called 'ger districts', have homes which are not connected to

the city's central heating grid, and burn coal, wood, and tires for heating and cooking. This fuel consumption practice combined with the city's high elevation, location within a mountain valley, and the extreme winter temperatures, result in what has been measured as the worst air quality in the world [5]. Everyone who lives in Ulaanbaatar is affected in some way by the extreme air pollution.

As a result of the long cold winters in Ulaanbaatar, power generation for heating creates some of the worst air pollution in the world. The main sources of this air pollution are the estimated 177,000 households located in the ger districts, four coal powered central heating and power stations, about 385,000 vehicles and 1,300 small individual building coal powered heating boilers [6]. The World Health Organization consistently ranks air pollution in Ulaanbaatar in the top 5 out of 1,100 major cities around the world. Emissions from these sources, notably particulate matter (PM), carbon monoxide (CO), and sulfur dioxide (SO₂) create enormous health risks [7]. In particular, high levels of PM₁₀ and PM_{2.5} have been shown to increase mortality rates, asthma attacks and respiratory infections [8]. PM_{2.5} are airborne particles less than 2.5 micrometers in size (20-100 times smaller than a human hair) which penetrate deep into the lungs. High levels of PM_{2.5} in Ulaanbaatar have been linked to childhood pneumonia, cardiovascular disease in adults, premature death in older people, and linked to a rise in spontaneous abortions between March and October. Other diseases which have been specifically linked to air pollution include ischemic heart disease (IHD), cerebrovascular disease (stroke), chronic obstructive pulmonary disease (COPD) and lung cancer [9]. Short term health effects of air pollution include illnesses such as bronchitis, pneumonia from respiratory infections and eye infections [10]. Long term illnesses from air pollution include chronic respiratory and heart disease (29% of deaths), lung cancer (40% of deaths), and damage to nerves, brain, liver and kidneys. It has been estimated that air pollution causes 10% of all deaths in Ulaanbaatar [8]. This research aims to better understand how exposure to high levels of air pollution may be affecting the health of children. Does the situation represent a slow-onset disaster in the context of children's livelihoods? "A slow-onset emergency is defined as one that does not emerge from a single, distinct event but one that emerges gradually over time, often based on a confluence of different events" [11]. The study objectives are understanding the differences in health and missed school days in children living in

diverse air quality districts of Ulaanbaatar. We hypothesized that the districts which had higher air pollution had higher number of missed school days and more respiratory tract infections.

Materials and Methods

Study geographic location and typical housing: Children were studied the Khan Uul, Songinokhairkhan and Chingeltei (Tolgoit) districts of Ulaanbaatar, Mongolia. Housing in Khan Uul is predominately apartments with radiant heating via an underground network of pipes that deliver hot water from a centralized source. This results in typically lower levels of local winter air pollution compared to the districts reliant on coal stoves to heat homes. In contrast, those living in Songinokhairkhan and Chingeltei districts predominately live in small homes and felt-covered circular tents called gers, so-called "ger districts," that are typically heated with coal-burning stoves resulting in higher levels of local air pollution.

Air pollution measurements: Hourly air pollution measurements were obtained from the Mongolian Ministry of Health and Sports, the Mongolian National Agency for Meteorology and Environmental Monitoring (NEMHEM), and the Open Air Quality website <https://openaq.org/#/> which measure the pollution levels in the Tolgoit and Misheel stations as representative measures of the air pollution in the Chingeltei, Khan Uul, and Songinokhairkhan Districts. Hourly measurements were averaged into 24-hour periods over the study period from October 1, 2015 to December 31, 2015. Data was also obtained from the Mongolian National Hydrological Center. The Tolgoit station in the Chingeltei district recorded 8 different pollution types (PM_{2.5}, PM₁₀, O₃, CO, NO₂). Unfortunately, Misheel Station in the Khan Uul district reported only three types of pollution (PM₁₀, O₃, and CO), resulting in limited comparisons. Measurements of air pollution were collected on an hourly basis and were converted into daily averages using a pivot table in Excel. Data was obtained for the periods between October 1, 2015 – December 31, 2015.

