INDOOR AIR POLLUTION RELATED HEALTH CHALLENGES FOR GEORGIA

An interim study of indoor air pollution in kindergartens

wecf

NCDC

2020

about

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Women Engage for a Common Future (WECF) is a worldwide network of 150 women's health and environmental organisations with a historical focus on Eastern Europe and Central Asia. WECF's NGO network brings people all over the world together for sustainable development and a healthy environment for all. Its branch office, WECF Georgia, works in the South Caucasus region to support project implementations together with partner organizations, empowering women and men to take a lead in shaping their sustainable futures, and to negotiate at the political level for legislation that serves environmental and health protection for all.

The National Center for Disease Control and Public Health of Georgia (NCDC) is a legal entity of public law accountable to the Ministry of Internally Displaced Persons from the Occupied Territories, Labour, Health and Social Affairs of Georgia. Its operation is mostly funded from state budget allocations. The Center is a leading organization in the implementation of communicable and non-communicable disease prevention and control at the national level. It develops national standards and guiding recommendations (guidelines), promotes the improvement of public health, sets up public health priorities, participates in the development of public health policy, carries out epidemiological surveillance and immunization programs, performs laboratory diagnostic and surveillance activities, conducts epidemiological studies, provides consultations, and responds to public health emergencies.

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Summary

This report includes an overview of specific indoor air pollutants found in Georgia, the existing (gap in) legislation around air pollution in the country, and the preliminary results of a study conducted by WECF Georgia and The National Center for Disease Control and Public Health of Georgia (NCDC). During the winter and spring seasons in 2019/2020, indoor air quality information was collected from 59 public kindergartens across nine municipalities and three regions of Georgia. These surveys requested information regarding each kindergarten's ventilation practices and their level of awareness of different indoor air pollution sources, including their potential health effects. Within this selected group of kindergartens, 20 recorded real-time levels of particulate matter (PM) pollution in one to three school week intervals with air quality sensors. The results found that although most kindergartens do not voice any concerns about poor air quality conditions, most children are exposed to unsafe levels of PM throughout the school day. Some kindergartens' data never met safe or "normal" levels of exposure during their monitoring periods, highlighting the importance to take urgent action to address this issue.

The leading cause of high indoor pollution levels is the use of wood-burning stoves, on which nearly half of all kindergartens in Georgia still rely. In this study, the kindergartens using wood as their main source of heating have 2.4 times higher PM levels than those that depend on central heating and natural gas. The pollution levels vary greatly between days and kindergartens, which further underlines the need for a concentrated effort to continue research on this issue so that all the activities, materials, or practices contributing to such unstable and unhealthy pollution levels can be thoroughly investigated.

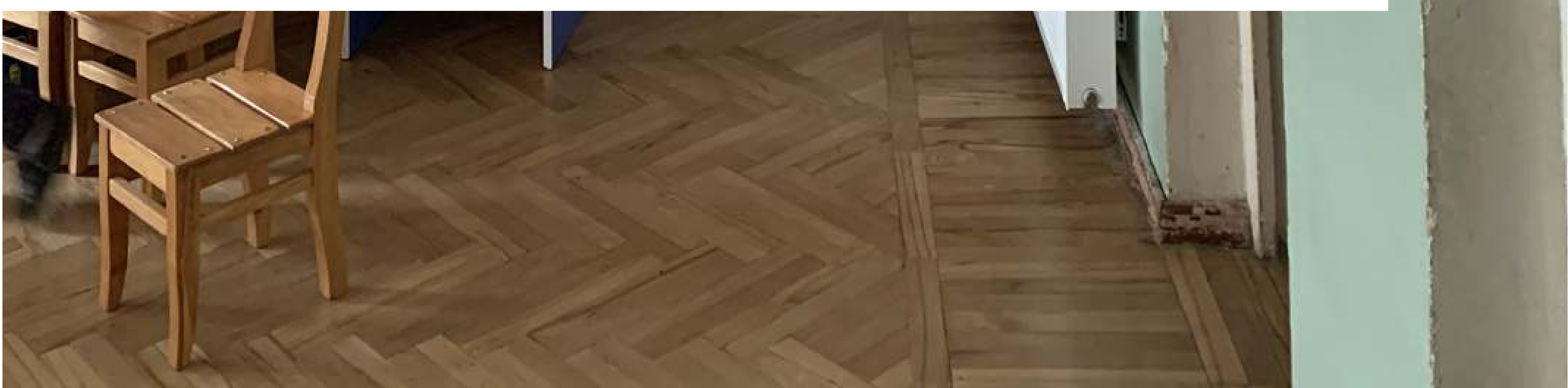
The study also revealed that kindergarten staffs' awareness of indoor air quality management practices is low. Only half of the kindergartens use an electric ventilator in the kitchen or bathroom. Although most open windows regularly for ventilation, classroom temperatures are not monitored and are suspected to be too high. 60 percent of kindergartens do not take their children outside during the heating season, and only a fraction take them for two hours or more.

Even though this study's sample size is small, the data demonstrates that our children and their care givers are being exposed to insufficient air quality. The report lays out a set of recommendations, including ones for further research, recommendations to adopt a legal framework, and practical recommendations that can be implemented by municipalities, kindergartens and households to improve poor indoor air quality conditions. Some of these actions, like replacing wood stoves, need investment and planning. A lot, however, can be done just by changing daily practices, such as properly ventilating classrooms throughout the day, ensuring enough time outside for children during the school day and the proper functioning of the stoves and chimneys.

Foreword

Indoor air pollution is a problem that affects us all: it's in our homes, schools, and workplaces. Recent studies have found that indoor spaces can be seriously more polluted than the outdoors, a concerning fact because of how much time we spend indoors nowadays, which, for the average person, is around 90 percent of the day [1]. For a lot of us, this issue goes unnoticed because indoor spaces are perceived to be clean, controlled areas that shelter us from external disturbances, such as the air pollution from industrial activities, car traffic, and many others. While ambient air does pose a huge threat to our health--over 4 million people around the world die prematurely every year from harmful outdoor air--indoor air can be just as or even more dangerous. As our communities work hard to improve their outdoor environments, this report addresses the need to do the same for our indoor spaces.

The project **Clean Air for Children** aims to raise awareness of the environmental and public health risks associated with indoor air-polluting activities by focusing on the current indoor environments of selected public kindergartens in Georgia. By collecting real-time indoor air data, this project works to mobilize stakeholders to identify and improve the indoor air quality (IAQ) in kindergartens throughout the country.



List of Abbreviations

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WECF	Women Engage for a Common Future
UNECE	United Nations Economic Commission for Europe
EU	European Union
WHO	World Health Organization
UNICEF	United Nations Children's Fund
NCDC	National Center for Disease Control & Public Health
JMP	Joint Monitoring Programme
DALY	Disability-Adjusted Life Year
WHO ECEH Bonn office	World Health Organization European Center for Environment and Health in Bonn, Germany
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CBRNEP	National Strategy for Chemical, Biological, Radiological and Nuclear Threat Reduction
FCTC	Framework Convention on Tobacco Control
UNFCCC	United Nations Framework Convention on Climate Change

Situation Review

According to the World Health Organization (WHO), air pollution is one of the main environmental health risks in the world, causing nearly 8 million premature deaths worldwide every year. 3.8 million of these deaths result from household exposure to smoke from dirty cookstoves and fuels [2]. Exposure to indoor air pollutants increases the risk of cardiovascular and respiratory diseases, as well as lung cancer.

In Georgia, 32 people out of 100,000 die prematurely from exposure to indoor air pollution each year. This amounts to more than 1,900 people annually, which is one of the highest mortality rates in the region [3]. Data from WHO on premature deaths attributed to household and ambient air pollution shows that Georgia is ranked as having the 3rd highest mortality rate among other European countries, standing narrowly behind Kyrgyzstan and Tajikistan [4]. This is mainly caused by the ongoing use of firewood, dung, and crop waste for heating and cooking purposes, on which more than half of Georgia's population still relies. UNICEF's report, 'Clear The Air For Children,' revealed three quarters of 4,000 European child deaths caused by diseases and infections could be attributed to indoor air pollution [5].

In rural areas of Georgia, wood-burning stoves continue to be one of the main heating and cooking appliances in both public and private buildings, of which many are ineffective and outdated, and therefore cause high levels of indoor air pollution.

Children are more vulnerable to environmental risk factors. As a result, they suffer a disproportionate share of the environmental health burden with regards to mortality and morbidity.

Indoor Air Quality

The quality of indoor air refers to the air quality within and around buildings and homes, and how it relates to people's health and overall comfort in these spaces [6]. Indoor air pollution, which reduces air quality, is a mixture of both outdoor and indoor emittance from a variety of sources, including vehicle exhaust, chemicals leaking from furniture, inefficient wood burning stoves, lead-based paints and toys, and many others.

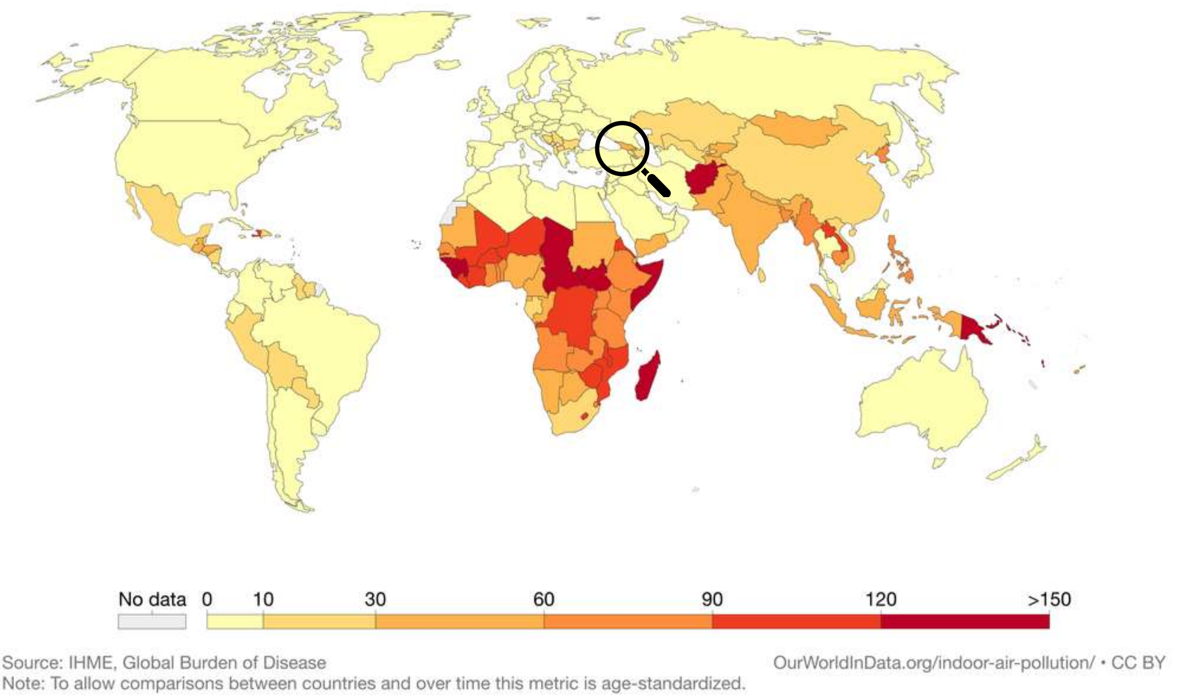

FIGURE 1. DEATH RATES FROM INDOOR AIR POLLUTION, 2017. DEATH RATES FROM INDOOR AIR POLLUTION ARE MEASURED AS THE NUMBER OF DEATHS PER 100,000 INDIVIDUALS.

The health impacts of indoor air pollution can be hard to determine since the effects of individual air pollutants on health cannot be extended to mixtures, which is almost always the reality of indoor environments. Different pollutants may interact with each other to cause more (or less) harmful effects than the sum of the effects caused by each pollutant separately. This leaves experts with an entirely new indoor environment to explore regarding the combined effects of indoor air pollutants.

Population groups that are potentially more vulnerable than others to indoor air pollution are children, pregnant women, elderly people, and people suffering from cardiovascular or respiratory diseases. Factors other than age and the presence of pre-existing health conditions that may render some people more vulnerable are genetic traits, lifestyle, and nutrition.

The issue of indoor air pollution has a clear economic split: it is a problem that has almost been entirely eliminated across high-income countries, but remains a large environmental and health problem at lower income levels. Additionally, within the population, low income groups tend to have less access to clean fuels, and use more polluting solid fuels with inefficient equipment, like stoves [7].

Some of the most common polluting practices and pollutants with the highest impact on indoor air quality in Georgia include the following*:

OUTDOOR AIR POLLUTION

Outdoor or “ambient” air pollution directly impacts indoor air quality. In Georgia, outdoor air pollution mainly comes from transportation vehicles, the energy sector, industrial facilities, and agricultural sectors. Among these emitters, vehicle emission stands out as the leading polluting source in the country.

Urban air pollution from particulate matter causes significant health problems throughout the region. According to WHO reports, cities with high levels of air pollution have mortality rates 15-20% higher than those with relatively clean air. Since substantial decreases in outdoor air pollution was made throughout most of the regions in the 1990s, progress in the last decade has been minimal. Over 92% of the urban population for whom relevant air quality data is available live in cities where air quality guidelines for PM10 is exceeded. Georgia does not significantly differ from the average European data on ambient air pollution indicators, and remains below the global average. This does not, however, imply outdoor conditions remain below pollution thresholds. According to 2016 data published by WHO, the combined mortality rate attributed to ambient and household air pollution amounts to 102 deaths per 100,000, which, like its household air pollution mortality index, is the third highest in the region [8].

CARBON DIOXIDE (CO_2)

When we breathe, we exhale Carbon dioxide, which is one of the most significant sources of indoor levels of this pollutant. Because our exhalations mix with the air around us, the Carbon dioxide levels in our blood can rise and make us feel tired and groggy. The amount of people and time spent indoors without proper ventilation greatly affects its amount in closed bedrooms, classrooms, and offices. Leaky furnaces, gas or wood stoves, fireplaces, candles, and tobacco smoke are all additional sources of Carbon dioxide. Even outside activities like burning trash and leaves and idling vehicles can increase the amount of Carbon dioxide indoors if buildings are nearby.

