CZECH UNIVERSITY OF LIFE SCIENCES

FACULTY OF ENVIRONMENTAL SCIENCES DEPARTMENT OF APPLIED ECOLOGY

EFFECTS OF AIR POLLUTION ON HUMAN HEALTH

(A CASE STUDY OF ULAANBAATAR, MONGOLIA)

BACHELOR THESIS

Supervisor: Mgr. Marta Martínková, Ph.D, Student: Namuun Turbold.

2023

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Environmental Sciences

BACHELOR THESIS ASSIGNMENT

Namuun Turbold

Environmental Engineering

Thesis title

Effects of Air Pollution on Human Health: a Case Study of Ulaanbaatar, Mongolia

---

Objectives of thesis

Environmental air pollution is a major risk factor for human health, causing both short- and long-term effects, with a global mortality burden of more than 4 million deaths per year. There is mounting evidence that air pollutants have a negative impact on human health, including respiratory diseases, cardiovascular disease, and cancer. Our health is inextricably linked to our surroundings. The goal of this study was to identify air pollutants of health importance to humans and determine their negative effects on human health, to determine if there is a correlation between exposure to environmental air pollutants and hospital visits due to symptoms of respiratory diseases, and to determine whether exposure to environmental air pollution has a significant effect on hospital visits due to symptoms of respiratory diseases.

Methodology

The data collected and analyzed will be used primarily in the thesis. The data was gathered from The First Central Hospital in Mongolia. Patients' data collected include hospital file number, gender, age, diagnosis, address, month of last hospital visit, positive family history of diseases, occupation, living area exposure to toxic substances, smoking, years of smoking, and number of packets of cigarettes per day.

The proposed extent of the thesis

30

Keywords

Air pollution, health, environment, respiratory disease.

Recommended information sources

Bernardini, F., et al., 2020. Air pollutants and daily number of admissions to psychiatric emergency services: evidence for detrimental mental health effects of ozone. Epidemiology and psychiatric sciences, 29, 29.

Gheorghe A, Ankhbayar B, van Nieuwenhuyzen H, de Sa R; National Center for Public Health and UNICEF Mongolia. Mongolia's air pollution crisis: a call to action to protect children's health. Ulanbataar, Mongolia: UNICEF Mongolia; February 2018 [accessed 2018 Mar 28.

Hystad P, D. P. (2014). Long-term residential exposure to air pollution and lung cancer risk. PubMed.

Liu P, W. X. (2016). Effects of Air Pollution on Hospital Emergency Room Visits for Respiratory Diseases: Urban-Suburban Differences in Eastern China. International journal of Environmental health research and Public health.

Zhong, S.; Yu, Z.; Zhu, W. Study of the Effects of Air Pollutants on Human Health Based on Baidu Indices of Disease Symptoms and Air Quality Monitoring Data in Beijing, China. Int. J. Environ. Res. Public Health 2019, 16, 1014.

Expected date of thesis defence

2022/23 SS – FES

The Bachelor Thesis Supervisor

Mgr. Marta Martínková, Ph.D.

Supervising department

Department of Water Resources and Environmental Modeling

Electronic approval: 6. 3. 2023

prof. Ing. Martin Hanel, Ph.D.

Head of department

Electronic approval: 7. 3. 2023

prof. RNDr. Vladimír Bejček, CSc.

Dean

Prague on 10. 03. 2023

Author's statement

I hereby declare that I have independently elaborated the bachelor/final thesis with the topic of: "Effect of air pollution on human health (a case study Ulaanbaatar, Mongolia)", and that I have cited all of the information sources that I used in the thesis as listed at the end of the thesis in the list of used information sources.

I am aware that my bachelor/final thesis is subject to Act No. 121/2000 Coll., on copyright, on rights related to copyright and on amendments of certain acts, as amended by later regulations, particularly the provisions of Section 35 (3) of the act on the use of the thesis.

I am aware that by submitting the bachelor/final thesis I agree with its publication under Act No. 111/1998 Coll., on universities and on the change and amendments of certain acts, as amended, regardless of the result of its defense. With my own signature, I also declare that the electronic version is identical to the printed version and the data stated in the thesis has been processed in relation to the GDPR.

In Prague, date: ....

Acknowledgments

I would like to thank my supervisor, Mgr. Marta Martínková, Ph.D., for the support and helpful advice she has so kindly given me during this work. I also wish to thank my family, especially my husband Amarsanaa Tsogoo and our child Amira Amarsanaa for the understanding, support, and encouragement they have given me throughout my study.

Abstract

Environmental air pollution poses severe challenges to human health, the effects which are mostly seen as respiratory diseases, cardiovascular diseases, and cancers. Our health is closely related to our environment.

The goal of this study was to identify air pollutants of health importance to humans and determine their harmful effects on human health, to determine if there is a correlation between exposure to environmental air pollutants and hospital visits due to symptoms of respiratory diseases, and to determine whether exposure to environmental air pollution has a significant effect on hospital visits due to symptoms of respiratory diseases.

Data on 299 patients who presented to The First Central Hospital of Mongolia with respiratory and infectious diseases from 1st January 2022 till 3rd March 2022 were acquired from their case files in compliance with the ethics committee's guidelines. The information gathered includes gender, age, diagnosis, address, the month of the last hospital visit, positive family history of the diseases, occupation, exposure to toxic substances in the living area, smoking, years of smoking, and the number of packets of cigarettes per day.

The Pearson correlation coefficients of correlation between environmental air pollutants and total hospital visits are 0.99, indicating a strong correlation, and the P value of 0.004 ($p<0.05$) using two-tail analysis shows that exposure to environmental air pollutants has a significant effect on total hospital visits due to illness symptoms at a 95% confidence interval.

The findings support that air pollution severely affects human health, particularly in causing symptoms and diseases.

Keywords: Air pollution, health, environment, respiratory disease

Contents

1. Introduction

1.1 Objectives of thesis

Environmental air pollution is a significant risk factor for human health, causing short-term and long-term effects, with a global mortality burden of more than 4 million deaths annually. There is mounting evidence that air pollutants have a negative impact on human health, including respiratory diseases, cardiovascular diseases, and cancer. Our health is inextricably linked to our surroundings. The goal of this study was to identify air pollutants of health importance to humans and determine their negative effects on human health, to determine if there is a correlation between exposure to environmental air pollutants and hospital visits due to symptoms of respiratory diseases, and to determine whether exposure to environmental air pollution has a significant effect on hospital visits due to symptoms of respiratory diseases.

1.2 Methodology

The data collected and analyzed will be used primarily in the thesis. The data was gathered from Mongolia's First Central Hospital. Patients' data collected include hospital file number, gender, age, diagnosis, address, the month of last hospital visit, positive family history of diseases, occupation, living area exposure to toxic substances, smoking, years of smoking, and the number of packets of cigarettes per day.

Keywords: Air pollution, health, environment, respiratory disease.

1.3 Study Background

Mongolia is a landlocked country located in Northeast Asia. It is located between Russia to the north and China to the southeast and west. Mongolia's territory is 1564100 square kilometers. Several distinctive natural zones characterize the country: the western and northern parts are high mountain and forested regions, the eastern part is grassy steppe, and the southern part comprises the famous Gobi Desert. The population of Mongolia was estimated at 3.35 million people in 2020 ((NSOM, 2020).

Founded in 1639, Ulaanbaatar has been the capital of the Mongolian People's Republic since 1924. The city is located on the Tuul River in the north-central part of Mongolia. As the capital and the largest city of Mongolia, Ulaanbaatar has been the political, economic, educational, and cultural Center of Mongolia (Byambadorj et al., 2011). According to the 2016 national statistics, Ulaanbaatar has a population of 1,440,000, which accounts for 46.2% of the total national population (Park et al., 2018). Ulaanbaatar's ger neighborhoods have experienced most of the city's rapid growth, resulting in unplanned, low-density districts that are inadequately connected to the city's infrastructure (drinking water, waste management, wastewater treatment, heating). Since its transitional years in the early 1990s and after the 1980s' harsh winters, which prompted nomadic migration movements, Ulaanbaatar, the capital city of Mongolia, has seen exponential rates of population growth. Most homes are timber (ger), which are traditional Mongolian tents, with coal and biomass burners providing inefficient heating and inadequate insulation. Ger areas represent about 60% of the population of the capital city, estimated to be about 800,000 people, and 27% of the country's population. The ger areas of Ulaanbaatar are highly vulnerable to climate change and hotspots of greenhouse emissions and air pollution.

Since the industrial revolution, there has been a sharp rise in environmental pollution, endangering human existence through climate change, global warming, and flooding. The impacts of environmental air pollution are underestimated and underreported, but they constitute a major threat to human existence. The effects of environmental pollution on our health are being diligently investigated by a number of scientists, researchers, international organizations, governmental and non-governmental organizations. The new data from recent research on the health consequences of environmental air pollution are both astonishing and frightening. In 2014, World Health Organization announced the classification of air pollution as a class I human carcinogen due to cumulative evidence by researchers across the world that air pollution is a predisposing factor to nasopharyngeal, lung, head, and neck cancer (Wong, 2014). According to the latest report and data released by WHO on 25th March 2014, about 7 million deaths in 2012 were attributed to air pollution exposure, the data which doubled the previous estimation. This data made the WHO term air pollution the largest single environmental health risk. Despite the abundance of scientific evidence produced in the last 50 years, there is still uncertainty, if not skepticism

(Goldman, 2019), on the causal role of air pollution in deteriorating human health or triggering acute responses in the body. This is due in part to the difficulty of comprehending the spatial and temporal variability of various air pollutants, which is required to properly attribute exposures to individuals and populations in epidemiological studies.