Study population: Children between 0 to 18 years of age in all childcare centers, schools, and those who visited the Primary Health Centers in the locations indicated previously were studied.

Health assessment methodology: Surveys were performed at each child care center and school and Primary Health Center assessing the frequency and type of air polluted-related illnesses

as well as their opinions of air quality and children’s health and education related to air pollution. Furthermore, the difference between school and primary health center surveys as mentioned below is that the school survey specifically focused on the number of days the child did not go to the childcare center or attend school because of upper and lower respiratory illnesses. The Primary Health Center’s survey focused on the number of children visiting primary health centers due to respiratory illnesses and other illnesses. It was also questioned regarding missed schoolwork make up and the impact that children not attending had on their parent’s work and income as well as their medication expenses. Data was also gathered in semi-structured interviews from individuals approached outside of District Health Departments, after community meetings, and in apartment blocks in Songinokhairkhan (N=51) and Chingeltei (N=65) districts. Interviewees from Khan-Uul district (N=32) were selected outside of shopping malls and apartment blocks. Interviews were conducted in January and questions covered the three-month period between October 1, 2015 and December 31, 2015.

Ethical Statement: The study was approved by the Ethics Committee of NOHA Network on Humanitarian Action programme, University of Groningen, The Netherlands. Informed consent was obtained from study participants.

Results

Air Pollution levels: The corresponding PM₁₀ concentrations in the Songinokhairkhan districts were higher than in Khan-Uul reaching 500 mg/m³ in Tolgoit and 180 mg/m³ in Khan-Uul. However, again, both exceeded the international exposure levels of 40 mg/m³ of PM₁₀. PM₁₀ level results indicate more air pollution in ger districts than in the apartment districts.

Assessment of health outcomes and wellbeing of children: A total of 148 people participated in semi-structured interviews. The common cold was the most common illness reported by parents during household interviews in all three districts. Bronchitis was second highest illness in Khan-Uul district (20%) and Songinokhairkhan district (19%) but it was not common in Chingeltei district (0.6%). Eye irritations were the second

Table 1. Respiratory illness from early October until end of the December

Symptoms	Primary Health Center		Primary School		Kindergarten	
	Apt*	Ger	Apt	Ger	Apt	Ger
Acute bronchitis	<1	13	<1	35	44	168
Acute laryngitis	2	5	0	29	0	100
Acute sinusitis	0	21	0	0	0	0
Acute tonsillitis	108	71	108	65	1028	333
Adenoids	0	3	0	0	0	0
Allergy	2	1	0	7	0	86
Asthma	<1	5	0	19	0	20
Eye irritation	22	47	0	0	0	52
Influenza	0	4	0	0	0	0
Throat irritation	0	4	0	28	245	61
Other	0	17	0	25	0	36

*Respiratory illnesses from Family Health Care Center, Primary school and kindergarten from early October until end of the December in Ger district of Songinokhairkhan, Chingeltei and apartment district of Khan-Uul

most frequently reported illness in Chingeltei district (13%) and third in Khan-Uul district (11%). Between 64% and 88% of all respondents said that their children had experienced an illness which they believe was related to poor air quality and between 38% and 58% of these illnesses required a visit to a health care facility. The majority of parents interviewed in all districts believed that their children’s illness had an effect on their work and income.

Primary health center surveys: Children in ger and apartment districts were diagnosed with air pollution related health complications at clinics at about the same rate (~1.5 per 10,000) in early October but by the end of December children in ger districts were diagnosed at nearly twice that rate (~4 per 10,000 vs ~2 per 10,000 respectively).

The apartment district reported higher rates of acute tonsillitis and throat irritations than in ger districts. However more serious illnesses were reported at higher rates in the ger districts such as acute bronchitis, acute laryngitis, asthma. (Table 1).

There were several air pollution related illnesses with only a small number of cases reported such as headache, lung infection, nausea, and chest ache, cough, and blocked nose.

