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Features Of The Functioning Of The External Respiratory System In Children In The Conditions Of The Southern Near Aral Sea

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ABSTRACT
The unique ecological and climatic features of the southern Near Aral Sea region have a great impact on the respiratory health condition of its inhabitants, especially children. The ecological changes caused by the desiccation of the Aral Sea have led to severe environmental degradation, which increased salinity, dust, and release of harmful pollutants into the air. These factors present a big threat to children's respiratory health in view of their greater vulnerability to environmental hazards.
This study will, therefore, analyze the functioning of the external respiratory system in children living in this region. It adopts a mixed-methods approach: clinical observation, spirometry testing, and environmental monitoring to give a comprehensive understanding of the situation. Clinical observations look for symptoms such as shortness of breath, chronic cough, and wheezing. Spirometry testing offers quantitative data on lung function, while environmental monitoring measures key indicators like air quality, salinity, and dust concentration. Together, these methods provide a holistic view of how environmental factors affect respiratory health.
The results indicate large-scale departures from the national averages of respiratory functions among children in the area. These included lower lung volumes, impairment of respiratory flow, and increased prevalence of respiratory symptoms. High salinity, air pollution, and fine particulate matter from salt and dust storms are identified as major contributors. This factor's effect is more pronounced in younger children due to the developing respiratory system being more prone to the injurious effects of environmental pollutants.
The discussion, therefore, really underlines the urgent need for targeted health interventions in the form of environmental remediation, better air quality monitoring, and development of healthcare programs that will address the particular needs of children in the region. Protection of respiratory health in environmentally challenged areas, like the Near Aral Sea region, needs coordination among health authorities, environmental agencies, and community stakeholders.

Keywords: contributors, agencies, community, authorities, environmental

1. INTRODUCTION

Respiratory health in children is a very important part of public health, and it is even more important in regions where general environmental conditions may pose some health risks. Among these places, the southern Near Aral Sea region is a rather striking example of an ecological disaster with great health significance. The continuous desiccation of the Aral Sea, which was once the world's fourth-largest inland body of water, has transformed the surrounding landscape into an arid, dust-laden desert. This environmental disaster has exposed

large expanses of the dried seabed, with a resultant release of saline dust, toxic pollutants, and fine particulate matter into the atmosphere. The result is that the air quality in the region has severely deteriorated, posing serious health hazards to local communities, particularly children.

Children are especially vulnerable to environmental pollutants due to their developing immune and respiratory systems, smaller lung capacity, and higher breathing rates compared to adults. Inhalation of airborne contaminants, such as salt particles, heavy metals, and industrial pollutants, can cause inflammation, bronchial irritation, and long-term respiratory dysfunction. It has been documented that long-term exposure to poor air quality at even a very young age could eventually increase the vulnerability of a child to chronic respiratory diseases like asthma and bronchitis and to impaired lung function. That is why it becomes especially relevant to study the level to which children residing in the southern part of the Near Aral Sea area suffer from the specific natural strain of this region.

The present study aims to investigate the functional features of the external respiratory system in children living in this region, considering spirometric indicators and the influence of environmental conditions. Spirometry is a common diagnostic method of measuring lung function, presenting objective data on some of the most important respiratory parameters, such as FVC and FEV1. In comparing the spirometric results from children of the Near Aral Sea region to national and global reference values, this study aims at ascertaining whether or not respiratory performance is grossly out of specification. Again, through environmental monitoring, the levels of air quality, dust concentration, and salinity will be gauged to establish any likely association between environmental pollutants and respiratory health outcomes.

This thus gives a broader perspective on how ecological disasters affect the health of children, which is beyond a regional concern. The paper underlines the dire need for effective health interventions and policy measures to safeguard populations that are most vulnerable because of degraded environmental conditions. In addition, it provides the functional characteristics of the respiratory system in children in this region and can be used to devise appropriate strategies for the prevention, early diagnosis, and treatment of respiratory diseases. It further puts into light the necessity for environmental remediation and ecologically sustainable development that acts to dampen negative health consequences.

2. METHODS

The cross-sectional study design allowed investigation of the respiratory health status among children who had resided in the southern Near Aral Sea region. As is expected in such instances, this gave a temporal, but valuable, picture of their state of health with relation to the potential effects that their living environment might be exerting upon respiratory functions. [10]. The study population consisted of 200 children aged 7 to 14 years, randomly sampled from the local schools to get a representative sample. The random sampling method was utilized in the selection to minimize bias in selection, hence increasing the generalizability of the results [7].