1.4 Aims of this study

My research goals are as follows:

- To identify air pollutants of health importance and to determine their negative impact on human health.
- To collect health data from patients at the Respiratory and Infectious Disease Department of the First Central Hospital in Ulaanbaatar, Mongolia.
- Using Pearson correlation analysis, examine the collected patient data to see if there is a link between exposure to environmental air pollutants and hospitalization for respiratory disease symptoms.

1.5 Null Hypothesis (H0)

1) There is no correlation between disease cases reported as a result of exposure to environmental air pollution and total hospital visits.

2) Exposure to environmental air pollutants has no effect on total hospital visits due to illness.

2. Air pollution in Ulaanbaatar Mongolia

In recent years, air pollution in Ulaanbaatar city has become the main problem for every citizen living in the Mongolian capital. Population growth caused mainly by rural-to-urban migration has led to major increases in the capital city's air pollution emissions. Much of the population growth has been in the city's low-income ger (Mongolian national dwelling) districts, where coal and wood are burned for heat. Most of the Ulaanbaatar's population lives in a ger, and each ger family burns an average of 5 tons of coal and 3 m^3 of wood per year (Guttikunda, 2007).

The air pollution sources in Ulaanbaatar include coal burning in gers, industrial boilers, dust emissions of construction, power plants, improved stoves, household heating systems, brick kiln operations, public and private transports, road resuspension, fly ash resuspension, and garbage burning. Of these, especially during wintertime, the smog of ger districts, motor vehicles, and power plants produces a very large amount of air pollutants (Amarsaikhan, 2014). Generally, in Ulaanbaatar city, combustion for domestic cooking and heating, motor vehicles, and power plants are the main sources of air pollution **(Fig. 1).**

Air pollution in Ulaanbaatar's ger areas. Credit: UBDHC, Erbar Agarjav

Fig. 1. *Main sources of air pollution: (a) ger area*

The most typical urban pollutants include suspended particulate matter (SPM), sulfur dioxide (SO_2), volatile organic compounds (VOCs), lead (Pb), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_X) and ozone (O_3). Of these pollutants, particulate matter (PM) is one of the most critical pollutants responsible for the largest health and economic damages. Because of the importance of PM pollution for human health, visibility, and the environment, many studies are focused primarily on PM pollution as a target pollutant (Guttikunda et al., 2013).

Compared to the average concentration of PM2.5 particles in the last nine years, 2011-2019, the concentration of particles is higher than the tolerance level from October to March of the following year. During these months, the average concentration of PM2.5 particles is 0.6-3.7 times higher than the standard tolerance concentration of Mongolia (**Fig. 2**).

The highest concentration was 0.34 mg/m^3 in January, which is seven times higher than the Mongolian standard and 14 times higher than the WHO recommendation (Urangoo, 2020).

This means that the citizens of Ulaanbaatar city breathe polluted air several times higher than the tolerance limit for 6 months of the year (**Fig. 2, Fig. 3**).

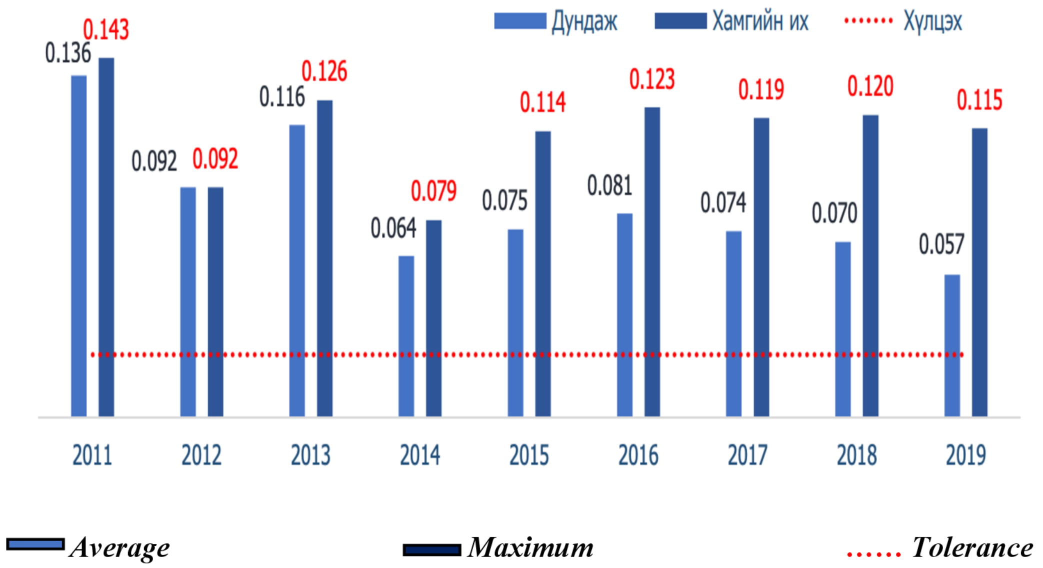

***Fig. 2**. Dust size less than 2.5 microns in the air of Ulaanbaatar city Annual average concentration for 2011-2019, mg/m^3* Source: Statistical database - www.1212.mn

Fig. 3. Ger districts in Ulaanbaatar 2021. Credit: Namuun Turbold

In terms of air quality, in ger districts' sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) levels are much higher than in people living in the urban area (**Fig. 4, Fig. 5**).

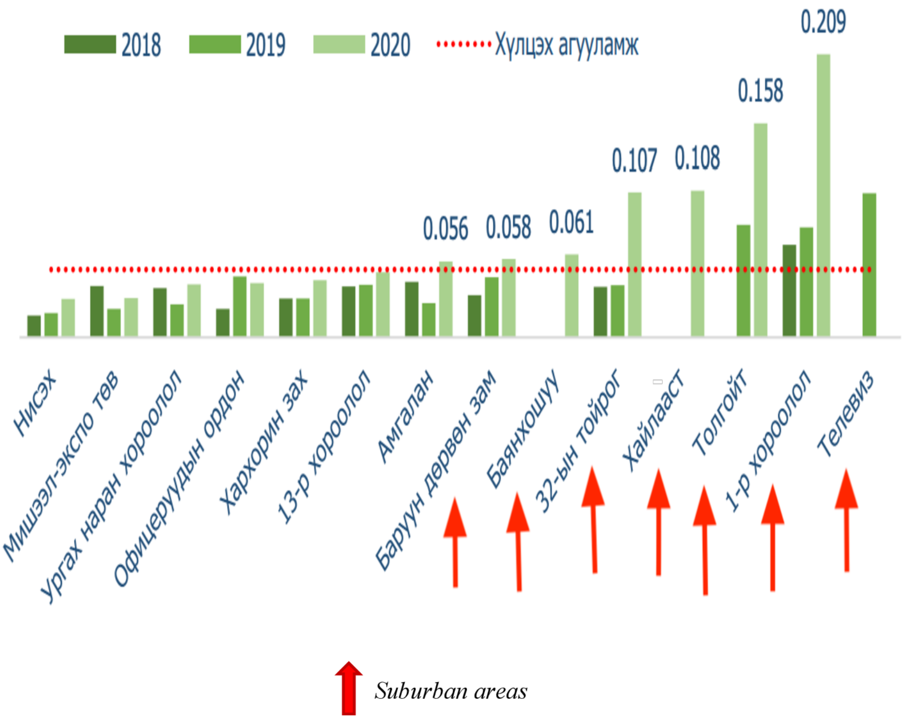

***Fig. 4**. Monthly average content of sulfur gas (mg/m^3), the average of the first three months of each year, by location. (Red arrows show suburban areas)* Source: Statistical database - www.1212.mn

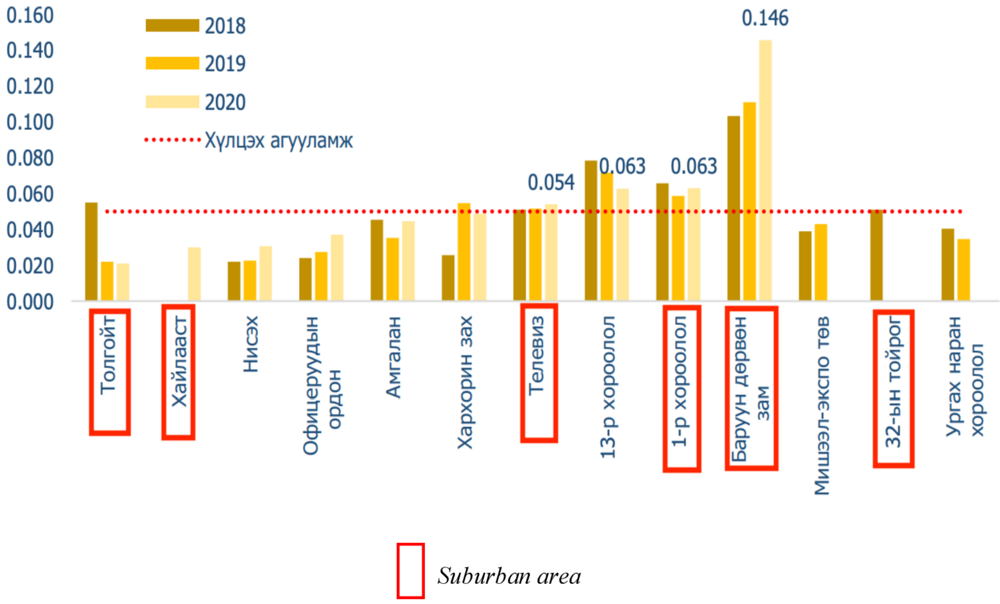

Fig. 5*. Average monthly concentration of nitrogen dioxide NO_2 in the air of Ulaanbaatar (mg/m^3), averaged over the first three months of each year, by location (Red squire shows suburban area)* Source: Statistical database - www.1212.mn

3. Environmental Air Pollution

The air we breathe is a complex blend of solid, liquid, and gaseous compounds.