School surveys report the number of children which were sick each day as recorded by teachers and school nurses in primary schools and kindergartens in the apartment district of Khan-Uul and the ger districts of Songinokhairkhan and Chingeltei districts. Children who are elementary school age started holidays a few days earlier than primary school age children. Elementary school age children’s number of sick days were higher than primary school age children.

The number of children reported sick in both ger and apartment district primary schools increased steadily over time from early October to December. At the beginning of the study, the rate of sick children reported was about the same for both ger and apartment district primary schools, however by the end of the study the number of children reported sick in the ger districts each day was higher than reported in apartment districts (~4 per 10,000 in apartment districts vs ~7 per 10,000 in ger districts).

In kindergartens the reported rates of sick children were very low but increased starting from the end of October until the end of the study. Illnesses in kindergarten aged children in ger districts were twice the rate of children in apartment districts (~40 per 10,000 in ger districts vs ~20 per 10,000 in apartment

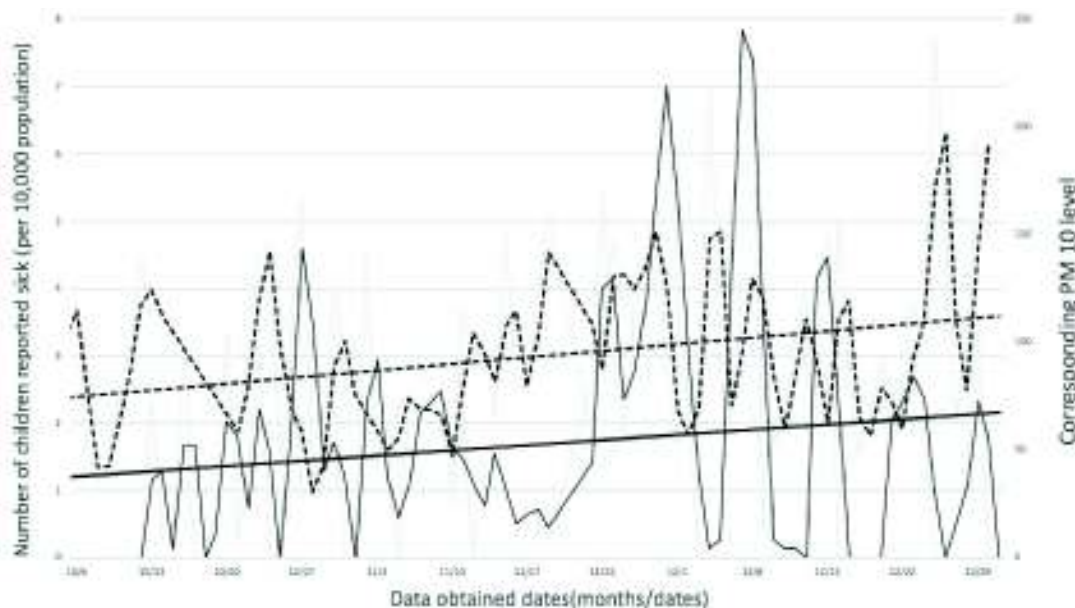


Figure 1. Number of children per 10,000 reported ill and PM10 levels in Ulaanbaatar

Note: Number of children per 10,000 reported ill in apartment district clinics (solid line, Axis on left side) and corresponding PM10 levels (dashed line, axis to the right) obtained from a nearby air quality monitoring station (Misheel) in Ulaanbaatar, Mongolia between October - December 2015.

Table 2. Reported income of interview respondents in 3 districts

Income	Districts		
	Khan-Uul (31)	Songino khairkhan (50)	Chingeltei (65)
0-500.000	0.3%	20%	52%
500.000-1.000.000	23%	30%	17%
1.000.000-1.500.000	42%	38%	28%
1.500.000-2.000.000	23%	12%	0.3%
>2.000.000	10%	0%	0%

districts). At the end of the study, rates of sickness reported was 5 and 6 times higher in kindergarten aged children than for primary schools in apartment and ger districts (Figure 1).