CARBON MONOXIDE (CO)

Carbon monoxide is an odorless, tasteless, but dangerous gas that is produced when fuels are not completely burned. The most common indoor producers include defected gas appliances (e.g. furnaces, ovens, and water heaters), wood stoves, and space heaters, while the primary outdoor source is vehicles. Breathing in Carbon monoxide, even at low levels, reduces the blood's ability to carry oxygen, making it harmful to people's health. Exposure to elevated levels is associated with headaches, visual impairment, and reduced ability to perform complex tasks [9]. Higher levels can lead to unconsciousness and eventually death [10].

A neighboring household burns their leaves next to a kindergarten in Dusheti.

PARTICULATE MATTER (PM)

In Georgia, high levels of PM exposure resulting from solid fuel use--mainly firewood--for the purposes of indoor cooking and heating are one of the key risk factors for people's health, especially for children and women. According to data from the WHO database, Georgia's indicators for solid fuel use are among the highest in Europe (84% of the rural population; 12% of urban population; national-46%), significantly exceeding the Overall Regional Index (<5%), as well as the Global Index (41%) [11].

Air sensor installed in a kindergarten's central classroom for monitoring levels of PM.

Out of all of the air pollutants, particulate matter causes the most concern with health experts because they are easy to inhale and can penetrate deep into the lungs. Sulfates, nitrates, ammonia, sodium chloride, carbon, mineral dust and water are all components of particulate matter, which refers to any mix of tiny solid and liquid particles in the air.

Specifically, PM10 (particles with aerodynamic diameters <10 μm) and PM2.5 (particles with aerodynamic diameters <2.5 μm) are considered the most dangerous particle sizes for health due to their capacity of penetrating deep into the bronchial peripheral areas and hampering air exchange.

TOBACCO SMOKE

In many countries, over 80% of children are regularly exposed to second-hand tobacco smoke in the home and even more outside the home. Although regulations from the framework convention on tobacco control have introduced spaces free from tobacco smoke--which have proved to be highly efficient in reducing its negative health impacts--they have yet to be introduced or developed in large parts of the regions. Tobacco smoke contains several types of harmful pollutants, including benzene and fine and ultra-fine particles. In adults, passive smoking can cause irritation, aggravated respiratory symptoms, and coronary heart disease. In children, it can lead to a number of illnesses ranging from middle ear infections to sudden death syndrome.

Despite clear measures outlined in the framework convention on tobacco control, the amendments have yet to be implemented on a comprehensive level, primarily regarding the campaign on maintaining tobacco-free schools and medical facilities, which is lagging behind in activities.

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MOLD

Dampness and mold are now established as major indoor air quality problems that disproportionately affect the health of disadvantaged populations. More than 20% of families live in houses where dampness and mold are evident. Molds are a form of fungus that thrive in moist and warm indoor and outdoor environments. Not only are there many different types that can grow indoors, they can also grow on a number of surfaces, including fabric, paper, wood, glass, and plastic. Common areas of mold growth range from hidden leaks in walls and roofs to build-ups in small corners of the home, which can spread to furnishings and clothing. Without proper ventilation, these humidity build-ups promote the growth of molds and bacterial microorganisms that can also lead to the release of additional pollutants into indoor air.

The majority of health effects linked to dampness and moisture in buildings are particularly concentrated in the respiratory system, including nose and throat symptoms, coughing, and wheezing. These damp environments have also been found to lead to the development of asthma in people who previously did not suffer from it, and lower respiratory symptoms such as chest tightness and shortness of breath in healthy children.

*More pollutants and polluting practices commonly found in Georgia can be found in Annex 1

Environment and Health Policy Framework and Legislation

Air pollution, from both indoor and outdoor sources, is a major environmental health concern. It can lead to serious health effects, ranging from diseases of the respiratory and central nervous systems to brain and lung cancers. Much progress has been made in Europe to improve outdoor air quality, and exposure thresholds have been set for several pollutants. Indoor air quality, however, has not been given the same amount of attention. This is especially alarming because of how much time people spend indoors. For this reason, it is important to establish which indoor air pollutants raise concern, how indoor air quality can be determined, and how indoor pollutant levels can be regulated by the EU and by national legislation in Georgia. At this stage in Georgia, as well as in the EU, laws regulating indoor air quality do not yet exist. In 2010, WHO developed and published indoor air quality guidelines that should've raised awareness about this issue in the Member states, but no normative regulations compliant to the mentioned guidelines have been established in Georgia and therefore need to be reflected in the air quality regulation acts.

Below are some of the existing national legislation and international agreements that should cover the right for clean indoor air inside public buildings, and/or can be amended to include provisions on indoor air quality regulations:

SUSTAINABLE DEVELOPMENT GOALS (SDGS)

SDGs, a set of universal benchmarks developed by the United Nations to take on urgent environmental, political, and economic challenges across the world, has one goal pertaining to air pollution [12]. As reported by WHO in 2016, the aim of Goal 3.9 is “to significantly reduce the diseases and mortality caused by hazardous chemical substances as well as air, water and soil pollution and contamination by 2030.” Progress specifically towards reducing air pollution is measured by the mortality rate attributed to household and ambient air pollution, which is calculated according to the new WHO methodology.

EU-GEORGIA ASSOCIATION AGREEMENT (AA)

The AA is part of a new generation of Association Agreements with Eastern Partnership countries whose primary goal is to activate the potential of EU-Georgian relations, focusing on supporting core reforms, on economic recovery and growth, and on government and sector cooperation [13]. Since its adoption in 2014, the national government has been spending efforts to improve the environmental health situation in Georgia. In accordance with the AA, a National Action Plan (NAP) was created to fulfill the Agreement’s corresponding commitments in the field of Air Governance. The National Action Plan facilitates the transposition of EU legal requirements in the field of air quality management and assists in fulfilling air quality-related international obligations. In order to fulfill the terms and conditions of the Association Agreement, regulatory acts and policy documents for the public health sector as well as relevant technical regulations and normative acts are being gradually developed.

GEORGIAN LEGISLATION

According to the Constitution of Georgia (Article 37. paragraphs 3.4.5), "Everyone shall have the right to live in a healthy environment, enjoy the natural and cultural surroundings [14]. Everyone shall be obliged to care for the natural and cultural environment. With the view of ensuring a safe environment, in accordance with ecological and economic interests of society, with due regard to the interests of the current and future generations, the state shall guarantee the protection of the environment and the rational use of nature. Everyone shall have the right to receive complete, objective and timely information as to the state of the environment."

The **Law of Georgia on Health Care** (Article 3, paragraph u) considers Public health care as a system of state obligations aimed to protect, maintain and restore a person's physical and mental health, prevent and control the diseases, study their prevalence, promote healthy lifestyle practices and a safe environment [15].

The **Law of Georgia on Public Health** (Article 1) aims to promote public health and healthy lifestyle practices; ensure a safe environment, promote reproductive health care and prevent the spread of noncommunicable diseases (NCDs) [16]. The law defines the rights and obligations of the population and legal entities in the public health domain. According to the Law, the Ministry of Labor, Health and Social Affairs develops quality standards, public health guidelines and technical regulations designed to ensure a safe environment.

The **Law of Georgia on Air Protection** regulates protection of ambient air from dangerous technogenic impacts in the territory of Georgia [17]. The Law defines types of harmful anthropogenic impacts on ambient air; pollution of ambient air with harmful factors; limitations of concentrations of harmful substances in ambient air; monitoring systems for ambient air and etc.

STATE PROGRAMME ON REDUCTION OF AIR POLLUTION

In 2016, the intergovernmental committee developed the State Programme on the Reduction of Air Pollution in Tbilisi. The programme covers several directions: road transport, construction, greening the city, improving the AQ Monitoring system, assessing the health effects of air pollution and raising public awareness around the issue. Assessing the health impacts of ambient and indoor air pollution on children's health is one of the long-term objectives of the National Environmental Health Action Plan (NEHAP 2) of Georgia, whose development is led by the NCDC, Ministry of Labour, Health and Social Affairs of Georgia in collaboration with the Ministry of Environment and Natural Resources Protection of Georgia with technical assistance of the WHO European Centre for Environment and Health Bonn office.

FIGURE 2. THE TIMELINE OF STRATEGIC OBJECTIVES FROM THE NEHAP 2.

Some additional objectives of this extensive plan that are directly tied to reducing children's exposure to ambient and indoor pollution include preventing their exposure to hazardous chemical substances, equipping schools and kindergartens with access to adequate facilities for physical activity, and improving the sanitation and hygiene (WASH) conditions in schools and kindergartens.

WHO AND EU GUIDELINE LIMITS

The European Union has developed an extensive body of legislation which establishes standards and objectives for a number of air pollutants. These air quality directives (2008/50/EC Directive on Ambient Air Quality and Cleaner Air for Europe and 2004/107/EC Directive on heavy metals and polycyclic aromatic hydrocarbons in ambient air [19,20]) set pollutant concentration thresholds that shall not be exceeded in a given period of time. In case of excesses, authorities must develop and implement air quality management plans. These plans should aim to bring concentrations of air pollutants to levels below the limit and target values.

The WHO guideline values are set for the protection of health, and are therefore generally stricter than the comparable, politically-agreed EU standards [21]. They address three groups of issues that are most relevant for public health:

- biological indoor air pollutants (dampness and mold)
- pollutant-specific guidelines (chemical pollution), and
- **pollutants from indoor combustion of fuels,**

of which the last is the central focus of this study. These guidelines are important as they provide a tool of reference for policymakers who are responsible for setting standards on air pollutants that pose a threat to our health. The guidelines below set the boundaries as to what is considered a "safe" level of exposure to particulate matter (PM) levels of 2.5 micrograms per cubic meter (µg/m3) [18].

WHO GUIDELINES LIMIT
for PM2.5

10 µg/m3
annual mean

25* µg/m3
24-hour mean

deze getallen zijn misschien niet voor iedereen duidelijk dat dit jullie metingen zijn. Misschien even een sterretje + verklaring er bij zetten

EU AIR QUALITY DIRECTIVE
for PM2.5

25 µg/m3
annual mean

* 99th percentile - 3 days/year

The Clean Air for Children Project

With little known about the indoor environments of public buildings in Georgia, WECF Georgia implemented the Clean Air for Children project to address and assess indoor air pollution in kindergartens within the regions of Imereti, Mtskheta-Mtianeti, and Samtskhe-Javakheti in collaboration with the NCDC. An estimated 1,000 kindergartens in Georgia use firewood in inefficient stoves to meet their heating needs during the cold season (4-6 months out of the year, depending on the region). This inevitably results in air pollution with small particles, and possibly other pollutants like CO and NO2, which impairs the healthy development of children. Additionally, poor ventilation remains widespread and results in high CO2 concentrations in classrooms.

The central goal of this initiative was to launch a formal investigation into the indoor air qualities, management, and practices of public kindergartens and share the results with policy makers and the public. Before kindergartens were closed due to the COVID-19 pandemic in early March, 2020, the project team was able to collect varying indoor air pollution and air quality management information from a number of kindergartens selected for the study.

Why Kindergartens?

Young children are more vulnerable than adults to air pollution, especially with exposure to particulate matter; even at low levels, air pollutants may disrupt the development of their lungs, cause coughing, bronchitis and other respiratory diseases, and worsen asthma symptoms.

Kindergarten children are vulnerable to harmful indoor air quality due to their long exposure time: nearly all students are in class eight hours a day, five days a week. They are especially more susceptible to airborne pollutants than adults not only because of their narrower airways, but also because they breathe more air per kilogram of body weight on average. The exposure of children to air pollution can result in several short and long-term health problems, including reduced lung function that persists through adulthood and an increased vulnerability to respiratory and cardiovascular diseases [22]. Although WHO publishes data on premature death due to indoor air pollution, no data is available on morbidity, or the level of pollution in households, schools or kindergartens.

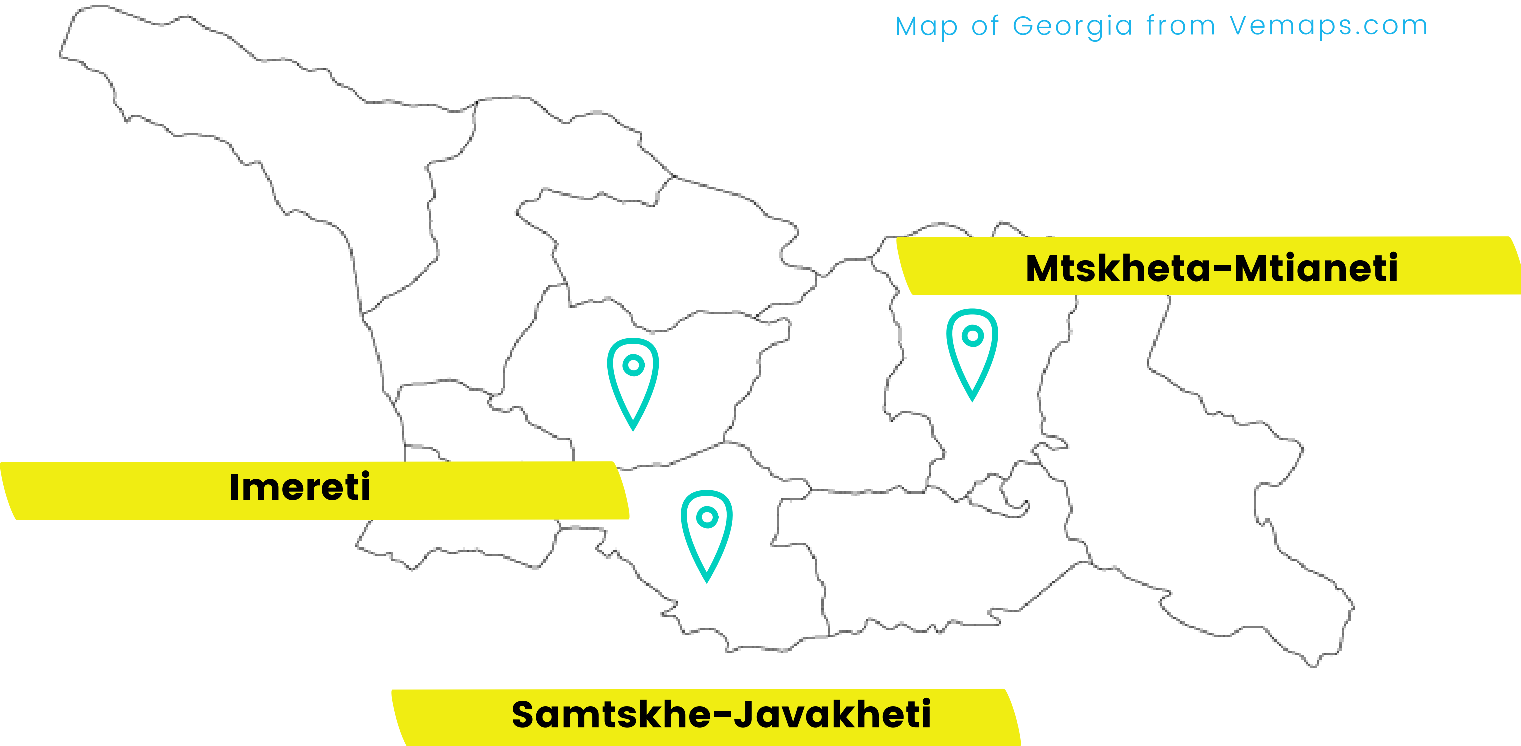
Study Approach and Methodology

A comprehensive survey of both air management practices and air quality data in kindergartens was taken among the regions of Imereti, Mtskheta-Mtianeti, and Samtskhe-Javakheti, and within the municipalities of Adigeni, Akhaltsikhe, Aspindza, Dusheti, Khoni, Mtskheta, Terjola, Tianeti, and Zestafoni, using a cross-sectional observational study design. The findings are presented in this report, accessible to all stakeholders on both WECF Georgia and NCDC official websites.