Broadly speaking, air pollutants in the solid phase are called "particles" and are usually classified on the basis of their size into PM10 (particles with an aerodynamic diameter smaller than 10 $\mu g/m^3$, sometimes called "inhalable" particles), PM2.5 (particles smaller than 2.5 $\mu g/m^3$, also called "fine" particles), PM2.5-10 (particles between 2.5 and 10 $\mu g/m^3$ in diameter, referred to as "coarse" particles), and UFP ("ultrafine particles", particles ≤ 0.1 $\mu g/m^3$) (Zoran et al, 2019).

Fine particles in non-urban areas, on the other hand, are mostly secondary, which means they are produced by chemical reactions involving gaseous precursors such as sulfur dioxide, nitrogen oxides (NO_X), ammonia, and volatile organic compounds (VOCs). Finally, coarse particles are mostly of primary origin, composed of sea salt and crustal materials, and are brought into cities by long-range transportation patterns or formed by mechanical dust resuspension processes.

Historically, environmental air pollution could be traced back to the city of London, which was known for coal mining and exportation. (Admassu and Wubeshet, 2006). The city was well known for 'big smoke,' fog, and smog. In 1873, over 700 people died as a result of smog, and in December 1952, approximately 4000 during Great London Smog (Oosthoek, 2014). During the nineteenth and twentieth centuries, the same trends that made London the headquarters of polluters were seen in the United States. However, one does not need to travel to London or the United States to experience the environmental and health effects of industrialization's air pollution.

Nowadays, the problem of air pollution is mostly felt in cities due to the increased consumption of products that emit by-products as air pollutants. Pollutant emissions have direct and indirect effects with a wide range of impacts on human health, ecosystems, agriculture, and materials (Dieter, 2012).

3.1 Definition of Air Pollution

World Health Organization in 1999 defines air pollution as 'substances put in by the activities of mankind in a concentration sufficient to cause harmful effects to health, properties, crop yield, or to interfere with the enjoyment of property' (Mukherjee, 2002).

Pollutants are defined as both natural and manufactured substances that harm the environment.

The pollutant must first be released into the atmosphere, go through some mixing or chemical transformation, and then have an impact on receptors for air pollution to be felt. In this usage, the term "receptor" might refer to a person, an animal, a plant, or a material. Also, the combustion of fossil fuels for transportation, power generation, and other human activities produces a complex mixture of pollutants comprising literally thousands of chemical constituents (Holgate et al., 1999). Exposure to such mixtures is a ubiquitous feature of urban life.

4. Major Environmental air pollutants and their health effects

There are numerous air contaminants that are significant for public health. They have significant negative effects on human health, including the development of asthma, respiratory conditions, infections, and cancer risk factors. A major health concern and even death could result from the amount of exposure and buildup of these toxins in the body over time. Carbon monoxide, nitrogen oxides, heavy metals, and particulate matter are some of these contaminants. In air pollution research, most studies have focused on the role of air pollution in triggering symptoms and exacerbations, i.e., the short-term (acute or subacute) effects of air pollution (Peacock, 2011).

4.1 Carbon Monoxide

It is a colorless, odorless, tasteless, and very poisonous gas. Its occurrence is natural in volcanoes, natural gas emissions, and seed germination (Bibhabasu Mohanty, 2014). It arises from the incomplete burning of hydrocarbons. Its affinity to hemoglobin molecules is roughly 240 times higher than that of oxygen (O_2) (Weaver et al., 2000), leading when present to the formation of carboxyhemoglobin by replacing the bounded O_2 (Mlcak et al., 2007). Once inhaled, CO leads to tissue hypoxia, primarily affecting areas of high blood flow and oxygen demand (Cancio, 2009).

Additionally, heaters and furnaces release this gas, particularly when they are not maintained properly. In metropolitan areas, this hazardous gas is continually present around people. This gas is also released by heaters and furnaces, particularly ones that are used in unclean environments. In addition to garbage incineration, other major contributors to anthropogenic carbon monoxide emissions include the metal industry, forestry, agriculture, and fisheries.

4.2 Health effects of CO

Carbon monoxide intoxication is one of the most common inhalation poisonings worldwide, which can lead to high morbidity and mortality involving multiple organ systems. Due to its variety of clinical presentations and lack of reliable blood tests with correlation to the clinical outcome, it remains a multidisciplinary challenge (Reumuth, 2019).

People might not be aware that they are being exposed to CO because it has no smell, no color, and is essentially invisible to human senses. Low to moderate CO poisoning's initial signs and symptoms resemble flu symptoms (but without the fever). They comprise:

- Headache
- Fatigue
- respiration difficulty
- Nausea
- Dizziness

High-level CO poisoning results in progressively more severe symptoms, including:

- Mental confusion
- Vomiting
- Loss of muscular coordination
- Loss of consciousness
- Ultimately death (Hampson, 2012).

The CO level and exposure time have an impact on the severity of the symptoms. Residents or medical professionals may misdiagnose mild to moderate CO poisoning symptoms for the flu in slowly increasing residential CO problems, which can sometimes lead to tragic deaths.

4.3 Oxides of nitrogen (NOX)

In monitoring and evaluating the quality of ambient air, the term nitrogen oxides (NO_X) is understood to refer to a mixture of nitrogen oxide (NO) and nitrogen dioxide (NO_2).

The higher oxides of nitrogen (NO, NO_2, and higher valence) are highly reactive compounds encountered in a variety of occupational exposures and are principal constituents of photochemical air pollution. Their chemical properties result in direct oxidation, free radical formation, nitrosation, nitrite ion release, and paramagnetic interactions with heme (Guidotti, 1978).

In 2020, no station exceeded the limit value for an hourly NO_2 concentration (200 g.m-3, with a maximum permitted the number of 18 cases exceeding the limit per year). At no station was the hourly NO_2 limit value exceeded.

4.4 Health effects of NOx

Ambient NO_2 exposure may increase the risk of respiratory tract infections through the pollutant's interaction with the immune system (Chen, 2007).

Nitrogen dioxide can decrease your lung function and make asthma worse. Long-term exposure to low levels of nitrogen dioxide can increase your risk of developing breathing problems, such as:

- coughing
- wheezing

People who may be more sensitive to nitrogen dioxide include those with the following:

- airborne allergies
- asthma
- chronic obstructive pulmonary disease (COPD)

4.5 Sulfur oxides

Sulfur oxides exist in two forms, Sulphur (IV) oxide (SO_2) and Sulfur trioxide (SO_3). Sulfur dioxide is colorless, but it has a distinct odor and taste that can be detected at high concentrations. Sulfur oxides dissolve easily in water, resulting in the formation of sulfurous acid or sulfuric acid in the atmosphere, which is a component of acid rain.

SO_2 can be emitted by natural and anthropogenic sources. Although efforts have been made to reduce sulfur dioxide emissions worldwide, this pollutant and its adverse effects remain a major concern, especially in developing countries (Eman, 2022).

The majority of sulfur oxides are produced during the combustion of sulfur-containing fuels. A significant source is also the roasting of metal sulfide ores. SO_X emissions are primarily produced by coal-fired power plants that use high-sulfur coal. Sulfur oxides can also be emitted by vehicles.

With regard to one of the most dramatical urban environmental exposures to air pollutants, the London smogs (Bell, 2001), sulfur dioxide (SO_2) is known as a major respiratory irritant for many years. Next to its acute effects, SO_2 may also be related to the incidence of chronic cough (Balmes et al., 2003).

4.6 Health effects of SOx

Sulfur dioxide affects the respiratory system, particularly lung function, and can irritate the eyes.

Sulfur dioxide irritates the respiratory tract and increases the risk of tract infections. It causes coughing and mucus secretion and aggravates conditions such as asthma and chronic bronchitis.

4.7 Particulate Matter (PM)

Particulate matter is a term used by the United States Environmental Protection Agency to describe a mixture of solid particles and liquid droplets found in the air (United States Environmental Protection Agency, 2022). PM is classified into three types based on particle size: coarse particles (PM), fine particles (PM 2.5), and ultrafine particles (PM 0.1). PM10 are aerodynamic inhalable particles between 10 µm and 2.5 µm. They typically reside close to busy roads and dirty industries.

4.8 Health Effect Particulate matter

Air pollution has both acute and chronic effects on human health, affecting a number of different systems and organs (Kampa, 2008).

The impact of particulate matter as a pollutant of concern to health has been the subject of numerous scholarly articles in recent years. In those with underlying heart or lung disease, such as asthma, airway irritation, nonfatal heart attacks, and irregular heartbeat, PM pollution has been associated with earlier mortality. Additionally, a diverse group of characteristics can lead to an increased risk of PM-related health effects, including life stage (i.e., children and older adults), preexisting cardiovascular or respiratory diseases, genetic polymorphisms, and low-socioeconomic status (Sacks et al. 2011).