Socioeconomic status of respondents: Unemployment amongst respondents varied widely between Khan-Uul district (0.3%) and the ger districts of Songinokhairkhan (18%) and Chingeltei (13%). Khan-Uul district is the wealthiest district. 33% of interviewees reported earning more than 1,500,000 tugriks/month (~750\$ US/month) while more than half of interviewees in Chingeltei district earned less than 500,000 tugriks/month (250\$ US/month) (Table 2).

Discussion

Study findings suggest that the higher exposure of air pollution in ger districts is related to children in these districts being more susceptible to respiratory tract infections and allergic conditions. The increase in the rate of reported cases of air pollution related sickness in apartment and ger district primary health centers increased about the same as the increase in PM_{10} levels measured at Misheel Station and Tolgoit Station in Figure 1 and Figure 2.

At the beginning of the study, the rate of children reported to be sick was about the same for both ger and apartment district primary schools, however by the end of the study the number of children reported sick in the ger district each day was about 60% more than reported in apartment districts (~4 per 10,000 in apartment districts vs ~7 per 10,000 in ger districts). At the end of the study, rates of sickness reported was 5 and 6 times higher in kindergarten aged children than for primary schools in apartment and ger districts.

The earliest effects of air pollution on the human body may

occur in utero, and air pollution exposure during pregnancy causes low birth weight. It has been documented that the use of indoor air filters in chronically polluted areas reduces levels of $PM_{2.5}$ leading to an increase in newborn weight by an average of 80 grams and an increase in height of 0.4 cm [12]. Air pollution in Ulaanbaatar is directly associated with pediatric respiratory diseases. Children who live in Ulaanbaatar visited hospitals because of respiratory diseases 7-8 times more than children that live in rural areas with less air pollution. The average annual rates of pneumonia for children under five years in four districts of Ulaanbaatar between 2010-2012 was 98.5 per 10,000. Pneumonia is a leading cause of child mortality around the world. Children in Ulaanbaatar have between 5-15 times higher rates of bronchitis than children in rural areas. Furthermore, soil and air pollution increase blood lead concentrations in children which results in a decrease in children's attention capacity and memory [13].

Children living in the most polluted regions of Ulaanbaatar have a 50% lower lung capacity than children living in rural areas of Mongolia [14]. Children who are living in the ger districts are highly exposed to small particulate $PM_{2.5}$ [15]. All children in Ulaanbaatar are exposed to air pollution above levels which the WHO considers acceptable, however those living in less polluted areas, typically on the south side of Ulaanbaatar, are exposed to lower levels of pollution while those living in the ger district (north side of Ulaanbaatar) are exposed to dangerously high levels of air pollution on a near daily basis for up to five months at a time [16]. Children are exposed to $PM_{2.5}$ on the way to school, when outside, when heating their gers with coal, when opening doors and windows, and when cooking. Children living in less polluted areas are exposed to $PM_{2.5}$ while going to school, during outdoor playtime and car rides.