These regional kindergartens were selected according to the following criteria in order to get a diverse sample for the study*:

- Amount of pupils attending the kindergarten
- Type of ventilation system: natural ventilation process (no artificial ventilation process present in classrooms, but rather solely through the opening of windows) and those with mechanical ventilation systems
- Primary sources of heating and cooking activities (e.g. wood-burning stoves, natural gas, central heating from firewood, etc.)
- Kindergartens located in both urban and rural settings
- Kindergartens at different elevation levels, taking into account the geography of the surrounding area varied (kindergartens located in both high, mountainous regions and in lowlands)

*More information about the kindergarten selection process can be found in Annex 2



Particulate matter levels were measured between 9-20 school days in 10 participating kindergartens at a time (3-4 kindergartens per region). After the first round was completed, another monitoring cycle in the next set of 10 kindergartens would begin. This repeated until 20 schools were monitored for the allotted period of time. The aim was to continue monitoring until 60 kindergartens were monitored, but due to COVID-19, kindergartens were closed between February 28th and March 2nd, and this stage of the project was delayed indefinitely.

Partner organizations, however, were able to administer and collect questionnaires from 59 out of the 60 pre-selected kindergartens to assess their conditions and factors that might influence indoor air quality.

Questionnaires were carried out by partner organizations across the regions of Imereti, Mtskheta-Mtianeti, and Samtskhe-Javakheti. While many were administered in person, a large number had to be conducted over the phone due to COVID-19-related obstructions.

Study Results

of Kindergarten Questionnaires

The results of this project include a customized questionnaire used to assess kindergarten conditions and factors that might influence indoor air quality. 59 kindergartens participated in answering these questionnaires. The data has been entered in statistical software SPSS and the analysis was done by an epidemiologist from the NCDC.

RESEARCH MATERIALS AND METHODS

The analysis included the following characteristics:

- General information about kindergartens (number of children, number of teachers, working hours, heating/cooking source, etc.)
- Indoor air practices (frequency of ventilation, temperature in the classroom, etc.)
- Cleaning practices (frequency of cleaning, cleaning methods and substances used for it, etc.)
- Ventilation practices (type of ventilation, level of knowledge about air quality and symptoms of poor air quality, etc.)
- Level of awareness related to the sources of indoor air pollution (level of street activity near kindergartens, density of the vegetation, kindergarten's waste removal practices, etc.)
- Level of knowledge how poor indoor air quality can impact healthQuestionnaires were conducted by the project partners after they had been trained by WECF Georgia and the NCDC. Questions were partly open-ended, and the interviewers encouraged the respondents to provide as much information as possible. All respondents were kindergarten directors.

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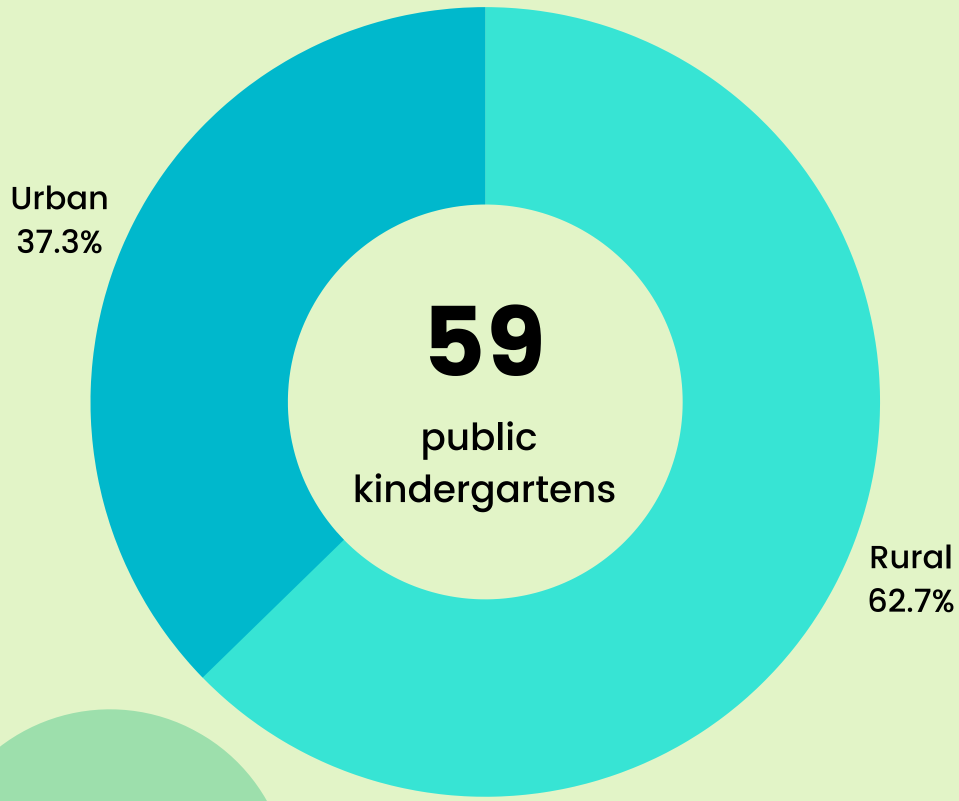
Questionnaire Results

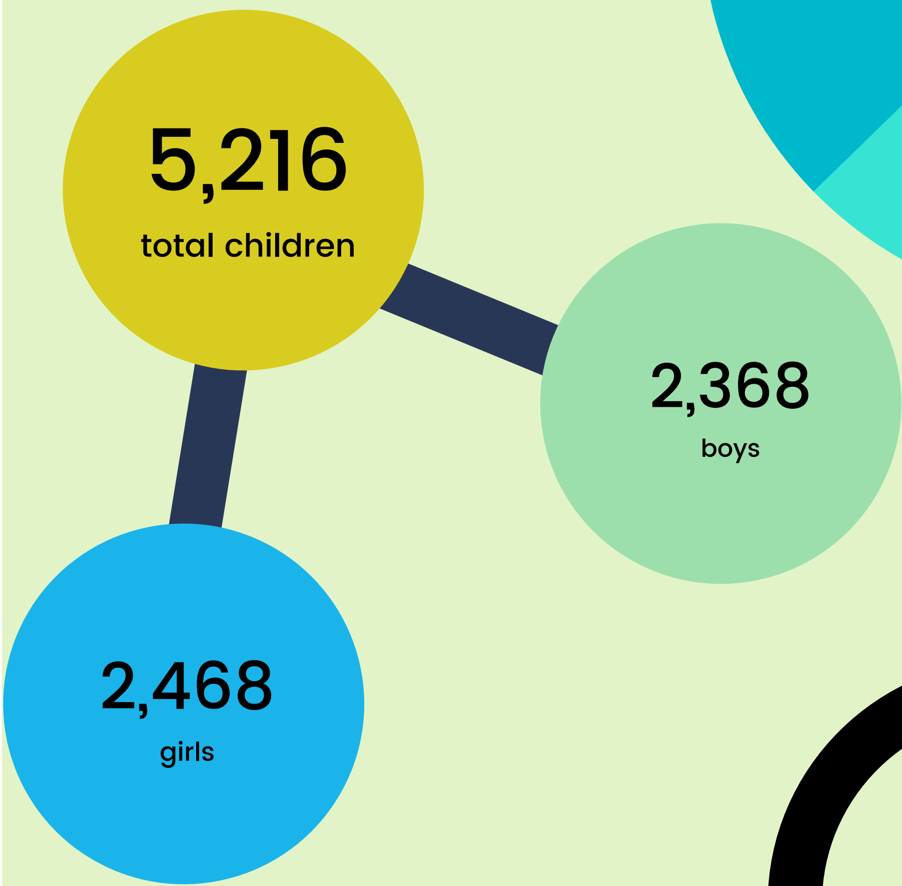
The following sections present the central findings of the kindergarten questionnaires, which are divided into six topics: general information about the participating kindergartens, their indoor air practices, cleaning practices, ventilation methods, kindergartens' knowledge about the impact indoor air pollution has on health, and their level of awareness related to sources of indoor air pollution.

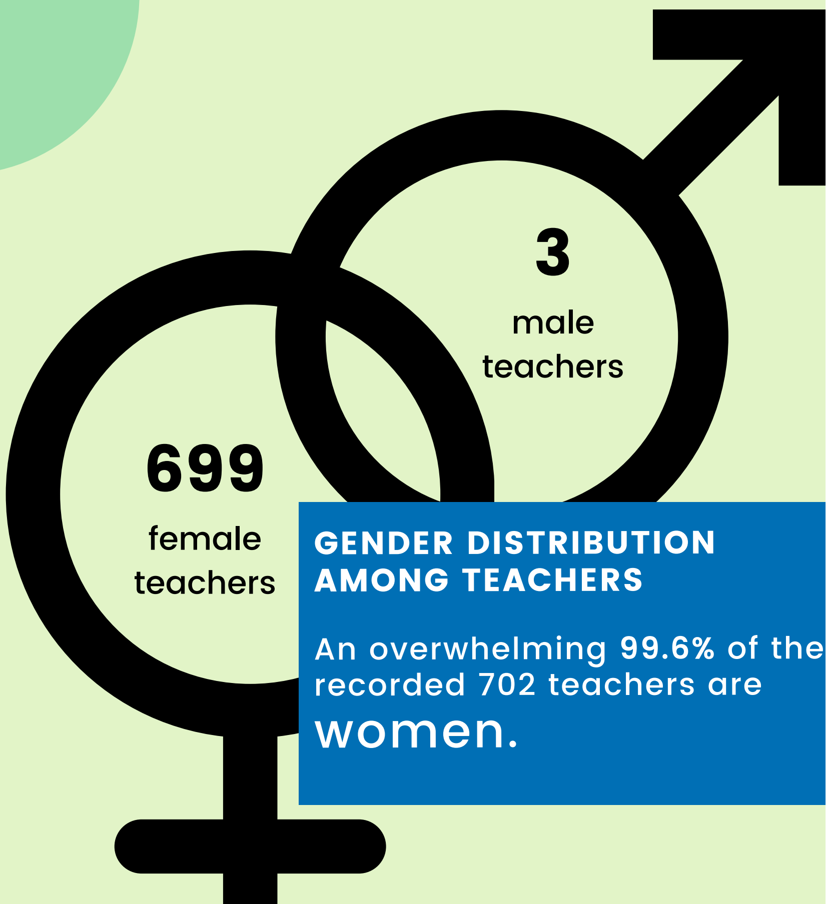
01 GENERAL INFORMATION ABOUT KINDERGARTENS

All kindergartens (total of 59) are public and none of them are private.

37 of the kindergartens are in rural areas and only 22 of them are in urban areas.







GENDER DISTRIBUTION AMONG TEACHERS

An overwhelming **99.6%** of the recorded 702 teachers are **women.**

KINDERGARTEN HOURS

The majority (78%) of kindergartens are working for 8 hours during the school week.

In each kindergarten, a designated classroom was selected for monitoring particulate matter levels. The maximum classroom size is 70 meters and the minimum is 28 meters. The average size is 48.48 meters. The size of the selected classroom is almost equally distributed in rural and urban areas.

The number of children in these selected classrooms is almost equally distributed among rural and urban settings:

27

average number of children per designated classroom

maximum:
52 children

minimum:
15 children

The main heating source in over half of the kindergartens is wood (52%). The distribution of heating sources differs greatly between urban and rural areas: while 54.5% of kindergartens in urban areas are already using gas for heating, nearly 65% of the kindergartens in rural areas still rely on wood.

While the majority of kindergartens are using wood for heating, the vast majority (86%) are using gas for cooking in both urban and rural areas.

02 INDOOR AIR PRACTICES

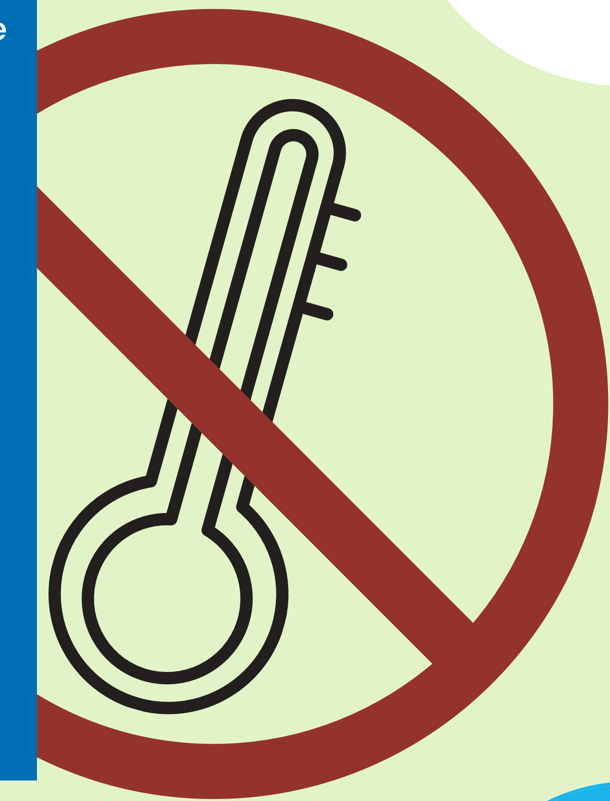
INDOOR TEMPERATURES

Only 30% of the respondents could answer the question of what the standard temperature in the classroom should be during play or nap time. Of those respondents, only 33% mentioned a temperature below 24 degrees during playtime.