4.9 Environmental air pollution's effects on human health

The harmful effects of air pollution are well-known and well-researched. Researchers from the fields of public health, environmental health, and international health, as well as from international organizations and agencies, have made great contributions to the study and publication of the links between environmental air pollution and human health in several scholarly journals. In addition to the allergic reactions and respiratory symptoms that may be linked to air pollution, other unexpected diseases may also appear and be difficult to link to air pollution as the underlying cause. The following are some of the diseases that can be linked to environmental air pollution:

- Respiratory diseases
- Cardiovascular diseases
- Diabetics
- infertility
- Birth related problems
- Cancer

5. Data collection and analysis

5.1 Description of the hospital

Oriental medicine was expanded to become a Clinical Hospital in 1935, and over the years, many of the world's leading hospitals have branched out.

The hospital was built in 1971 with the help of Czechoslovakia. It has 240 beds and a hospital building with an area of 24,656 m^2. The hospital was expanded to serve as the State Clinical Central Hospital with 600 beds. In 2015, another 6,542 m^2 hospital extension building was commissioned and now has a total of 568 beds. The name of the State Clinical Central Hospital was changed to the First State Central Hospital by Resolution No. 231 of the Government of Mongolia dated 4th July 2012.

Today, the First State Central Hospital provides specialized medical referral services nationwide, conducts medical training and research, provides tertiary referral services to all levels of medical institutions, and develops diagnostic and treatment standards, clinical guidelines, and methodologies. It is the first public hospital in the country to conduct surveillance of population morbidity, disease prevalence, and other clinical areas.

The Center provides outpatient and inpatient care in 21 government and nine districts of Ulaanbaatar. It provides outpatient care to more than 370,000 people annually in 495 countries, with a total area of 31,504 m^2, with a staff of more than 800 people. It provides surgical care to more than 12,000 people. This hospital is the city hospital and is responsible for lung-related diseases and infections. They receive referrers from public hospitals, policlinics, and other tertiary institutions on lung-related diseases. This hospital was chosen because it is the primary facility in Ulaanbaatar city for the treatment of lung diseases. It is a tertiary hospital that also trains medical students and specialists in respiratory diseases. Because most environmental air pollutants enter the human body through inhalation, and the lung is the first internal organ to be exposed to these pollutants, it is not surprising that the effects of these pollutants will be more pronounced on the lungs. Choosing this hospital for this research and data collection is thus regarded as a wise decision.

5.2 Data collection and representation method

This study collected hospital case files from patients who presented at this hospital between 1st January 2022 till 3rd March 2022. It is critical to emphasize that all of the patients at this hospital have respiratory and infectious diseases. Patients' data were collected and recorded as follows sex, age, diagnosis, comorbidity, address, the month of the last hospital visit, positive family history of the diseases, occupation, exposure to toxic substances in living area, smoking, years of smoking, and the number of packets of cigarette per day. Without compromising the privacy of the patient's information, the data gathering complied with hospital policies, rules, and regulations, as well as the ethical committee's guidelines. The information gathered is only used for academic and research purposes.

Data were gathered on 299 patients in total. The patients excluded from these data are those who are now being discharged, have previously been discharged, and have been hospitalized. Using Excel 2013, the data were logged and examined. When presenting and displaying data, tables, pie charts, and histograms were used.

6. Results

In total, 299 patients' data were taken and analyzed, 185 male and 74 female, as shown in **Fig. 6** below.

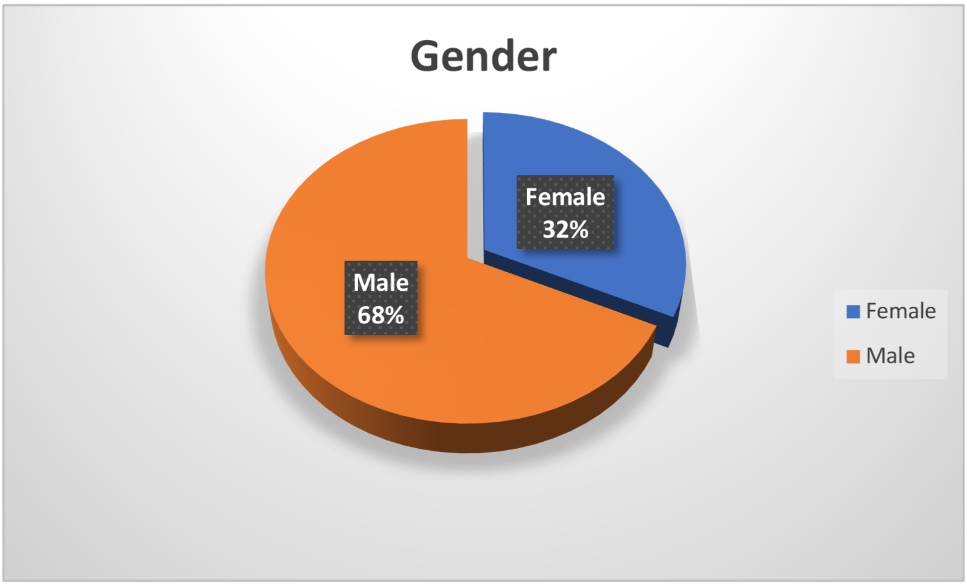

Fig. 6*. The gender pattern of patient's presentation at the hospital.*

It was noted that the majority of patients who presented to this hospital with infectious and respiratory disorders were older. According to research, the aged are a vulnerable population that is more prone to illness and impairment (WHO, 2006). Another explanation would be that environmental toxins build up in the body over time and eventually become noticeable. For instance, those who smoke and are exposed to harmful chemicals run the risk of being sick later in life (**Fig. 7**).

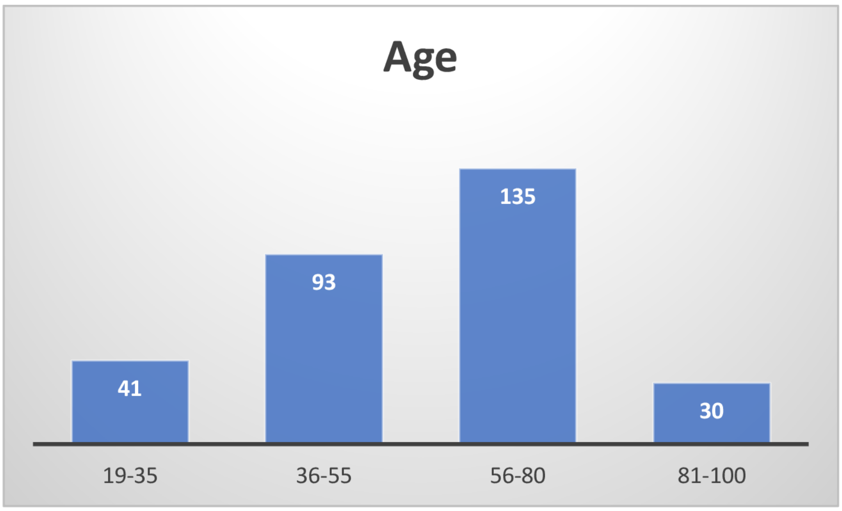

Fig. 7. The age distribution of patients presented at the hospital. 41 patients between the ages of 19-35, 93 patients between the ages of 36-55, 135 patients between the age of 56-80, and 30 patients between the ages of 81-100.

6.1 Diagnosed diseases

The fig 8 below shows the diseases that the patients presented at this hospital usually have.

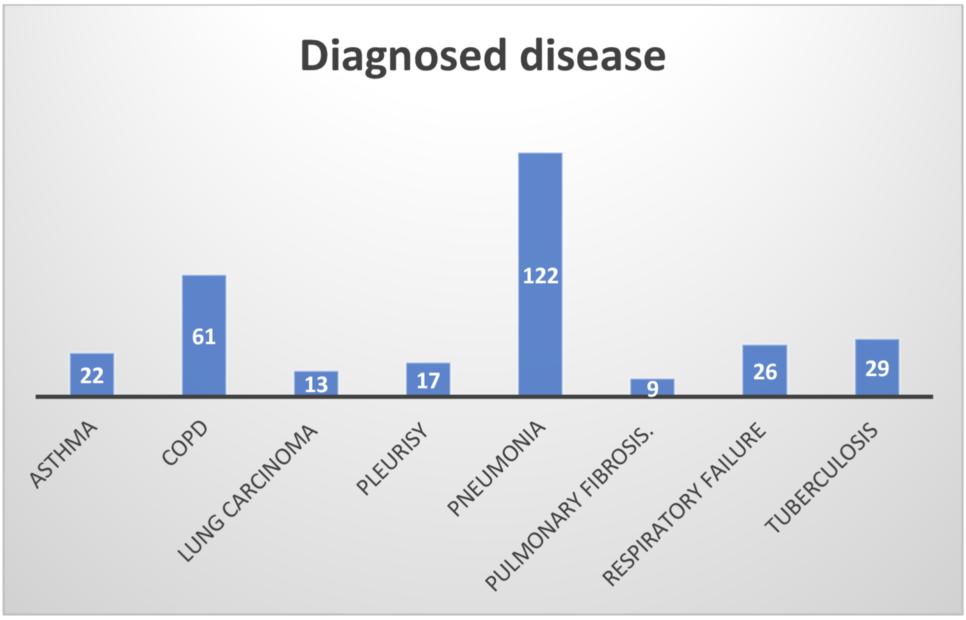

***Fig. 8**. The distributions of diagnosed diseases.*

61 patients have been diagnosed with chronic obstructive pulmonary disease (COPD), 122 patients with pneumonia, 22 patients with asthma, 29 patients with tuberculosis, 13 patients with lung carcinoma, 26 patients with respiratory failure, 17 patients with pleurisy, and 9 patients with pulmonary fibrosis.