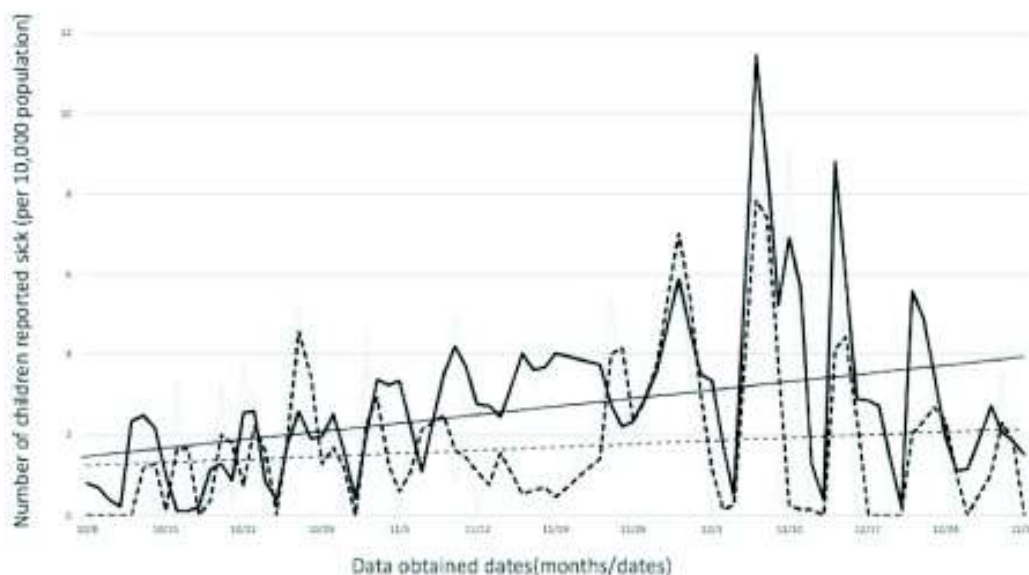


Figure 2. Number of children per 10,000 reported sick in both districts

Note: Number of children per 10,000 reported sick in apartment (Dashed line) and in ger districts clinics (Solid line) in Ulaanbaatar, Mongolia between October - December 2015

Results from the study revealed that illnesses in kindergarten children in ger districts were twice the rate of children in apartment districts (~40 per 10,000 in ger districts vs ~20 per 10,000 in apartment districts). Children in ger and apartment districts were diagnosed with air pollution related health complications at clinics about the same (~1.5 per 10,000) in early October but by the end of the study children in ger districts were diagnosed at nearly twice the rate (~4 per 10,000 vs ~2 per 10,000 respectively). Overall air pollution related health care expenses amounted to 2% of household income in Khan-Uul and Chingeltei districts and 4% for Songino khairkhan residents, both mostly living in gers or cabins. Nakao et al found that during the cold seasons, Mongolian adults' health related quality of life is inversely correlated to the air pollution $PM_{2.5}$ as well as PM_{10} level, suggesting the polluted air is decreasing the quality of life in adults [17]. The same phenomenon holds true in our study. The ger district children are suffering more due to air pollution and susceptibility to respiratory tract diseases, leading to missed school and kindergarten days. In addition to the potential for children to fall behind in school, chronic exposure to dangerously high air pollution in Ulaanbaatar is a social burden causing expense of health care and lost time spent caring for children. In all three districts, most parents did not believe that their children were able to make up for the class time missed when missing

school due to illness. If they are unable to catch up on their lessons this may limit their opportunity for success in the future. The result of such events on the future of Mongolian's children could be a slow-onset disaster for the country, one that does not emerge from a single event.

The study emphasized not only the health burden of the air pollution mediated respiratory tract disease, but also the consequences such as children's unattendance in their kindergarten and schools. The children's right of study is not only a basic human right, but also directly influences their quality of life and personal development. Therefore, further studies are recommended to investigate the impact of air pollution is not only the children's health but also on their education and their quality of life.

Limitation

It was hard to determine if an illness or missed day at school had long lasting negative effects on children's education or not. This would require a long-term study tracking same individuals and testing their education levels. This was not possible in a three-month study. Being able to compare children from different livelihood backgrounds and different income and living conditions was challenging. Even though the school and primary health care are system is a public systems, the operating

conditions were quite different between the north and south regions of Ulaanbaatar.

Conclusion

This study suggests that air pollution is not only affecting children's health but also affecting their education in Ulaanbaatar. If a large portion of children in Mongolia are growing up chronically sick and unable to learn well this could be the start of a slow-onset disaster.

Conflict of Interest

The authors state no conflict of interest.

Acknowledgements

Thanks to all of the high school and kindergarten teachers, primary health center doctors, and to all the people that participated in the household survey for being part of the research during the 3 months. Also, thanks to the following for helpful comments: Ichinkhorloo, Ariunbold, and Bayasgalan from the Etugen Medical University; and Khaliunaa Kherlen, Prof. Dr Joost Herman, and Prof. Dr. Tjalling Halbertsma from the University of Groningen; and Dr. Byambasuren Vanchin from the Mongolian National University of Medical Sciences; and Dr. John Payne and Dr. Kirk Olson.