57% provided an answer to what the actual temperature is during playtime and nap time. 63% of these kindergartens indicated temperatures 24 degrees or higher.

88%

of kindergartens do not use a thermometer to measure indoor temperature



While stoves are not used for cooking purposes in most of the kindergartens (69.5%), they **are** used for heating in 67.8% of them. In urban areas, however, there is a more even split between kindergartens, with 45.5% of them using stoves as a heating source, and 54.5% not. In rural areas, the divide is much more drastic, with only a mere 18.9% of them not relying on stoves as a source of heating.

81.8%

30 of the 37 surveyed kindergartens from rural areas use stoves as a source for heating.

Out of the kindergartens that use stoves for either cooking or heating purposes, 54.2% are burning firewood, and 25.4% are burning natural gas.

19
m3

The average amount of firewood used/burned during the heating season, from the 8 kindergartens that responded. Within this group, the maximum amount used is 35 cubic meters and the minimum is 8 cubic meters.

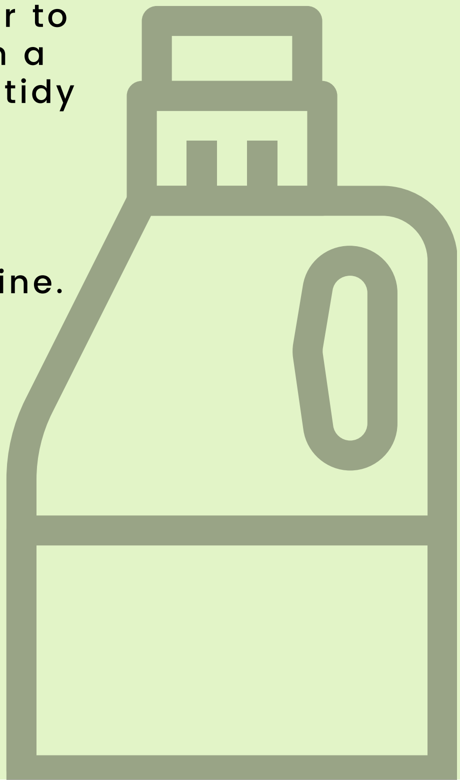
3487
m3

The average amount of natural gas used/burned during the heating season, from the 7 kindergartens that responded. Between urban and rural settings, there is a large disparity: the average usage in urban areas is 4659.5 cubic meters, while in rural areas it is only 1923.3 cubic meters.

CLEANING PRACTICES 03

The frequency of cleaning in all kindergartens is done on a daily basis. Half of them (50.8%) use a vacuum cleaner to clean, followed by cleaning all horizontal surfaces with a wet towel. The other half (40.7%) just uses a broom to tidy up.

The most frequently used cleaning detergents and chemical substances for classrooms include: special disinfectants, Domestos, Dezotec, Septokvat and Chlorine. The most frequently used cleaning detergents and chemical substances for bathrooms are Chlorine, Domestos, and Niposevt.



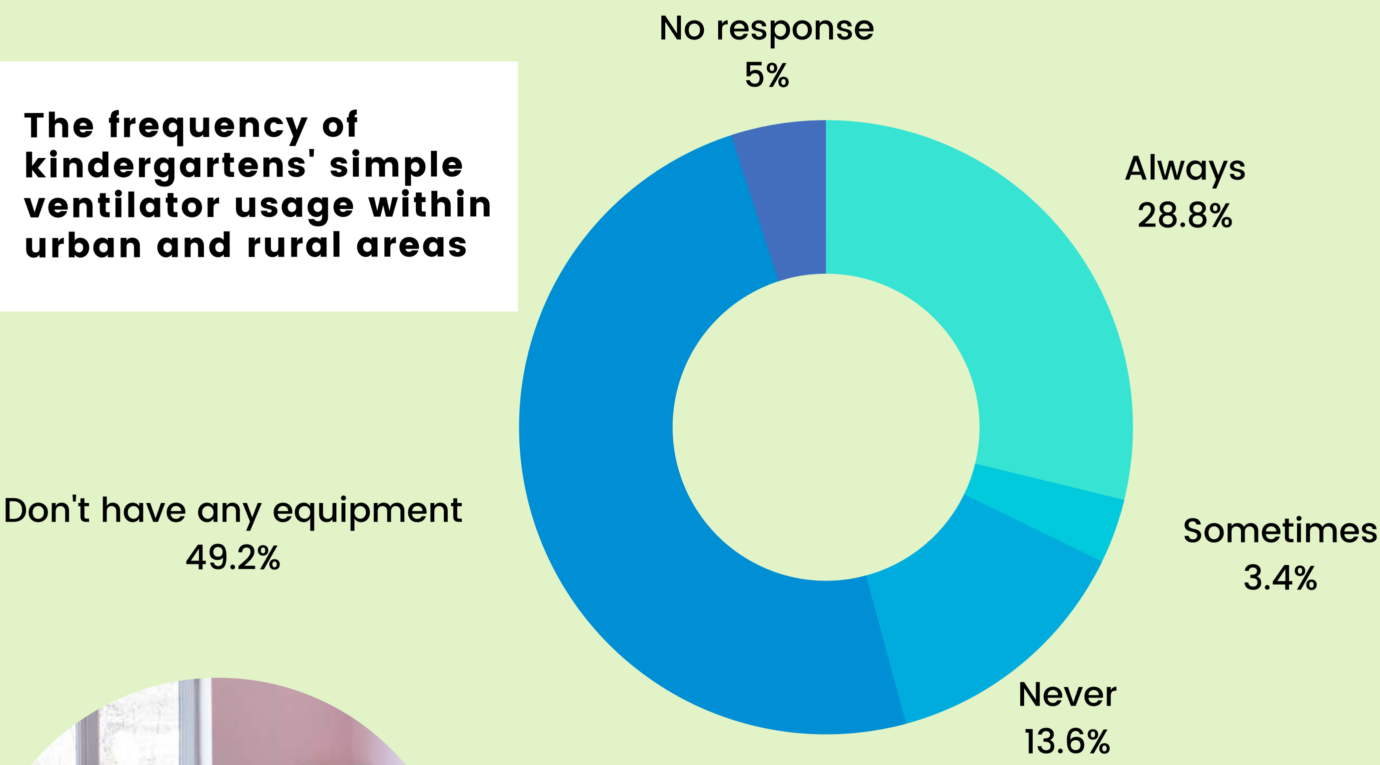
04 VENTILATION

VENTILATION SYSTEMS

A majority (54.2%) of the kindergartens do not have a ventilation system to remove indoor smoke or steam, but the rest of them, a total 27 kindergartens, have different types of systems, including kitchen and bathroom ventilation, built-in wall ventilation, direct ventilation, and others.

Almost half of the kindergartens (49.2%) do not have a simple ventilator to remove smoke and steam during cooking. Most of these kindergartens are located in rural areas.

The frequency of kindergartens' simple ventilator usage within urban and rural areas



Nearly 95% of kindergartens have metaloplast double-glazed windows

and only one in a rural area has single-glazed wooden windows.

NATURAL VENTILATION

61% of kindergartens open their windows hourly for ventilation during the heating season, while 39% do not. 62.7% of kindergartens open their windows in the morning before class and 47.5% after class additionally/only.

The distribution is slightly different during the non-heating season: 76.3% tend to open their windows hourly, 18.6% twice a day, and 5.1% on a daily basis.

3

the amount of kindergartens that say poor air quality bothers them during the typical workday, which is due to it being “too warm” indoors.

CHIMNEY CONDITIONS

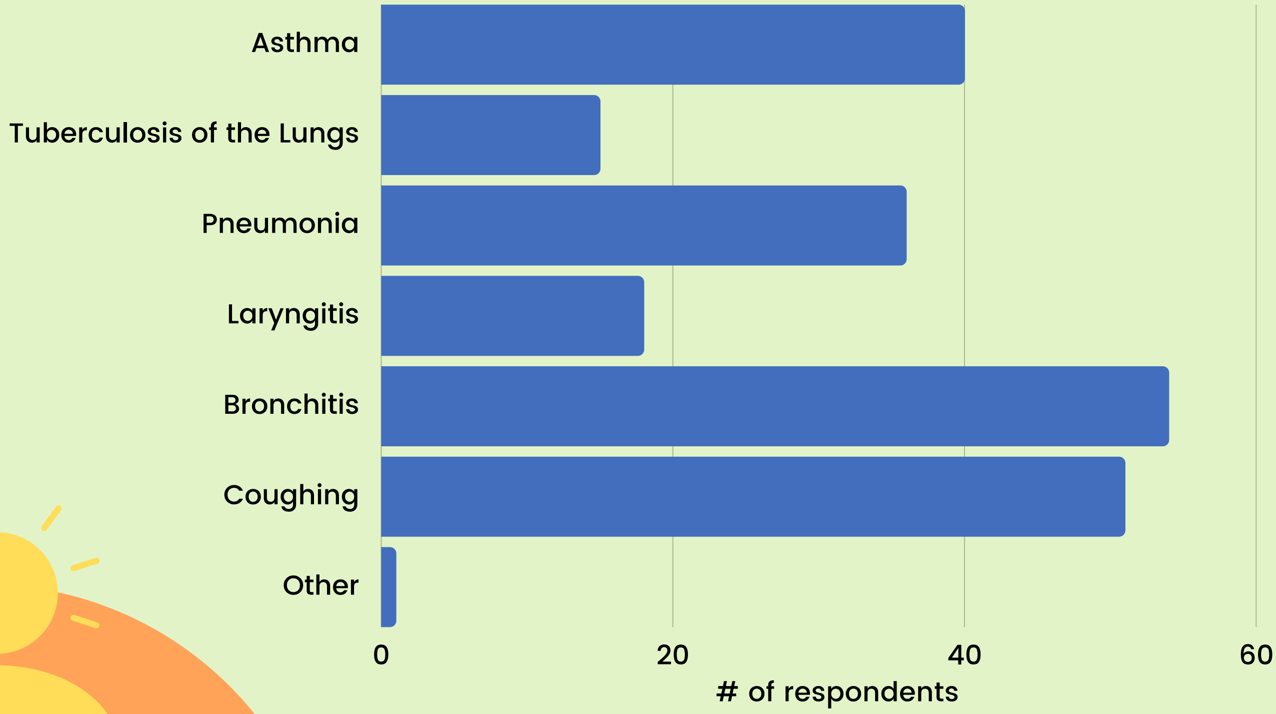
42.4% of kindergartens indicate that windy weather affects the ventilation capacity of the stove by allowing smoke to re-enter the room throughout the day. 25% of kindergartens are not familiar with their chimney working conditions at all.

05 KNOWLEDGE OF POOR INDOOR AIR QUALITY’S IMPACT ON HEALTH

Knowledge and awareness about common respiratory diseases among children are almost equally distributed between rural and urban kindergartens.

94.9% marked that they are familiar with them in general, with Bronchitis and Coughing being the most known respiratory diseases among respondants (as shown on the next page).

The distribution of knowledge on common respiratory diseases

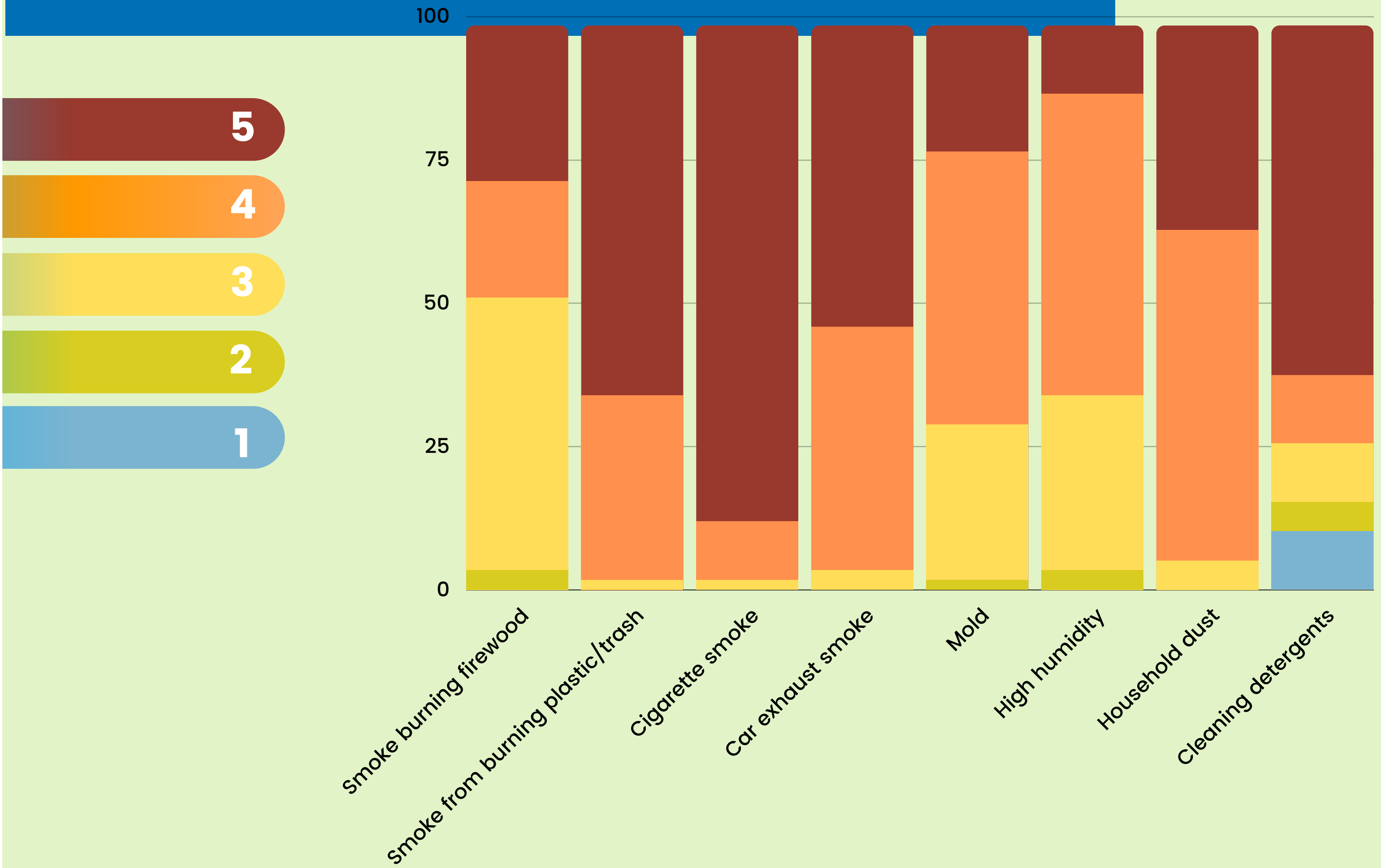


93.2% of kindergartens are aware that air pollution can cause respiratory diseases among children, which they mainly learn from TV and radio programs (93.2%) and from health workers (89.8%).