According to the graph, this hospital diagnoses more pneumonia cases than any other, followed by COPD, tuberculosis, and respiratory failure. Respiratory failure is a consequence that can emerge from other respiratory illnesses that can be identified either apart from the original illness or as a comorbidity. According to the literature review that was conducted previously in this research, all the diseases described above are linked to ambient air pollution. As shown in **Tab. 1,** to have a clearer picture of the age group of disease case.

Tab. 1: Age group of disease case

	19-35	**36-55**	**56-80**	**81-100**	**Total**
Asthma	2	8	8	4	22
COPD	10	20	26	5	61
Lung carcinoma	4	3	5	1	13
Pleurisy	4	5	8	0	17
Pneumonia	16	38	52	16	122
Pulmonary fibrosis	0	4	5	0	9
Respiratory failure	3	5	16	2	26
Tuberculosis	2	10	15	2	29

6.2 Exposure to environmental air pollutants

Smoking and living in a hazardous environment are significant factors connected with the development of various diseases related to environmental air pollution when analyzing the lifestyle and living habits of the patients (**Fig. 9**).

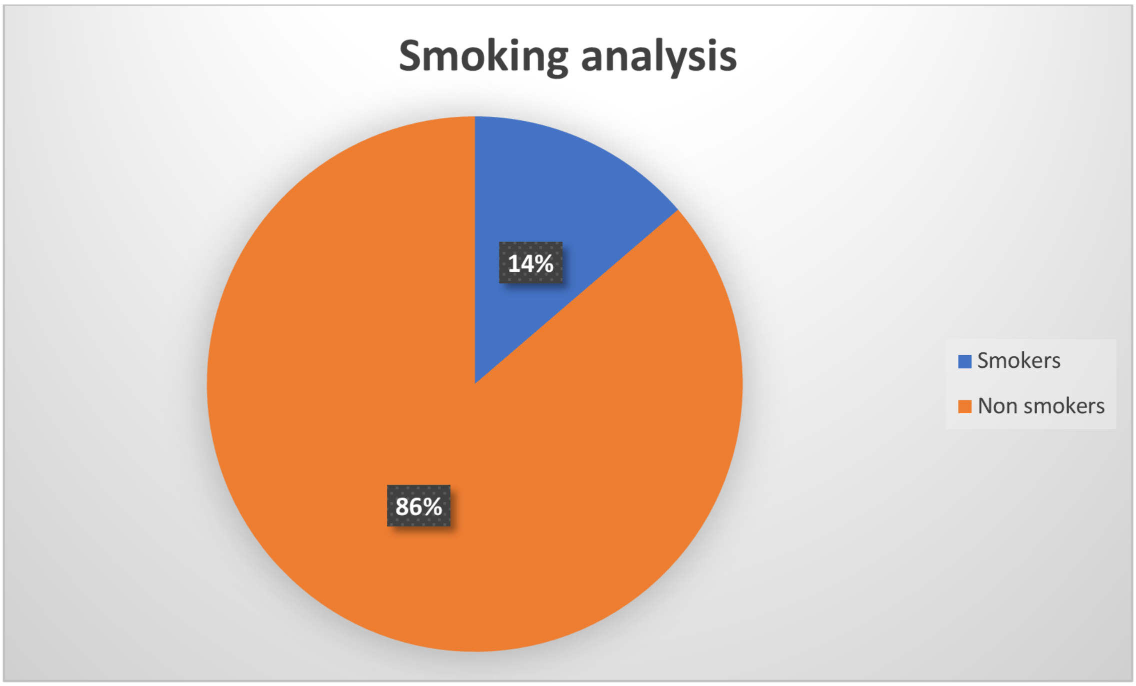

Fig. 9. *Showing the smoking habits of the patients. 41 patients were smokers, and 258 patients were non-smokers.*

Among 41 patients that smoke, eight patients are within the age group of 19-35, 11 patients are within the age group of 36-55, 19 patients are within the age group of 56-80, and 3 are within the age group of 81-100 as shown in **Fig. 10**.

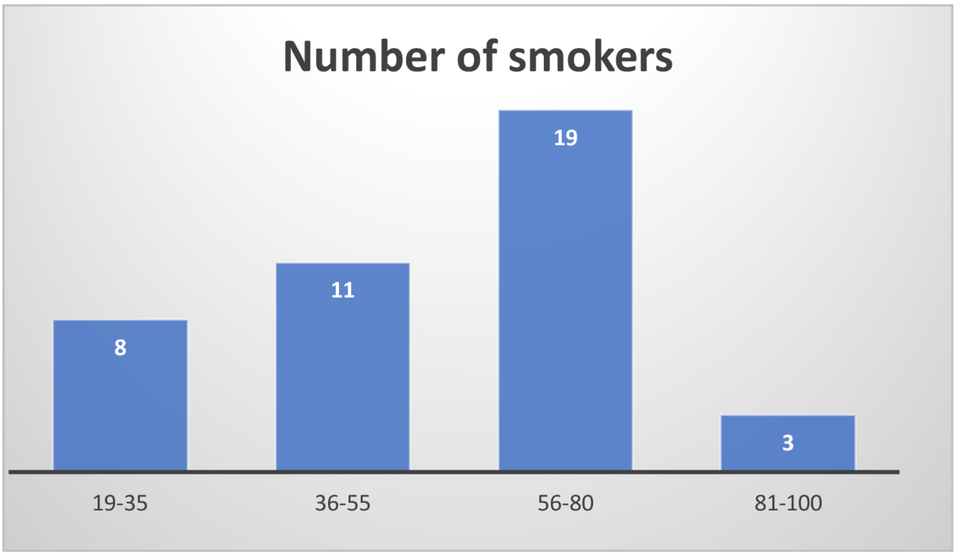

***Fig. 10**. Number of patients that are smoking and their age group.*

Among 41 patients that are smoking, the age group of 36-80 diagnosed COPD patients account for the largest percentage shown in **Fig. 11**.

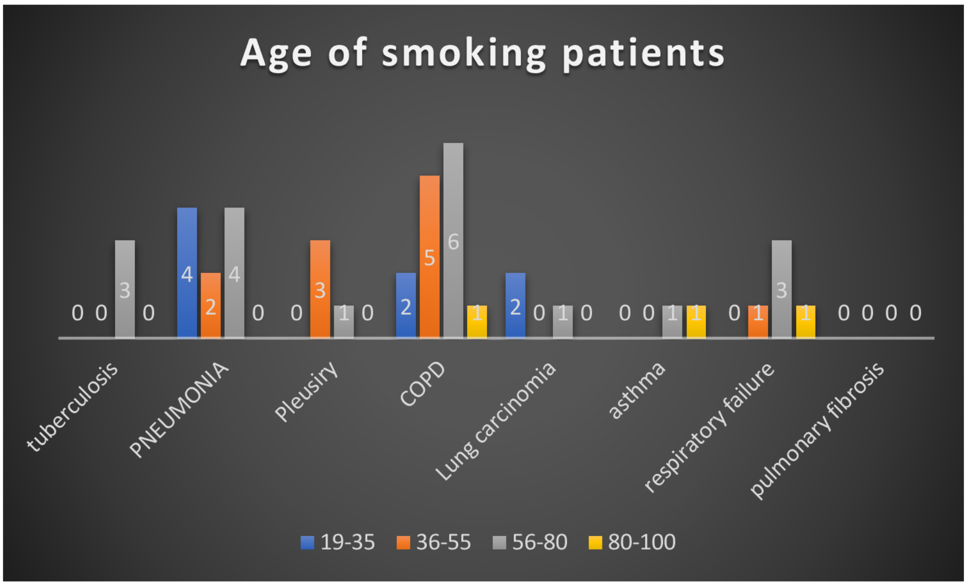

***Fig. 11**. Number of diagnosed patients that are smoking and their age group.*

When looking at the 299 total diagnosis cases among 134 patients who were smokers involving seven diseases, such common diseases in the descending orders are COPD, pneumonia, tuberculosis, and respiratory failure. This is shown in **Fig. 12**.

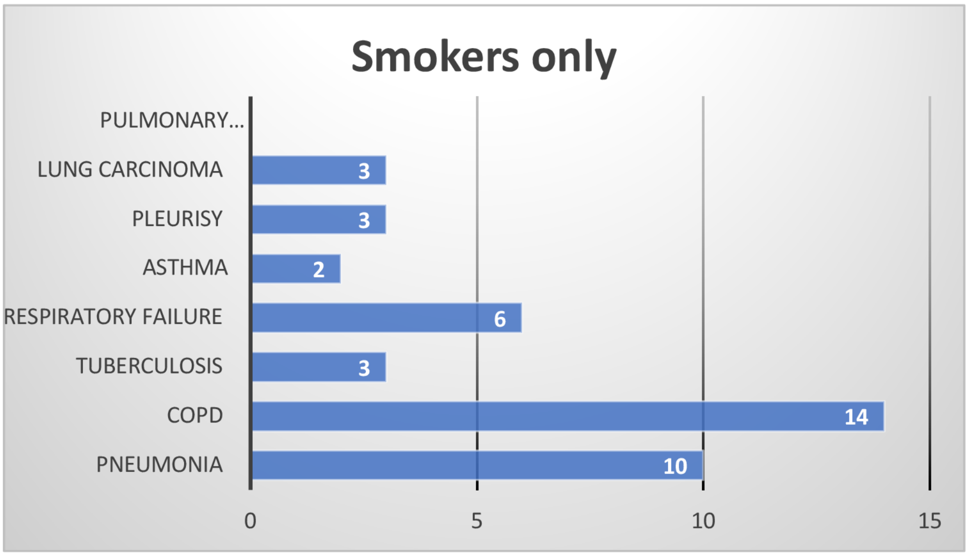

Fig. 12. *Chart showing 299 diagnosed cases of different diseases among 41 patients who were smokers.*

On the other hand, among 258 non-smoking patients, eight total diseases were seen. The common diseases among non-smokers who were resented at this hospital in descending order were pulmonary fibrosis, pneumonia, and asthma (**Fig. 13**).