References

- Smith K, Bruce N, Balakrishnan K, Adair-Rohani H, Balmes J, Chafe Z, et al. Millions dead: How do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution. *Annu Rev Public Health* 2014; 35:185-206.
- World Bank. Clean air and healthy lungs: enhancing the World Bank's approach to air quality management 2015 [accessed on 31 December 2019]. Available at: <http://documents.worldbank.org>.
- Energy sector management assistance programme. Impact of improved stoves on indoor air quality in Ulaanbaatar, Mongolia 2005 [accessed on 31 December 2019]. Available at: <https://esmap.org/>.
- Smith KR, Samet JM, Romieu I, Bruce N. Indoor air pollution in developing countries and acute lower respiratory infections in children. *Thorax* 2000;55(6): 518-32.
- Guttikunda S. Urban air pollution analysis for Ulaanbaatar. Ulaanbaatar, Mongolia: SIM series; 2008. p 2-9.
- United Nations Development Program. United Nations Development Framework 2012-2016 [accessed on 26 December 2019]. Available at: <https://www.mn.undp.org/>.
- Guttikunda SK, Lodoysamba S, Bulgansaikhan B, Dashdondog B. Particulate pollution in Ulaanbaatar, Mongolia. *Air Qual Atmos Health*. 2013;6(3): 589-601.
- Allen RW, Gombojav E, Barkhasragchaa B, Byambaa T, Lkhasuren O, Amram O, et al. An assessment of air pollution and its attributable mortality in Ulaanbaatar, Mongolia. *Air Qual Atmos Health*. 2013; 6: 137-50.
- Ministry of the Environment and Green Development, Mongolia. Air pollution and health in Ulaanbaatar. Final project report 2014 [accessed on 31 December 2019]. Available at: <https://static1.squarespace.com/>.
- Health Effects Institute. Outdoor air pollution and health in the developing countries of Asia: a comprehensive review 2010 [accessed on 31 December 2019]. Available at: <https://www.healtheffects.org/>.
- United Nations Office for Coordination of Humanitarian Affairs. OCHA and slow-onset emergencies, Occasional policy briefing series [accessed on 25 December 2019]. Available at: <https://www.unocha.org/>.
- Barn P, Gombojav E, Ochir C, Boldbaatar B, Beejin B, Naidan G, et al. The effect of portable HEPA filter air cleaner use during pregnancy on fetal growth: The ugaar randomized controlled trial. *Environ Int* 2018;121: 981-9.
- World Health Organization. Country cooperation strategy for Mongolia 2010-2015. [accessed on 25 December 2019]. Available at: <http://www.wpro.who.int/>.
- Dashdendev B, Fukushima LK, Woo MS, Ganbaatar E, Warburton D. Carbon monoxide pollution and lung function in urban compared with rural Mongolian children. *Respirol* 2011; 16(4): 653-8.
- Dashnyam U, Brugha R, Tserenkhi I, Davaasambuu E, Enkhtur S, Munkhuu B, et al. Personal exposure to fine-particle black carbon air pollution among schoolchildren living in Ulaanbaatar, Mongolia. *Cent Asian J Med Sci* 2015;1(1): 67-74.
- Warburton D, Warburton N, Wigfall C, Chimedsuren O, Lodoisamba D, Lodoysamba S, et al. Impact of seasonal

winter air pollution on health across the lifespan in Mongolia and some putative solutions. *Annals Am Thorac Soc* 2018;15: S86-90.

17. Nakao M, Yamauchi K, Ishihara Y, Omori H, Ichinnorov D, Solongo B. Effects of air pollution and seasons on

health-related quality of life of Mongolian adults living in Ulaanbaatar: cross-sectional studies. *BMC public health* 2017;17: 594.