The leading mechanism kindergartens use to prevent a child from getting a cold during the heating season is hand-washing promotion (93.2%). Some also ask parents to get their children immunized (22%). Only 9% of kindergartens conduct their own health examinations. One kindergarten indicated that they advise parents to keep their child at home if they are showing symptoms of illness.

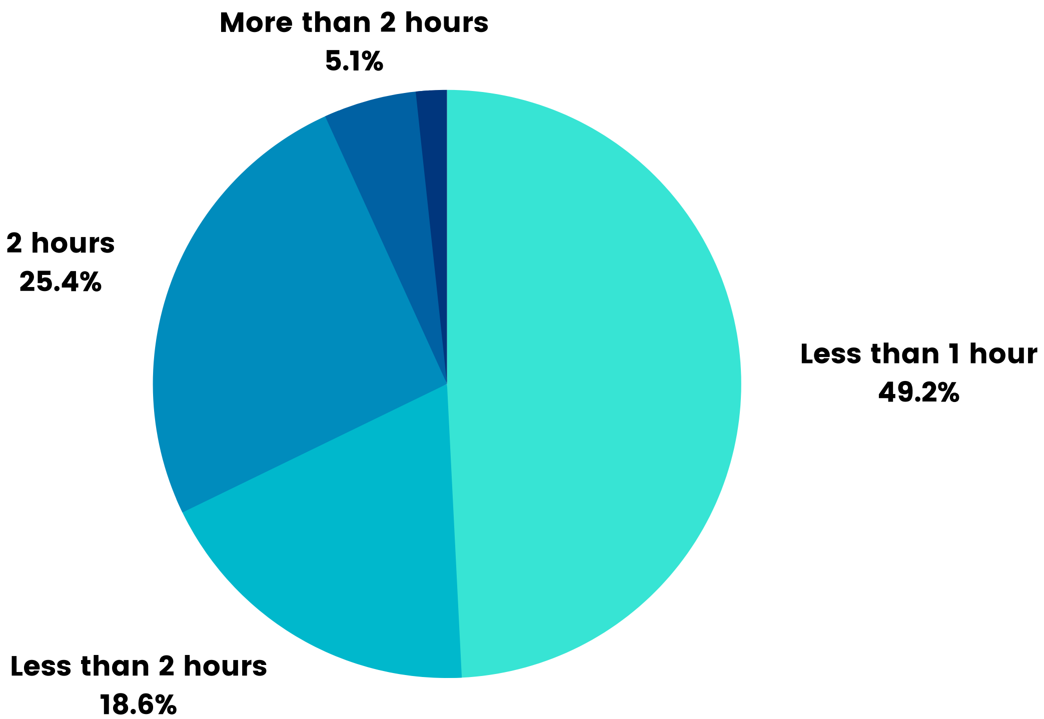
The impact of common sources of indoor air pollution on respiratory health is rated on a scale of 1 (not harmful to one's health) to 5 (very harmful to one's health). A majority of kindergartens give a 5-mark rating to cigarette smoking (86.4%) and to smoke from burning trash and plastics (64.4%), while many identify smoke from wood-burning fires, mold, and high humidity as being "less harmful."

THE IMPACT DISTRIBUTION ON RESPIRATORY HEALTH



Less than half (40.7%) of kindergartens take children outside during the heating season on a daily basis, and over a third of them (35.6%) only during warm and sunny days.

The duration of outside walking/play in most of the kindergartens (49.2%) is less than 1 hour a day. Responses slightly different among urban and rural areas



06 LEVEL OF AWARENESS RELATED TO THE SOURCES OF INDOOR AIR POLLUTION

KINDERGARTENS' OUTDOOR SPACES

Among 59 kindergartens, 55.9% are located near a “middle” amount of street activity. Only 4% are near very busy streets. The average distance to the nearest major road is 177 meters, while the minimum is 10 meters and maximum 350 meters.

The distribution of dominant vegetation is equally distributed among urban and rural areas, with the leading vegetation being mainly native species (94.9%). The density of existing vegetation varies from medium (49.2%) to sparse (42.4%), which slightly differs in urban and rural areas.

WASTE DISPOSAL OF FOLIAGE AND TRASH

A majority of kindergartens (64.4%) put any fallen leaves from trees and other organic materials from the yard in municipal waste containers. Only 22% seem to dump them elsewhere.

There is a slight difference regarding kindergarten waste disposal (e.g. of paper, food scraps, plastic, etc.) of which 98.3% of kindergartens put their trash in municipal containers.

98.3%

of children's bathrooms are inside the central kindergarten building (one did not respond)

Waste is openly burned near 29% of the kindergartens

Study Results

of Sensor Data in Kindergartens

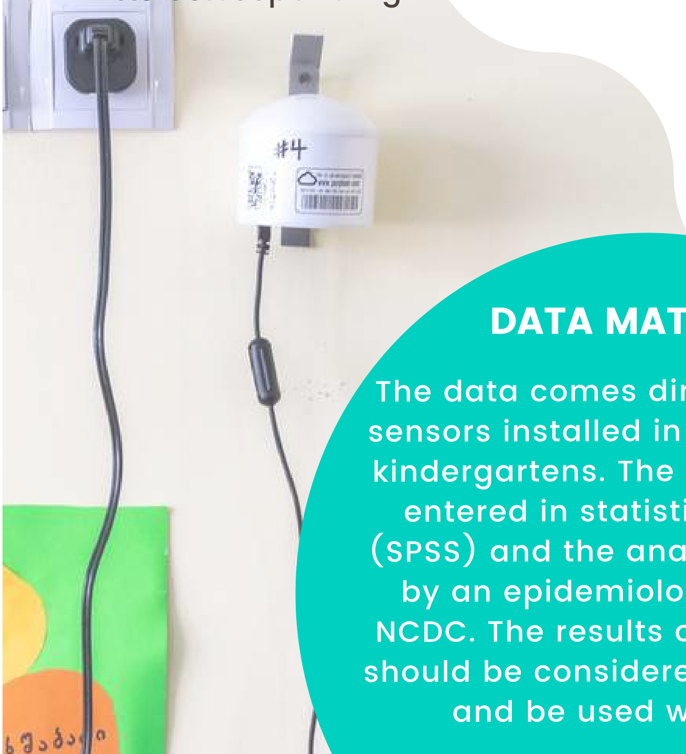
Within this project, PurpleAir sensors measured airborne particulate matter (PM) in a diverse set of 20 kindergartens. The kindergartens were selected according to criteria listed in the Study Approach and Methodology section.

RESEARCH MATERIALS AND METHODS

The analysis included the following characteristics, which are calculated according to US EPA standards of the Air Quality Index (AQI):

1) **pm2.5_aqi_cf_1** (CF is meant to be used for indoor or controlled environment applications.)

These monitoring sensors produced daily data of PM2.5 concentrations. The information derived from the data includes: daily 8-10 hours averages calculated for each kindergarten during 9-20 school days of monitoring (weekends were not included). These 8-10 hour periods took place during the standard kindergarten work day, which is typically between 09:00 AM and 6 PM, but can open as early as 8:00 AM. These daily averages were compared to the AQI, which is a tool used to report air quality. With a range between 0 and 500, the index divides measured levels of air pollutants into six categories, each of which corresponds to a different level of health concern. In this section, each daily average of measured PM2.5 levels are marked by its corresponding color level for each kindergarten.



DATA MATERIALS

The data comes directly from the sensors installed in each of the 20 kindergartens. The data has been entered in statistical software (SPSS) and the analysis was done by an epidemiologist from the NCDC. The results of this analysis should be considered approximate and be used with care.

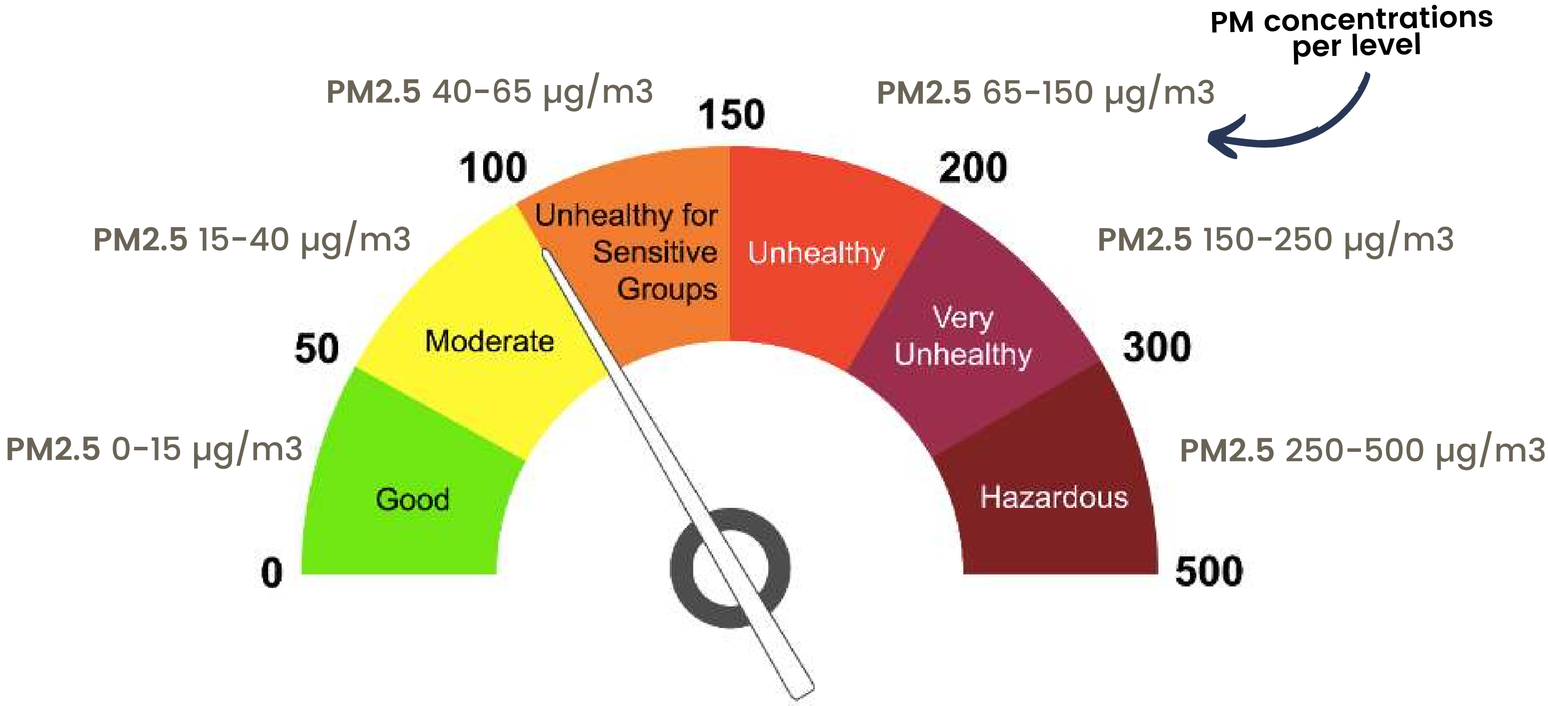
ABOUT THE SENSORS

The PurpleAir sensors (model PA-II-SD) use laser particle counters to count the number of particles by particle sizes 0.3, 0.5, 1, 2.5, 5, and 10 µm, and use the count data to calculate mass concentrations of PM1.0, PM2.5, and PM10 in approximate two-minute intervals. The sensors also measure temperature, dew-point, and humidity, though these are relative to each sensor's exposure to external factors. For the sake of the study, we concentrate on PM 2.5, as it can severely affect health at any age, in both the short and long-term.

Sensor Data Results

The following section presents the average daily indoor air quality index levels of PM2.5 across 20 kindergartens that participated in the study.

THE AIR QUALITY INDEX (AQI)



This index categorizes levels of air pollutants into six categories. An AQI value of 50 or under represents good air quality, but when values are above 100, the indoor environment begins to become unhealthy for sensitive groups, and eventually for everyone as values grow. This particular index is specific to particulate matter.

The following table includes all of the monitoring days and their air quality index averages among all 20 of the public kindergartens. They are in order of highest to lowest daily average levels of PM2.5 pollution.