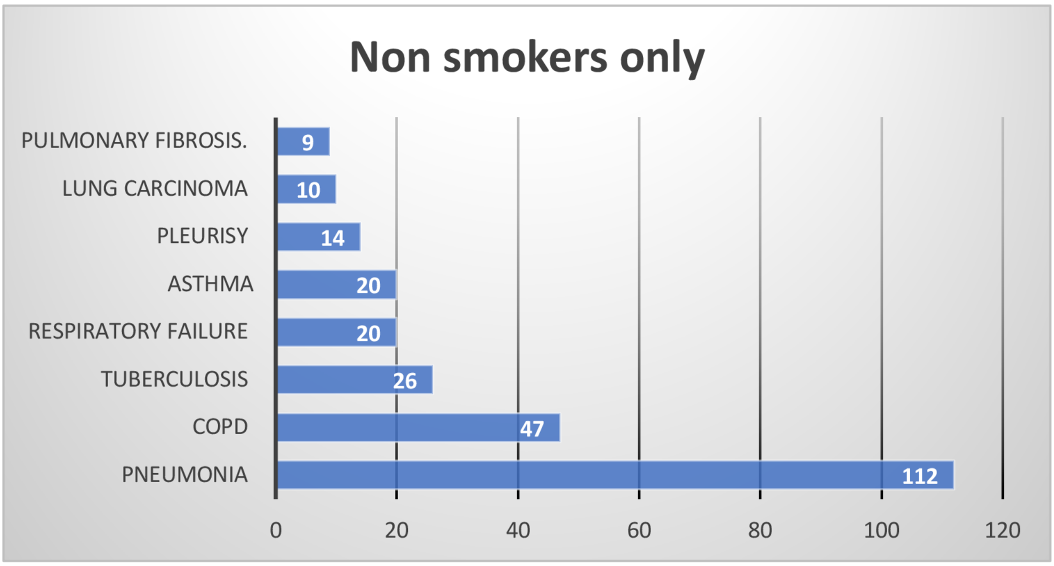

Fig. 13. *Chart showing 8 diagnosed cases of different diseases among 258 patients who were non-smokers.*

In addition to smoking, the address information is very vital in the course of taking the history of the patients. Some patients live in a toxic environment (suburban) where the risk of exposure to environmental air pollutants or health consequences is high, which puts them at a higher risk of developing certain diseases than their counterpart which are not living in a toxic environment (urban). The chart in **Fig. 14** shows the result of exposure and non-exposure to toxic substances.

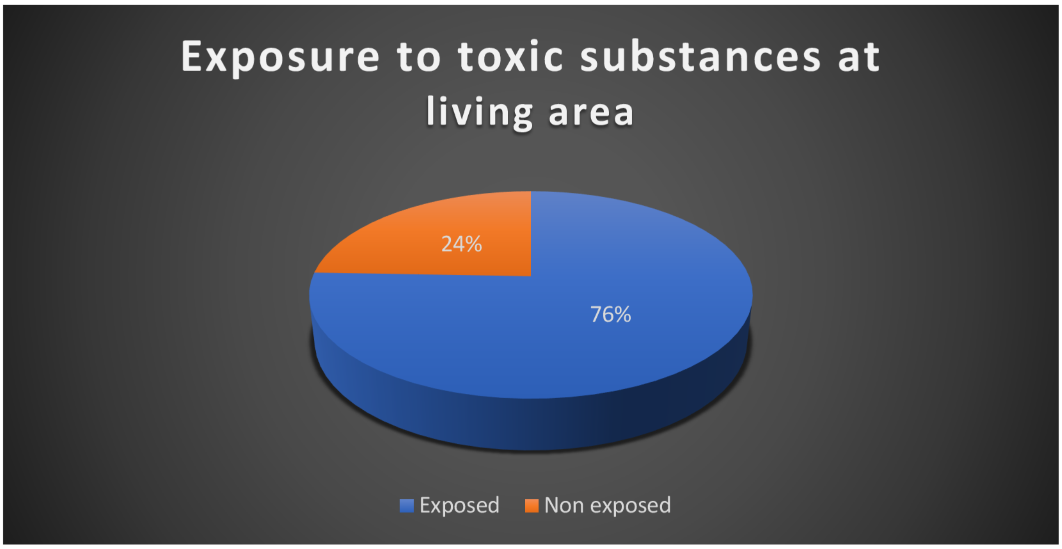

Fig. 14. *Pie chart showing the exposure of patients to toxic substances, also termed environmental air pollutants, in the living area. 226 patients were exposed, and 73 patients were not exposed.*

Among 226 patients who were exposed to the toxic environment due to living area, eight total diseases were seen. The common diseases among these patients who were presented at the hospital in descending order were pneumonia, tuberculosis, COPD, tuberculosis, and asthma (**Fig. 15**).

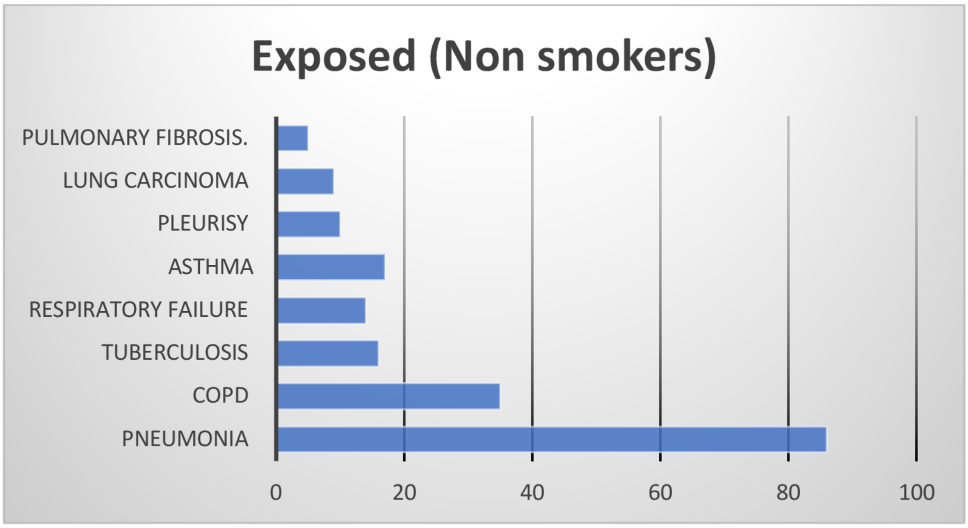

Fig. 15. Chart showing eight different diseases among 192 patients who were exposed to the toxic environment in the living area and were non-smokers

Most interestingly, people who live in toxic conditions without smoking are diagnosed with the highest number of respiratory diseases (**Fig. 16**).

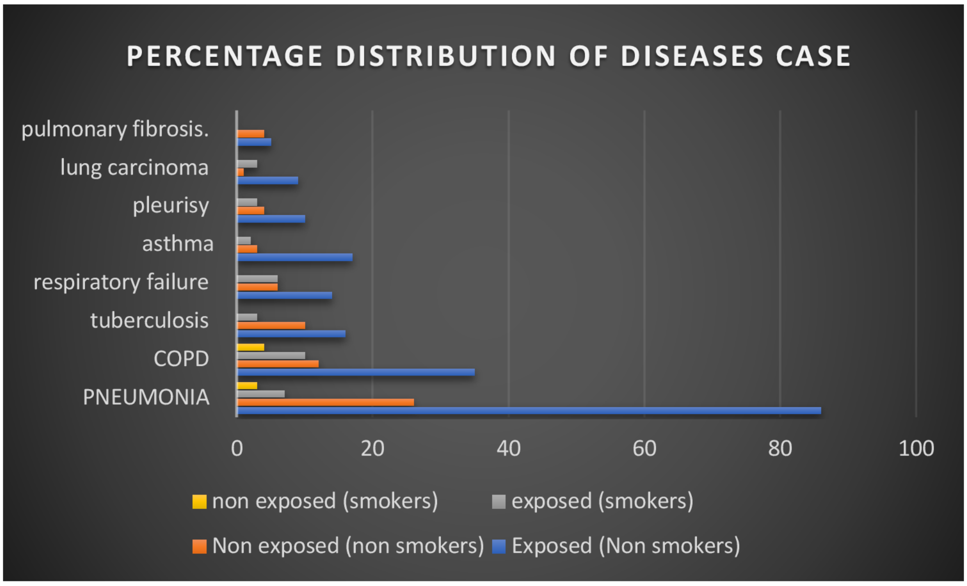

Fig. 16. Percentage distribution of disease cases among non-smokers, smokers, and patients exposed and non-exposed to environmental air pollutants.