TABLE 1. DAILY AVERAGE AQI VALUES OF ALL 20 PARTICIPATING KINDERGARTENS

kindergarten names

Gordi	23-Jan	24-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb	10-Feb	11-Feb	12-Feb			
Average PM2.5 AQI Value	761.17	524.78	583.89	598.77	616.21	394.56	396.74	507.79	797.94	565	281.76	250.49	382.58	550.22	622.05			
Akhaltsikhe N.2	16-Jan	17-Jan	20-Jan	21-Jan	22-Jan	23-Jan	24-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb	10-Feb
Average PM2.5 AQI Value	217.97	228.11	335.53	326.6	302.34	309.4	291.87	287.6	320.2	333.93	332.14	276.21	326.12	265.79	250.72	512.48	213.21	267.56
Ude	27-Nov	28-Nov	29-Nov	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec
Average PM2.5 AQI Value	253.69	209.85	191.1	182.37	176.82	148.26	163.2	148.27	307.01	159.2	215.85	171.68	240.18	303.54	287.7	284.41	277.04	301.7
Varkhani	21-Jan	22-Jan	23-Jan	24-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb				
Average PM2.5 AQI Value	180.38	153.52	141.25	no data	203.05	225.87	185.73	173.96	151.85	149.94	133.57	145.12	206.71	122.35				
Akhaltsikhe N.4	12-Feb	13-Feb	14-Feb	17-Feb	18-Feb	19-Feb	20-Feb	21-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb					
Average PM2.5 AQI Value	157.75	140.47	212.56	221.25	153.12	198.96	151.08	162.61	147.79	166.81	96.13	131.85	166.99					
Kukhi	28-Nov	29-Nov	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec	
Average PM2.5 AQI Value	170.43	97.67	206.49	157.88	154.84	108.5	118.61	179.51	162.27	173.69	102.09	175.9	273	151.28	151.58	172.77	164.2	
Zarzma	28-Nov	29-Nov	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec	
Average PM2.5 AQI Value	105.6	103.4	74.8	79.6	143.9	121.4	121.4	182.3	81.5	173.1	189.5	122.5	106	143	221.3	250.4	294.6	
Khoni N.1	28-Nov	29-Nov	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec	
Average PM2.5 AQI Value	161.12	158.79	119.07	114.89	102.99	138.45	123.38	161.12	95.14	129.39	198.85	143.53	144.81	131.79	80.93	94.36	101.51	
Matkhoji	23-Jan	24-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb	10-Feb	11-Feb	12-Feb	13-Feb		
Average PM2.5 AQI Value	131	59	143	113	120	118	74	161	62	275	325	31	78	54	97	103		
Kutiri	23-Jan	24-Jan	27-Jan	28-Jan	29-Jan	30-Jan	31-Jan	3-Feb	4-Feb	5-Feb	6-Feb	7-Feb	10-Feb	11-Feb	12-Feb	13-Feb		
Average PM2.5 AQI Value	118.57	163.79	73.09	88.31	179.24	76.92	25.56	84.87	206.37	59.07	134.96	33.94	98.1	73.45	70.59	87.98		

monitoring dates

air quality index values and corresponding colors

Tianeti N.1	26-Nov	27-Nov	28-Nov	29-Nov	3-Dec	4-Dec	5-Dec	6-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec	27-Jan	28-Jan	29-Jan
Average PM2.5 AQI Value	114	156	115	93	40	28	51	81	56	113	130	117	113	79	86	113	59	73	98	158	140

Tushurebi	26-Nov	27-Nov	28-Nov	29-Nov	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	17-Dec	18-Dec	19-Dec	27-Jan	28-Jan
Average PM2.5 AQI Value	62.37	81.41	106.74	74.56	64.43	78.37	92.99	83.78	75.79	63.82	112.4	76.3	55.75	105.12

Zestafoni N.1	18-Feb	19-Feb	20-Feb	21-Feb	24-Feb	26-Feb	27-Feb	28-Feb
Average PM2.5 AQI Value	57.26	97.31	95.43	113.65	48.84	31.65	47.01	81.69

Khoni N.3	28-Nov	29-Nov	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec
Average PM2.5 AQI Value	146.3	58.9	39.5	62.9	54.3	37	41	111.9	84.6	81.3	51.3	64.3	64.6	46.3	64.6	80.9	87.1

Simoniantkhevi	26-Nov	4-Dec	5-Dec	6-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	17-Dec	18-Dec	19-Dec	20-Dec
Average PM2.5 AQI Value	64.1	44.86	34.76	60.65	53.64	88.61	88.51	100.96	102.29	67.82	47.47	101.03	52.54	38.58

Adigeni Town	28-Nov	29-Nov	2-Dec	3-Dec	4-Dec	5-Dec	6-Dec	9-Dec	10-Dec	11-Dec	12-Dec	13-Dec	16-Dec	18-Dec	19-Dec	20-Dec
Average PM2.5 AQI Value	99.24	69.3	19.28	28.36	53.8	36.29	57.1	142.76	58.05	58.82	66.49	72.13	109.5	97.3	44.94	31.63

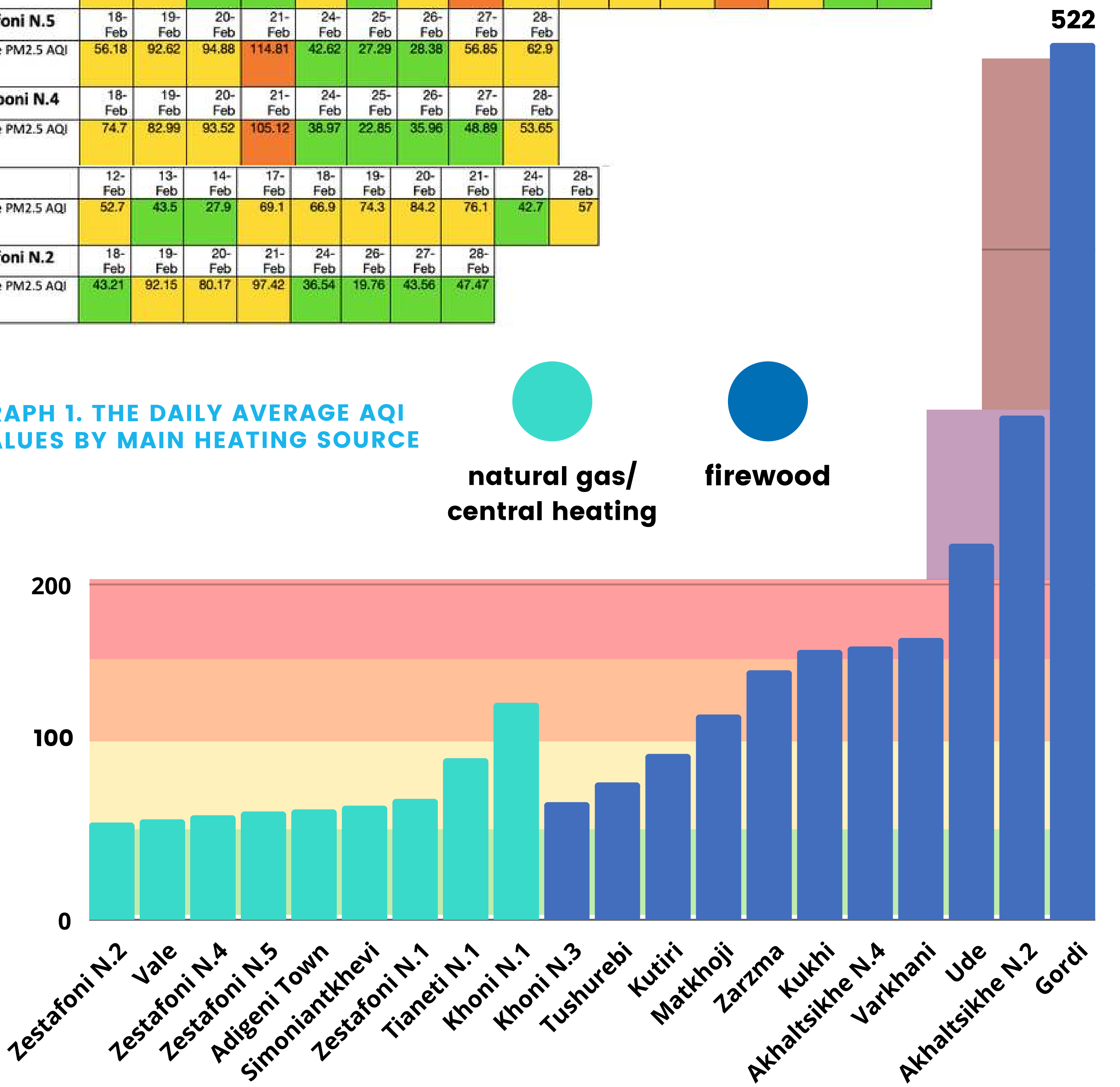
Zestafoni N.5	18-Feb	19-Feb	20-Feb	21-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Average PM2.5 AQI Value	56.18	92.62	94.88	114.81	42.62	27.29	28.38	56.85	62.9

Zestaponi N.4	18-Feb	19-Feb	20-Feb	21-Feb	24-Feb	25-Feb	26-Feb	27-Feb	28-Feb
Average PM2.5 AQI Value	74.7	82.99	93.52	105.12	38.97	22.85	35.96	48.89	53.65

Vale	12-Feb	13-Feb	14-Feb	17-Feb	18-Feb	19-Feb	20-Feb	21-Feb	24-Feb	28-Feb
Average PM2.5 AQI Value	52.7	43.5	27.9	69.1	66.9	74.3	84.2	76.1	42.7	57

Zestafoni N.2	18-Feb	19-Feb	20-Feb	21-Feb	24-Feb	26-Feb	27-Feb	28-Feb
Average PM2.5 AQI Value	43.21	92.15	80.17	97.42	36.54	19.76	43.56	47.47

GRAPH 1. THE DAILY AVERAGE AQI VALUES BY MAIN HEATING SOURCE



Central Findings and Discussion

of Kindergarten Questionnaires and Sensor Data in Kindergartens

HEATING WITH FIREWOOD

The average PM levels in the majority of kindergartens heating with a wood stove (6 out of 11) are unhealthy; in nine of them, there was at least one or more days that the air quality was very unhealthy or dangerous. Only three out of the 11 kindergartens had a moderate air quality on average, with several days at unhealthy levels. On average, kindergartens using firewood stoves for heating had 2.4 times higher PM levels than those using gas or central heating. Further research and deeper analysis is needed to explain the vast differences between the kindergartens.

The quality and efficiency of the stove, the maintenance of the chimney and the humidity level of wood are expected to highly influence PM levels. The scope of their effects needs to be researched in a larger amount of kindergartens.

Khoni N.3 kindergarten had a very low PM level during most days. It is possible to suspect that they did not use the stove on those days since outdoor temperatures were high and the recorded sensor temperatures were constant, showing no peaks in the morning. Further investigations and monitoring are needed to find out what the reason is for the extremely high levels in Gordi kindergarten, and to a lesser extent in Akhaltsikhe N.2 and Ude kindergartens.

Before such further research, however, immediate action is needed to mitigate and prevent the severe effects these high exposure times and levels impose on children's health.

HEATING WITH NATURAL GAS/CENTRAL HEATING

In general, kindergartens using gas for heating or central heating have much lower PM levels than those using firewood. However, some of them still suffer from PM levels that are unhealthy for sensitive groups and experience days unhealthy for the general public as well. Further research is needed to explain these differences. In these kindergartens, ventilation and cleaning practices are expected to be crucial factors for improving air quality. In areas with heavy traffic or with outside burning of waste, the outdoor air quality can negatively affect the indoor air quality of kindergartens.

It is obvious that there is a strong demand--and many possibilities--for improvement among kindergarten directors and staff. Some measures take investment in hardware, but in many cases, the air quality can be improved by changing practices which require minimal to no resources. All recommendations will be discussed in the next chapter.

VENTILATION PRACTICES

Generally, ventilation has almost always a positive influence on the indoor air quality. With all but one kindergarten using double glass plastic windows, there is a reduced air exchange with the outside and an increased need for artificial ventilation or frequent opening of outside windows. 87% of the kindergartens using firewood indicate that they open the windows hourly, while only 30% of kindergartens using gas or central heating adhere to this practice.

Our limited data did not show any evidence of this practice influencing the PM levels. We also could not detect any effect of this practices in the graphs showing the changes during the day, except in some cases using gas a general decrease in PM during the learning hours. In most kindergartens however no effect was observed and PM levels were elevated during the day. Better analysis of the existing data, more data and a logbook containing weather data and ventilation practices are needed to assess this.

DAY-TO-DAY POLLUTION LEVELS

The air pollution levels vary widely among and within kindergartens, especially among the more polluted ones, which can be seen in the graphs below. Even within three of the five least polluted kindergartens, the PM pollution on some days reaches levels that can be dangerous for groups that are sensitive to air pollution, which includes children, people with pre-existing health conditions, and older adults. Gordi and Akhaltsikhe N.2 kindergartens stand out as having particularly high and hazardous levels of pollution almost every day throughout their monitoring periods, and Ude kindergarten shows slightly lower, yet extremely unhealthy levels of pollution as well. Almost all of the other kindergartens have a mix of various levels of poor air quality, with a few days here and there of low or "safe" levels of PM pollution.

Further research is needed to determine the causes of these variations between the days. A possible explanation can be the weather outside: a majority of kindergartens indicated that wind effects the efficiency of their chimneys, as wind is blown into the room during days of heavy wind. The graphs suggest a correlation between the PM levels recorded in Adigeni and Ude, which are located in the same region, supporting the argument that the weather is influencing the PM levels.

DISCUSSION ON AWARENESS AND PRACTICES

There is low awareness about the **health effects** of wood smoke among the selected kindergarten group, with 50% of the respondents considering it to be less harmful than other sources of pollution. High humidity, which can lead to mold growth, is also seen as slightly less harmful than others. In highly-polluted kindergartens, none of the respondents indicated that the air quality bothered them during the school day. Additionally, almost all respondents are aware that air pollution can be linked to certain respiratory diseases, but specific relevant diseases are mentioned by only 50% or less of the respondents (see page 30).