When comparing the patients that were not exposed to air pollution to exposed patients, it was observed in all cases the number of disease cases presented by the exposed group of patients was more than the number of cases presented by the group of non-exposed patients, as shown in **Tab. 2**.

Tab. 2: Comparison of disease cases exposed and non-exposed to air pollution groups of patients

Disease	Exposed to toxic environment	Non-exposed to toxic environment	Total
PNEUMONIA	93	29	122
COPD	45	16	61
tuberculosis	19	10	29
respiratory failure	20	6	26
asthma	19	3	22
pleurisy	13	4	17
lung carcinoma	12	1	13
pulmonary fibrosis	5	4	9
total	226	73	299

It is vital to display the data in an instructive table, as shown in **Tab. 3,** to have a clearer picture of the facts obtained in this research and to apply comparative analysis to help us come to a well-informed conclusion.

Tab. 3: Categories of patients and disease cases presented

Disease	Exposed (Nonsmokers)	Non-exposed (Non-smokers)	Exposed (Smokers)	Non-exposed (smokers)	Total
PNEUMONIA	86	26	7	3	122
COPD	35	12	10	4	61
Tuberculosis	16	10	3	0	29
Respiratory failure	14	6	6	0	26
Asthma	17	3	2	0	22
Pleurisy	10	4	3	0	17
Lung carcinoma	9	1	3	0	13
Pulmonary fibrosis	5	4	0	0	9
Total	192	66	34	7	299

6.3 Analysis

To determine whether there is a relationship between exposure to environmental air pollutants (either through smoking or toxic exposure in a living area, or both) as analyzed by the number of cases seen because of exposure and the total number of hospital cases seen or recorded, correlation analysis using the Pearson correlation coefficient was performed on the data. The scattered diagram in **Fig. 17** shows the relationship between exposure to environmental air pollution against the number of hospital visits. X-axis: the number of hospital visits because of a given disease (the disease was diagnosed), and Y-axis: the number of hospital visits by the patients exposed to air pollution because of a given disease.

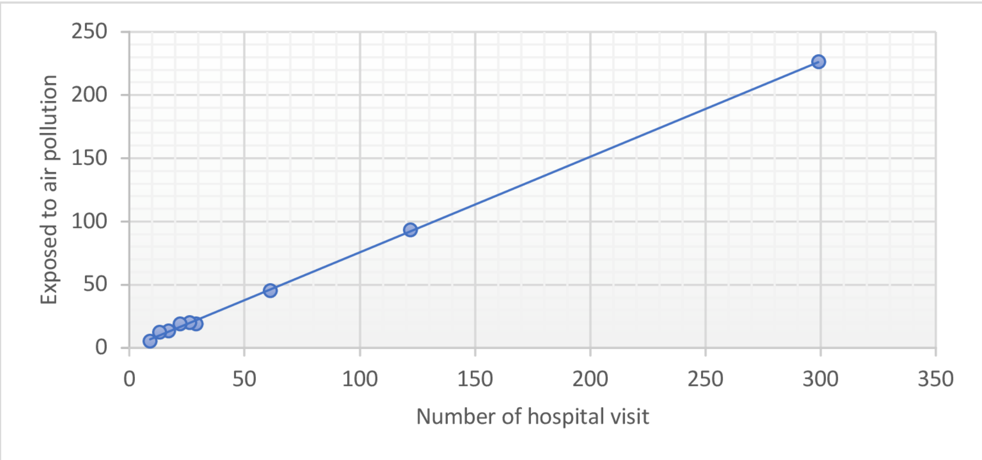

Fig. 17. *Scatter diagram showing a relationship between exposure to environmental air pollution and hospital visits due to respiratory illness.*

Using a 95% confidence interval and a two-tailed test, the null hypothesis—according to which there is no significant relationship between exposure to outdoor air pollutants and hospital visits for sickness (total cases diagnosed).

According to **Tab. 4**, there is a substantial association between the number of hospital visits (represented by total cases seen or recorded) and exposure to outdoor air pollution, with a Pearson correlation coefficient of 0.9979. Thus, the null hypothesis is rejected (H0). The total number of diseases recorded during the study indicates that the number of observations is 8.

With a 95% confidence interval, the P value of 0.02 ($p< 0.05$) using two-tail analysis demonstrates a significant relationship between exposure to outdoor air pollutants and the overall number of hospital admissions for sickness.

Tab. 4: Pearson's correlation test results

t-Test: Paired Two Sample for Means		
	Hospital visit	*Exposed to air pollution*
Mean	37,375	28,25
Variance	1424,267857	821,3571429
Observations (diseases)	8	8
Pearson Correlation	0,997904414	
Hypothesized Mean Difference	0	
P(T<=t) two-tail	0,027800335	

7. Discussion

From the analysis of the result, when looking at the sex distribution of the patients that presented at the respiratory and Infectious diseases hospital, The 1st Central Hospital of Mongolia, it was seen that 68% of the patients were male while 32% were female. Although there is no clear association between environmental air pollution and gender, a stronger association is seen in occupational health, where respiratory diseases were associated more with women (Clougherty, 2009). It was observed that most of the people present at this hospital for respiratory-related and infectious diseases were majorly elderly, where the largest numbers of patients were within the 56-80 age group, followed by the 36-55 age group. It has been established that the elderly are regarded as a vulnerable group of people, and hence their ability to fight against diseases is limited due to their aging immune system. Another reason may be due to the fact that environmental pollutants accumulate in the body, especially when the rate of metabolism and excretion is less than uptake and manifests their effects later in life. For instance, people that are smoking and exposure to toxic chemical substances may develop the illness at a later stage in life. The result clearly showed that pneumonia is the most present disease at this hospital, followed by COPD, tuberculosis, and respiratory failure. In older adults, exposure to ambient nitrogen dioxide and PM2.5 is associated with hospitalization for community-acquired pneumonia (Neupane et al., 2009).

Certain diseases are common among smokers in this hospital, for instance, in the order of commonest, COPD, pneumonia, and respiratory failure. When compared to non-smokers with pneumonia, pulmonary fibrosis, asthma, and COPD from **Fig. 12** and **Fig. 13**. These studies also agreed with many authors and researchers that smoking is a risk factor for many diseases and the number one risk factor for lung cancer according to Center for disease control and prevention. Cigarettes consist of over 4000 chemical substances, some of which are carcinogenic (Hoffman et al., 2001; Li et al., 2002). Living in a toxic environment also has a large impact on human health in this study, as seen in **Fig. 16**, page 23, where respiratory diseases such as pneumonia, tuberculosis, COPD, pleurisy, and respiratory failure are the disease that common.

The combined effect of smoking and exposure to environmental air pollutants was also seen to have major effects on human health. Among this group of patients, the most presented case is pneumonia, followed by COPD and tuberculosis, as seen in **Tab. 3**. Cigarette smoking is associated with the accelerated decline of lung function, increased mortality, and worsening of symptoms in both asthma and COPD (Tamimi, 2012). Patients in this group have a combined high risk of high severity of these diseases, although more studies will be needed in the future to support this observation.

On analysis of those that were exposed to environmental air pollution, which is either by living in a toxic environment or by smoking or both, in the order commonest, the following diseases could be attributed to environmental air pollution pneumonia, COPD, tuberculosis, respiratory failure. Given the other recent findings of both acute and chronic effects of particulate pollution, these associations are likely causal (Schwartz, 1993). This group of cases represents exposure to environmental air pollution. This result shows that the diseases are in line with the established facts stated in the literature review.

The statistical results of the analysis, Pearson correlation coefficients of **0.99** which shows that there is a strong correlation between the exposure to environmental air pollutants and total hospital cases representing total hospital visits, shows the strength of this study. It is, therefore, of public importance to limit exposure to environmental air pollutants in the living area and strict regulation on smoking, especially in public places, to reduce the effect of passive smoking effect.

Air pollution represents a major threat to public health in Ulaanbaatar, Mongolia, and reducing home heating emissions in traditional housing areas should be the primary focus of air pollution control efforts (R Allen, 2013). The P value of **0.02** at 95% confident interval shows that exposure to environmental air pollutants has a significant effect on the hospital visit due to illness is another strength of this study. A scenario analysis of air pollution emissions in Ulaanbaatar for the years 2010 and 2020 indicates that unless the government makes a concerted effort to address the issue at multiple levels, air pollution and its corresponding health impacts will be significant (Guttiikunda, 2008). Residents of Ulaanbaatar's suburbs must act quickly to prevent air pollution.

8. Conclusions

Certain diseases are more common among exposed patients when compared to non-exposed patients. It can be concluded that COPD, asthma, lung carcinoma, respiratory failure, and other forms of carcinoma are more common among patients that were exposed to environmental air pollution.

The result of the Pearson correlation coefficients rejects the null hypothesis (H0) that there is no correlation between the disease cases presented as a result of exposure to environmental air pollution and a total hospital visit. The Pearson correlation between the exposure to environmental air pollutants against total hospital visits (represented by total cases seen or recorded) is 0.99, which shows a strong correlation.

The P value of 0.02 at 95% confidence interval also reject the null hypothesis (H0) that exposure to environmental air pollutant does not have a significant effect on the total hospital visit due to illness.

The results of this study confirmed that air pollution has adverse health effects on people living in suburban Ulaanbaatar, Mongolia. That is why these results suggest countermeasures or interventions by the policymakers to reduce air pollution among the suburban's residents of Ulaanbaatar.