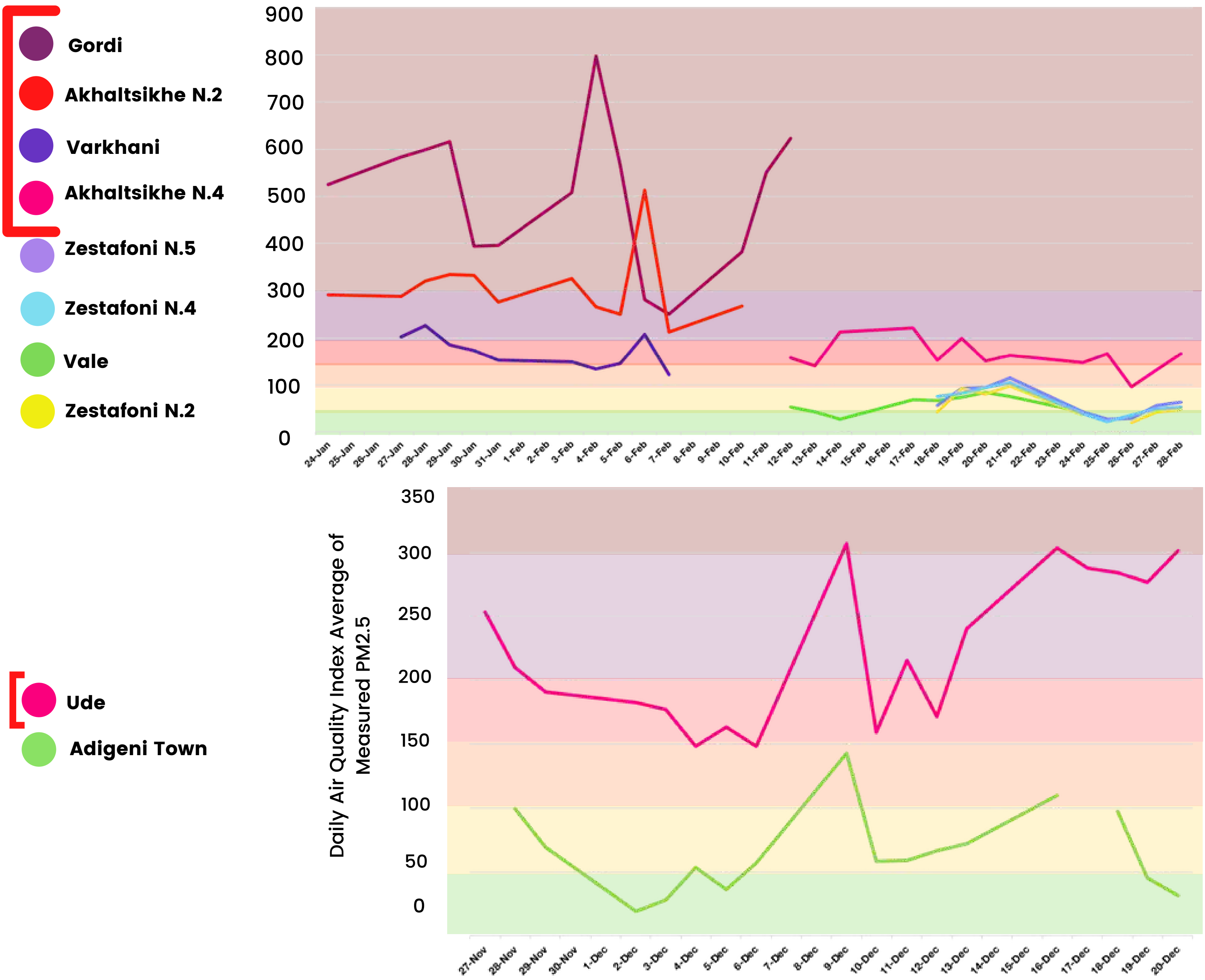
There is a lack of knowledge on actual and recommended **temperatures** for classrooms and sleeping areas, with only a small fraction able to answer what the actual and recommended temperatures are. 88% of the kindergartens do not use a thermometer to measure the temperature. As far as we know, official recommendations on temperatures do not exist, as they depend on many factors. During colder periods (the heating season), however, kindergartens should take care not to overheat classrooms. Indoor air temperatures should not be too elevated and should stay between 18-22 degrees Celsius [23]. The majority of kindergartens indicate that the actual and ideal temperatures is 24 degrees or more, which may be considered too warm. Also, the sensors measuring relative temperature, along with PM, indicate that during certain times temperatures are too high in the classrooms. More precise measurements should be taken to confirm the problem, in addition to an information campaign on healthy indoor temperatures.

In 60% of the kindergartens, **children do not go outside** during the heating season. When they do go outdoors, only 25% of all surveyed kindergartens take them for 2 hours or more. The official recommendation is that children should spend at least two hours outside every day, regardless of the weather conditions. Keeping children inside in combination with the high pollution levels can aggravate the problem even more.

TOP 5 KINDERGARTENS WITH THE OVERALL HIGHEST AND LOWEST AQI AVERAGES

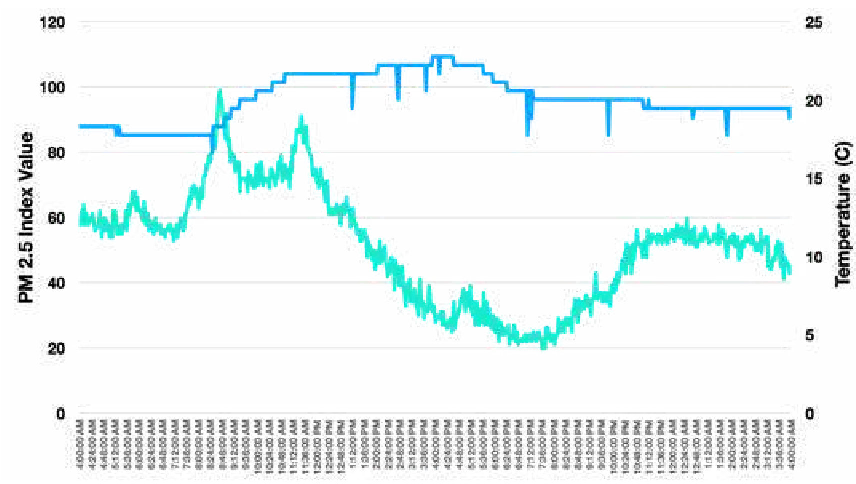
There is one clear distinction between kindergartens that consistently produced the highest levels of PM pollution, and those with the most moderate to normal levels. The top 5 with the most pollution all use firewood as their main heating source during the heating season, while the top 5 with the least amount of detected pollution all use natural gas/central heating as their primary source. In almost all of the top 5 with the highest index levels (denoted below with red brackets), the air quality ranges from unsafe to hazardous during the day, which is further evidence of the need to study indoor air pollutants further and assess such high exposure levels on children's health.

GRAPHS 2 & 3. THE DAILY AQI AVERAGE VALUES AMONG THE TOP 5 MOST POLLUTING AND LEAST POLLUTING KINDERGARTENS, DIVIDED BY MONITORING PERIODS

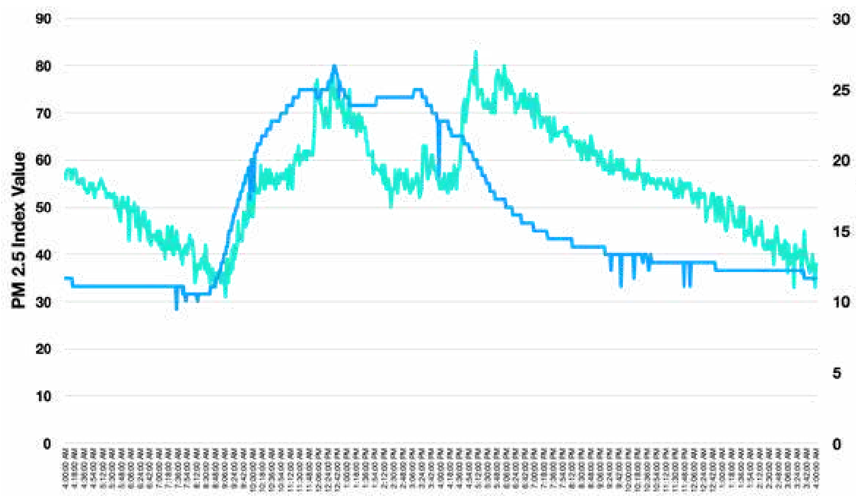


Kindergartens that use natural gas

GRAPH 4. TEMPERATURE AND PM INDEX ACROSS 24-HOUR PERIOD ON FEBRUARY 28, 2019 IN VALE KINDERGARTEN



GRAPH 5. TEMPERATURE AND PM INDEX ACROSS 24-HOUR PERIOD ON NOVEMBER 28, 2019 IN ADIGENI TOWN KINDERGARTEN



PM2.5 Index Value

uitleg over de index value is? 100 is de norm?

Sensor's Temperature (°C)

TEMPERATURE TRENDS

The temperature was measured by the PM sensors along with the data. Although the temperature values are not precise as they measure the temperature inside the sensor and not the air temperature directly, they do show trends of when the temperature is generally rising and falling throughout the day.

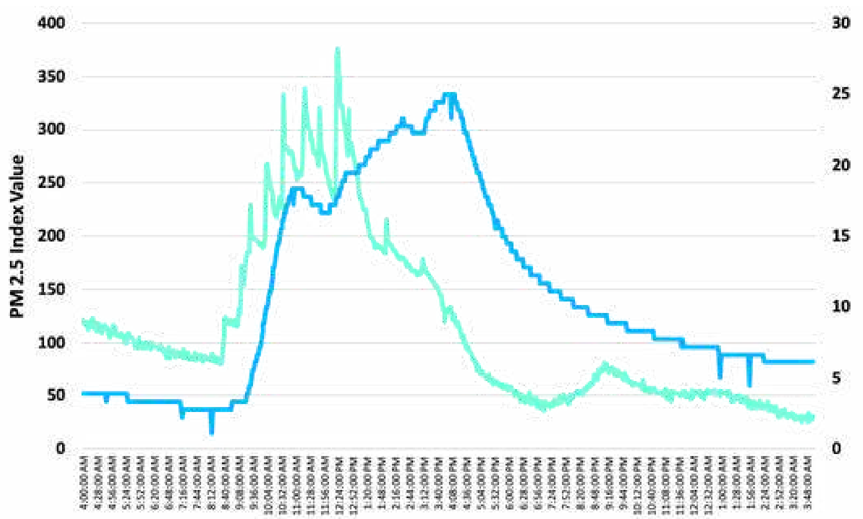
In all kindergartens that participated in the monitoring process, the temperature tends to drastically increases in the morning as the children arrive, which could likely be because this is when the heating system would be turned on.

In kindergartens using natural gas or electricity as a main heating source, PM trends tend to differ. For example, in Vale, after an initial rise in PM levels, the classroom manages to improve air quality throughout the day even as the temperature stabilizes. Although these graphs suggest a connection between the heating systems and their effect on pollution levels inside these classrooms, more research is needed to understand the relationship between temperature change and pollution levels. but the most obvious method would be to regularly ventilate. In Adigeni, the indoor air quality is only of moderate quality throughout the day, although also here an improvement can be observed in the afternoon.

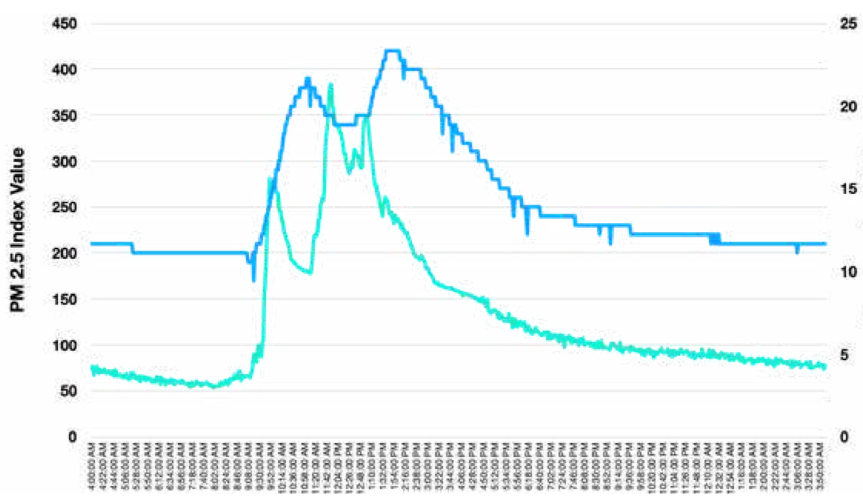
Kindergartens that use firewood

Kindergartens using firewood as their main heating source often see an increase in temperature that is preceded by a sharp rise in PM levels, most likely because the stove is turned on, producing smoke that then enters the classroom. During the day, the levels decrease somewhat, but remain in the unhealthy range. In some days, an increase around noon can be observed. During the night, PM levels are decreasing in all cases.

GRAPH 6. TEMPERATURE AND PM INDEX ACROSS 24-HOUR PERIOD ON JANUARY 21, 2020 IN VARKHANI KINDERGARTEN



GRAPH 7. TEMPERATURE AND PM INDEX ACROSS 24-HOUR PERIOD ON NOVEMBER 27, 2019 IN UDE KINDERGARTEN



PM2.5 Index Value

Sensor's Temperature (°C)

Recommendations

The findings of the report show that there is a serious problem in Georgia's kindergartens, of which about half use firewood for heating. There is enough global evidence to show that heating with solid fuels causes elevated levels of PM. This is confirmed by this study, with PM2.5 levels exceeding "healthy" limits of exposure in kindergartens using wood-burning stoves.

With about half of the kindergartens in Georgia using firewood for heating, it is clear that children's health is at risk, and urgent action is needed to reduce high exposure levels.

However, the differences between kindergartens and practices show that even with wood-burning stoves, kindergartens can take measures to improve their indoor air spaces, some of which are listed here. Some kindergartens not using wood stoves still have high PM levels and will be able to improve their air quality with simple measures, such as ventilation. This section begins with policy related recommendations addressing 1) the need for more research and data, 2) the improvement of a legal framework around indoor air pollution, and 3) the structural problems related to the lack of access to clean energy. It also formulates practical recommendations for kindergartens and local governments, which can also be applicable for households.

RECOMMENDATIONS ON FURTHER RESEARCH

More research needs to be conducted on indoor air pollution in more kindergartens and other public and private buildings. The practices as identified in the questionnaire should be linked to pollution levels to identify possible correlations. This will be more relevant with a higher sample size than the scope of this study (and COVID-19) allowed us to collect. Also asking kindergarten staff to keep a logbook on weather and relevant practices during measuring PM levels will give insight in the effect of IAQ management practices. Additionally, more pollutants should be measured. We recommend to prioritize CO2, CO, NOx, and again PM at different sizes, as they are the most prevalent pollutants that are the easiest to measure.