9. References

1. Admassu, A & Wubeshet, M., 2006: Air pollution. Ethopia, Ethopia Public Health Training Initiative. https://uomustansiriyah.edu.iq/media/lectures/6/6_2021_04_17!03_23_24_PM.pdf
2. Allen, R.W., Gombojav, E., Barkhasragchaa, B. et al., 2013: An assessment of air pollution and its attributable mortality in Ulaanbaatar, Mongolia. Air Qual Atmos Health 6, 137–150 (2013). https://doi.org/10.1007/s11869-011-0154-3
3. Amarsaikhan, D., Vandansambuu, B., Nergui, B., et al., 2014: A Study on Air Pollution in Ulaanbaatar City, Mongolia. Geoscience and Environment Protection, pp. 124-128.
4. Balmes, J., Becklake, M., Blanc, P., Henneberger, P., Kreiss, K., Mapp, C., Milton, D., Schwartz, D., Toren, K., & Viegi, G., 2003: American Thoracic Society Statement: Occupational contribution to the burden of airway disease. Am J Respir Crit Care Med, 167: 787–797, 10.1164/rccm.167.5.787
5. Bell, M, L., & Davis, D, L., 2001: Reassessment of the lethal London fog of 1952: novel indicators of acute and chronic consequences of acute exposure to air pollution. Environmental Health Perspectives, 109 Suppl 3: 389–394. https://doi.org/10.1289/ehp.01109s3389
6. Byambadorj, T., Amati, M., & Ruming, K., 2011: Twenty-first century nomadic city: Ger districts and barriers to the implementation of the Ulaanbaatar city master plan, Asia Pacific Viewpoint 52(2):165 – 177
7. Cancio, L. C., 2009: Airway management and smoke inhalation injury in the burn patient. Clin Plast Surg, Pp 555-567
8. Chen, T. M., 2007: Outdoor Air Pollution: Nitrogen Dioxide, Sulfur Dioxide, and Carbon Monoxide Health Effects. The American of the Medical Journal Science, Outdoor air pollution, Pp 249-256. https://doi.org/10.1097/MAJ.0b013e31803b900f
9. Clougherty, J. E., 2009: A Growing Role for Gender Analysis in Air Pollution Epidemiology. Environmental health perspectives, Vol. 118, No. 2
10. Dieter, S., 2012: Review of Urban Air Quality in Sub-Saharan Africa Region: Air Quality Profile of SSA Countries. World Bank Group, https://openknowledge.worldbank.org/handle/10986/26864

11. Eman, M., 2022: Effects of sulfur dioxide inhalation on human health: a review. De Gruyter, https://doi.org/10.1515/reveh-2022-0237
12. Goldman, G., 2019: Don't abandon evidence and process on air pollution policy. Science 10.1126/science. aaw9460 (2019).
13. Guidotti, T. L., 1978: The higher oxides of nitrogen: Inhalation toxicology. Environmental Research, Pp 443-472. https://doi.org/10.1016/0013-9351(78)90125-1
14. Guttikunda, S., 2007: Urban Air Pollution Analysis for Ulaanbaatar. The World Bank Consultant Report (pp. 1-132). Washington DC, USA.
15. Guttikunda, S., 2008: Urban Air Pollution Analysis for Ulaanbaatar. SIM Working Paper No. 2008-005, http://dx.doi.org/10.2139/ssrn.1288328
16. Guttikunda, S., Lodoisamba, S., Bulgansaikhan, B., & Dashdondog, B., 2013: Particulate Pollution in Ulaanbaatar, Mongolia. Air Quality, Atmosphere and Health, 6, 589-601. http://dx.doi.org/10.1007/s11869-013-0198-7
17. Hampson, N. B., Dunn, S. L., 2012: Symptoms of carbon monoxide poisoning do not correlate with the initial carboxyhemoglobin level. Undersea & Hyperbaric Medicine, Bethesda Vol. 39, Iss. 2, Pp 657-65. https://www.proquest.com/scholarly-journals/symptoms-carbon-monoxide-poisoning-do-not/docview/1008553641/se-2
18. Hoffmann, D., Hoffmann, I., & El-Bayoumy, K., **2001**: The less harmful cigarette: a controversial issue. A tribute to Ernst L. Wynder. Chem. Res. Toxicol. 14 (7), 767– 790, DOI: 10.1021/tx000260u
19. Holgate, S. T., Samet, J. M., Koren, H. S., Maynard, R. L., 1999: Air pollution and health. Academic Press, London, ISBN: 9780123523358
20. Kampa, M., & Castanas, E., 2008: Human health effects of air pollution. Sience Direct, Environmental Pollution, Pp 362-367. https://doi.org/10.1016/j.envpol.2007.06.012
21. Li, S., Banyasz, J. L., Parrish, M. E., Lyons-Hart, J., & Shafer, K. H., 2002: Formaldehyde in the gas phase of mainstream cigarette smoke. J. Anal. Appl. Pyrolysis 65 (2), 137– 145, DOI: 10.1016/S0165-2370(01)00185-1 [Crossref], [CAS], Google Scholar
22. Mlcak, R. P., Suman, O. E., & Herndon, N. D., 2007: Respiratory management of inhalation injury. Burns, Pp 2-13

23. Mohanty, B., 2014: Air pollution. Retrieved from http://www.slideshare.net/bibhabasumohanty/air-pollution-14820250
24. Mukherjee, A., 2002: Perspectives of the Silent Majority. Air Pollution, Livelihood and Food security, Hampshire, Ashgate Publishing Company.
25. National Statistical Office of Mongolia (NSOM)., 2020: Statistical Yearbook 2020, Ulaanbaatar National Statistical Office of Mongolia 2005, 2010, 2020.
26. Neupane, B., Jerrett, M., Burnett, R. T., et al., 2009: Long-Term Exposure to Ambient Air Pollution and Risk of Hospitalization with Community-acquired Pneumonia in Older Adults, PubMed: 19797763 https://doi.org/10.1164/rccm.200901-0160OC
27. Nguyen, N. T., Chinn, J., Ferrante, M. D., et al., 2021: Male gender is a predictor of higher mortality in hospitalized adults with COVID-19. https://doi.org/10.1371/journal.pone.0254066
28. Oosthoek, J., 2014: Environmental History Resources. Retrieved from www.eh-resources.org, http://www.eh-resources.org/index.html
29. Park, H., Fan, P., John, R., & Ouyang, Z., 2018: Spatiotemporal changes of informal settlements: Ger districts in Ulaanbaatar, Mongolia, Landscape and Urban Planning, https://doi.org/10.1016/j.landurbplan.2019.103630
30. Peacock, J. L., Anderson, H. R., Bremner, S. A., et al., 2011: Outdoor air pollution and respiratory health in patients with COPD. Thorax 2011; 10.1136/thx.2010.155358
31. Reumuth, G., & Alharbi, Z., 2019: Carbon monoxide intoxication: What we know, Burns, Pp 526-530
32. Sacks, J. D., Stanek, L. W., Luben, T. J., Johns, D. O., Buckley, B. J., Brown, J. S., & Ross, M., 2011: Particulate Matter–Induced Health Effects: Who Is Susceptible? Environmental Health Perspectives, Vol. 119, No. 4, https://doi.org/10.1289/ehp.1002255
33. Schwartz, J., 1993: Particulate Air Pollution and Chronic Respiratory Disease. Environmental Research, Volume 62, Issue 1, Pp 7-13, ISSN 0013-9351, https://doi.org/10.1006/enrs.1993.1083.
34. Tamimi, A., Serdarevic, D., Hanania, N. A., 2012: The effects of cigarette smoke on airway inflammation in asthma and COPD: Therapeutic implications. Respiratory Medicine, Volume 106, Issue 3, Pp 319-328, ISSN 0954-6111, https://doi.org/10.1016/j.rmed.2011.11.003.

35. United State Environmental Protection Agency., 2022: Retrieved from United State Environmental Protection Agency, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM
36. Urangoo, G., 2020: Impact of Air Pollution on Human Health in Ulaanbaatar City (pp. 1-44), Ulaanbaatar Mongolia. https://www2.1212.mn/BookLibraryDownload.ashx?url=Ub_health_2019.pdf&ln=M
37. Weaver, L. K., Howe, S., Hopkins, R. C., & Chan, J, K., 2000: Carboxyhemoglobin half-life in carbon monoxide-poisoned patients treated with 100% oxygen at atmospheric pressure. Chest, Pp 801-808
38. Wong, I. C. K., et al., 2014: Cancers of the lung, head, and neck on the rise. Perspectives on the genotoxicity of air Pollution. PubMed, PMID: 25011457
39. World Health Organization., 2006: Preventing diseases through healthy environments. Geneva, Switzerland, https://books.google.cz/books?hl=en&lr=&id=zfFoDTrVY_EC&oi=fnd&pg=PA6&dq=World+Health+Organization.+(2006).+Preventing+diseases+through+healthy+environments.+Geneva,+Switzerland&ots=sNkRMD1YJx&sig=gOW_MWN1C7SD0r7-6wcFR9M9qm0&redir_esc=y#v=onepage&q&f=false
40. Zoran, M., Savastru, R., Savastru, D., & Penache, M.C., 2019: Temporal trends of carbon monoxide (CO) and radon (222Rn) tracers of urban air pollution. J. Radioanal. Nucl. Chem.320, 55–70.