The European Commission Scientific Committee on Health and Environmental Risks (SCHER) concludes the following:

- The principles used in the EU for risk assessment of chemicals should also be applied to the health risk assessment of pollutants in indoor environments.
- Carbon monoxide, formaldehyde, benzene, nitrogen oxides and naphthalene are compounds of particular concern because they have caused adverse health effects as indoor pollutants or have a high potential to do so. Environmental tobacco smoke, radon, lead and organophosphates are also of concern.
- More research is needed to understand how humidity and mold problems in buildings can affect health and to evaluate the seriousness of the problem in Georgia

POLITICAL RECOMMENDATIONS ON THE LEGAL FRAMEWORK FOR THE GOVERNMENT OF GEORGIA

Based on other SCHER conclusions, the following political recommendations should be applied in Georgia:

- Developing health-based guideline values for key indoor air pollutants and other general practical guidances to help with risk management, as well as a Health Impact Assessment based on the WHO guidelines.
- Integrating the guidelines on indoor air pollution in the national legislation as part of the SDG goals and indicators, as well as the NAHAP and other relevant legislation and processes, while ensuring their implementation.
- Considering the impact of indoor pollution exposure when evaluating the health effects of outdoor air pollution, given that concentrations of air pollutants are usually higher indoors and that people tend to spend more time indoors. This issue is especially important during the COVID-19 pandemic.
- Considering all possible routes of exposure (inhalation, ingestion, or skin absorption) when assessing the risks, which would require gathering more data on the combined effects of indoor pollutants and evaluating all relevant sources known to contribute to indoor air pollution, such as tobacco smoke, stoves and open fires, building materials, furniture, pets and pests, use of household products, and conditions that lead to the mold growth.
- Collecting widespread indoor air monitoring data and systematizing practical experiences to establish evidence-based risk assessment approaches in the frame of the Environmental Public Health Tracking System by the NCDC.

- Regulating the illegal use of firewood and measure and integrate indoor air pollution as an important co-benefit to the Green Climate Fund project “Enabling Implementation of Forest Sector Reform in Georgia to Reduce GHG Emissions from Forest Degradation [24]”
- Shifting the health sector to work more intersectionally on effective preventive health policies is the way forward to address environmental causes including air pollution related morbidity and mortality, and, ultimately, in transforming the global burden of disease.

RECOMMENDATIONS FOR LOCAL GOVERNMENTS

According to the Law of Georgia on Early Childhood and Preschool Education, local governments are responsible to ensure a healthy and safe environment in kindergartens. Therefore, local self-government bodies should ensure the safe functioning of kindergarten heating systems and the safety of used fuel. The results of the study confirmed that air pollution is highest in the gardens where firewood is used for heating.

- Communal budgeting should include finances to install central heating or gas heating and increase energy efficiency and the use of solar thermal appliances in all kindergartens using wood stoves as soon as possible to preserve the health of our youth.
- Information campaigns should take place among kindergarten staff and parents to communicate the risks of indoor air pollution and in particular of PM from (wet) wood burning in stoves, and measures for correct air quality management. The recommendations for kindergartens as outlined below can be used in the communication as well as posters, flyers and infographics developed by the NCDC and WECF. (link to website)
- Outdoor burning of waste especially commonly practiced in fall should be actively discouraged and fined.

PRACTICAL RECOMMENDATIONS FOR KINDERGARTENS

Poor air quality is a serious threat to children's health. Children are sensitive to air pollution and face special risks since their lungs and immune systems are growing and they have more respiratory infections, thus proper indoor air quality management is a major challenge kindergartens face.

For kindergartens and other buildings using firewood (technical):

- Prioritize the installation of an electric or gas stove and heater instead of a wood stove or fireplace.
- Vent all fuel-fired combustion appliances to the outdoors (including stoves, heaters and furnaces)
- If you do burn wood, use "seasoned" (dry) wood in a stove with a high efficiency that regulates air flow. Wet wood is considered to burn longer, but it is less efficient and causes more smoke.
- The wind can affect the efficiency of drafting smoke out of the chimney and smoke is blown into the room. In order to reverse this, a deflector (van to be installed on the chimney) can be used to guarantee proper ventilation, drawing most of the smoke outside.

For all kindergartens and buildings (technical):

- Install and use exhaust fans vented to the outside when cooking or heating.
- Have a trained professional inspect, clean and tune-up heating system (furnace, flues and chimneys) annually. Repair any leaks properly.
- Renovate buildings to be more energy efficient, including roof and where possible floor and wall insulation, and installing double glass windows and well closing doors, and use solar thermal appliances in order to reduce the need for heating.

BEHAVIORAL RECOMMENDATIONS FOR KINDERGARTENS AND HOUSEHOLDS

- Make sure that children spend two hours or more each day outside as a means to support their immune system, mitigate effects of bad indoor air quality and to improve their overall development and learning ability.
- Ventilate often, at least three times a day by opening two windows opposite of each other, or keeping the windows open if temperatures allow.
- Temperatures should be kept between 18 - 22 degrees in the heating season. Often children are physically active and are comfortable in around 2 degrees lower temperatures than adults [25].
- Ensure that toys and furniture do not carry harmful chemicals. Everything that smells chemical, like glue or otherwise strange, is probably harmful and should not be used.
- Make sure that no leaves, plastic or other waste are burned around you. It is illegal and it causes harmful smoke full of PM, CO, CO_2, NO_x and possible dioxins if plastic is included, which can also affect the indoor air quality over a longer amount of time.

Sources

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ANNEX 1

A list of additional pollutants and/or polluting sources that greatly affect indoor air quality:

- **Radon**, a naturally-occurring gas in certain regions, can often be found indoors. The main source of indoor radon is when it infiltrates from the soil into buildings, which can happen if there are cracks in the flooring, walls, or around service pipes. It can also occur simply due to diffusion from the ground. There is no healthy level of exposure to radon indoors and may lead to lung cancer in both smokers and nonsmokers alike.

- **Lead**, a toxic metal that is still present in some of the paint of old houses and water pipes, is harmful to children and adults alike even at low levels of exposure.

- **Organophosphate pesticides**, which are often used against insects in the home, can affect the development of the nervous system and could be of concern for children.

- **Volatile organic compounds (VOCs)**, such as benzene, formaldehyde and naphthalene, are known to have a long list of health effects ranging from headaches to damage to the liver, kidneys, or central nervous system. VOCs may react with ground-level ozone to form secondary pollutants that can cause irritation to the eyes, nose, and throat.

- Several **household consumer products** emit chemicals into the air and thereby affect people's health. These include cleaning products, floor care products, furniture and household fabrics, air fresheners, glues, paints, paint strippers, personal care products, printed matter, electronic equipment, candles and incense. Some studies show a link between the use of consumer products and adverse health effects, however, it is not clear to what extent pollutants are responsible for the observed effects because other factors may also contribute to them.

ANNEX 2

Further explanation of the methodology behind selecting kindergartens for the study

The sensor and questionnaire data were manually entered in SPSS and carried out all analysis using IBM SPSS Statistics 25. A p-value of < .05 was considered to be statistically significant, based on two-sided tests. For study purposes, the sample size of kindergartens was calculated using the T Sample Size Calculator from Creative Research Systems survey software.

This sample size of 60 kindergartens (24 of which were rural and 36 were urban) has a confidence level 95% and a MoE 8.95% (24 Rural, 36 Urban) with the following stratification:

Region	Districts	AV%	Calculate Number	N_selec_Kinder
Imereti	Khoni	19,83%	5,55	6
	Terjola	33,46%	9,4	9
	Zestaponi	46,71%	13,07	13

Region	Districts	AV%	Calculate Number	N_selec_Kinder
Mtskheta-Mtianeti	Dusheti	22,83%	3,88	4
	Mtskheta	57,55%	9,78	10
	Tianeti	19,62%	3,33	3

Region	Districts	AV%	Calculate Number	N_selec_Kinder
Samtskhe-Javakheti	Adigeni	26,36%	3,95	4
	Akhaltsikhe	65,15%	9,25	9
	Aspindza	8,49%	1,25	2

ANNEX 3

Additional tables and explanations of the kindergarten questionnaire results of Section 1: General Information about Kindergartens. Full versions of the questionnaire can be provided upon request.

The total number of children from all 59 kindergartens is 5,216 and the total number of teachers is 702. Only 2 kindergartens do not indicate the number distribution by gender (See Tables 1 and 2).

TABLE 1. DISTRIBUTION BY SEX OF CHILDREN POPULATION IN RURAL AND URBAN AREAS (N=5216)

Gender	Number	Share (%)	Rural		Urban	
			Number	Share (%)	Number	Share (%)
Boys	2368	45.4	1012	46.4	1356	44.6
Girls	2468	47.3	1097	50.3	1371	45.1
Total	5216	100	2179	41.8	3037	58.2

TABLE 2. DISTRIBUTION BY SEX OF TEACHERS IN RURAL AND URBAN AREAS (N=702)

Gender	Number	Share (%)	Rural		Urban	
			Number	Share (%)	Number	Share (%)
Women	699	98.9	373	100	326	99.1
Men	3	0.4	0	0	3	0.9
Total	702	100	373	53.1	329	46.9

ANNEX 3

Additional tables and explanations of the kindergarten questionnaire results of Section 1: General Information about Kindergartens

Size distribution of classroom sizes:

TABLE 3. THE CLASS SIZE OF THE SELECTED ROOM FOR MONITORING IN URBAN AND RURAL AREAS

	Total	Urban	Rural
Average	48.48	47.7	48.96
Minimum	28	39	28
Maximum	70	52	70

Distribution of sources used for heating and cooking practices in kindergartens:

TABLE 4. THE HEATING SOURCE DISTRIBUTION IN URBAN AND RURAL AREAS

Source	Number	Share (%)	Urban		Rural	
			Number	Share (%)	Number	Share (%)
Electricity + Gas	2	3.4	2	9.1	0	0.0
Electricity + Wood	1	1.7	1	4.5	0	0.0
Gas	24	40.7	12	54.5	12	32.4
Wood	31	52.5	7	31.8	24	64.9
Unknown	1	1.7	0	0.0	1	2.7

TABLE 5. THE COOKING SOURCE DISTRIBUTION IN URBAN AND RURAL AREAS

Source	Number	Share (%)	Urban		Rural	
			Number	Share (%)	Number	Share (%)
Electricity	8	13.6	4	18.2	4	10.8
Gas	36	61.0	18	81.8	18	48.6
Compressed Gas	15	25.4	0	0.0	15	40.5

ANNEX 3

Additional tables and explanations of the kindergarten questionnaire results of Section 2: Indoor Air Practices

Distribution of sources used for heating and cooking practices in kindergartens:

TABLE 6. THE DISTRIBUTION OF STOVE USAGE FOR HEATING WITHIN URBAN AND RURAL AREAS

Source	Number	Share (%)	Urban		Rural	
			Number	Share (%)	Number	Share (%)
Using Stove	40	67.8	10	45.5	30	81.1
Not-Using Stove	19	32.2	12	54.5	7	18.9

TABLE 7. THE DISTRIBUTION OF BURNING MATERIALS WITHIN URBAN AND RURAL AREAS

Source	Number	Share (%)	Urban		Rural	
			Number	Share (%)	Number	Share (%)
FireWood	32	54.2	7	31.8	25	67.6
Gas	15	25.4	6	27.3	9	24.3
Unknown	12	20.3	9	40.9	3	8.1

Only **8 kindergartens** answer how much firewood is used/burnt during the heating season: the maximum amount is 35 cubic meters and the minimum is 8 cubic meters, which averages out to 19 cubic meters.

Only **3 kindergartens** answer how much the firewood cost per season: the maximum amount is 1400 GEL and the minimum 600 GEL.

ANNEX 3

Additional tables and explanations of the kindergarten questionnaire results of Section 2: Indoor Air Practices

Only **7 kindergartens** indicate natural gas usage, with an obvious difference between urban and rural areas: the average usage in urban areas is 4659.5 cubic meters, while in rural areas it is 1923.3 cubic meters.

Only **8 kindergartens** answer how much natural gas costs per season: the maximum amount is 6000 GEL and the minimum 1740 GEL.

TABLE 8. THE AMOUNT OF NATURAL GAS USED PER SEASON WITHIN URBAN AND RURAL AREAS

	Total	Urban	Rural
Average (m3)	3486.9	4659.5	1923.3
Minimum (m3)	1300	2450	1300
Maximum (m3)	6820	6820	2350

Additional table and explanation of the kindergarten questionnaire results of Section 4: Ventilation

Distribution of kindergartens among rural and urban settings that use a simple ventilator to reduce smoke and/or steam during cooking activities:

TABLE 9. THE FREQUENCY OF SIMPLE VENTILATOR USAGE WITHIN URBAN AND RURAL AREAS

Frequency			Urban		Rural	
	Number	Share (%)	Numbe r	Share (%)	Numbe r	Share (%)
Always	17	28.8	8	36.4	9	24.3
Sometimes	2	3.4	1	4.5	1	2.7
Never	8	13.6	2	9.1	6	16.2
Do not have any equipment	29	49.2	9	40.9	20	54.1

ANNEX 3

Additional tables and explanations of the kindergarten questionnaire results of Section 5: Knowledge of poor Indoor Air Quality's impact on health

Almost half (40.7%) of the kindergartens take children outside during the heating season on a daily basis, and some of them (35.6%) only during warm and sunny days.

TABLE 10. DISTRIBUTION OF OUTDOOR TIME AMONG URBAN AND RURAL AREAS

Frequency	Number	Share (%)	Urban		Rural	
			Number	Share (%)	Number	Share (%)
Less than 1 hour	29	49.2	9	40.9	20	54.1
2 hours	15	25.4	6	27.3	9	24.3
Less than 2 hours	11	18.6	5	22.7	6	16.2
More than 2 hours	3	5.1	2	9.1	1	2.7

Additional table and explanation of the kindergarten questionnaire results of Section 6: Level of awareness related to the sources of indoor air pollution

Almost half (54.2%) of the kindergartens do not use one play room for all children during the heating season:

FIGURE 1. THE DISTRIBUTION OF USAGE ONE PLAY ROOM FOR ALL CHILDREN