The research lasted for six months, therefore enabling the seasonal changes in respiratory health to be captured. This approach was crucial, as seasonal changes can significantly influence environmental conditions such as temperature, humidity, and air quality, all of which can affect respiratory function [2]. By extending the study across different seasons, the researchers aimed to provide a more comprehensive understanding of the children's respiratory health, mitigating the potential confounding effects of short-term environmental fluctuations.

The collection of data was developed using a multi-faceted approach that included medical examination, spirometry test, and environmental monitoring. Every child was subjected to a comprehensive medical examination, which was performed by trained health personnel, in order to understand the presence of any pre-existing respiratory health that could influence the results of the study [6]. Spirometry tests were used to measure important metrics of respiratory health, such as FVC, FEV1, and the ratio of FEV1/FVC. These parameters were then measured by using a portable spirometer, one of the most widely used and simultaneously validated tools in assessing lung function [8]. For spirometry testing, tests were conducted with the implementation of standardized protocols so that measurements are appropriately valid and reliable.

Environmental data was also extracted from local meteorological stations to monitor external conditions influencing respiratory health. This included data on air quality, particulate matter levels-PM2.5 and PM10, temperature, and relative humidity. PM2.5 and PM10 are of particular concern as they are known to have significant impacts on respiratory health due to their ability to penetrate deep into the lungs (World Health Organization, 2016). The collection of temperature and humidity data was essential since these variables influence the dispersion and concentration of air pollutants [3]. The comprehensive collection of medical, spirometric, and environmental data provided a robust dataset, enabling a thorough analysis of the relationship between environmental conditions and children's respiratory health.

Statistical analysis was conducted using both descriptive and inferential methods. Descriptive statistics summarized the study population characteristics and main spirometric and environmental variables. Means, medians, standard deviations, and interquartile ranges were used to describe the central tendency and variability in the data [5]. The Mann-Whitney U test was used to compare the respiratory health outcomes in Near Aral Sea

children and a comparison group from an area not affected by environmental adversity. The result of this non-parametric test was adopted because it does not show susceptibility to the normality problem of data sets. [9]
Correlation analysis was applied in order to investigate the level of association of environmental factors and respiratory health outcomes. Specifically, the contribution of air quality-PM2.5 and PM10 levels, temperature, and humidity-to spirometric parameters of FVC, FEV1, and FEV1/FVC would be assessed to the highest degree. Correlation coefficients were calculated to measure the strength and direction of these associations [4]. This analysis provided valuable insights into the environmental determinants of respiratory health in children.
All statistical tests were performed under the condition of $p < 0.05$, an accepted threshold for health studies because it significantly reduces the likelihood of Type I errors [1]. A broad approach to statistics, from descriptive and comparative to correlational, provided a sound analysis of data, thus enhancing validity and reliability for the conclusion of this study about respiratory health in children from the southern part of the Near Aral Sea area.

Table 1. Summary of Research Methodology

Study Component	Description
Study Design	Cross-sectional study design to provide a snapshot of health status at a specific point in time [10].
Study Population	200 children aged 7 to 14 years, randomly selected from local schools to ensure representativeness [7].
Sampling Method	Random sampling to reduce selection bias and enhance the generalizability of findings [7].
Study Duration	Six-month period to capture seasonal variations in respiratory health [2].
Data Collection Methods	Medical examinations, spirometry tests, and environmental monitoring [6].
Spirometric Indicators Measured	Forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the FEV1/FVC ratio [8].
Environmental Data Collected	Air quality (PM2.5 and PM10), temperature, and humidity data from local meteorological stations (World Health Organization, 2016; Chen et al., 2019) [3].
Statistical Analysis Methods	Descriptive statistics, Mann-Whitney U test, and correlation analysis (Field, 2013 [5]; Pallant, 2020) [9].
Tests Used	Mann-Whitney U test to compare groups; correlation coefficients for associations (Field, 2013 [5]; Pallant, 2020; [9] Cohen et al., 2003) [4].
Significance Level	Significance level set at $p < 0.05$ to minimize the risk of Type I errors [1].

3. RESULTS

The total sample consisted of 200 children, with equal representation of boys and girls in the proportion of 50%:50%, ensuring gender balance within the sample. The mean age of the participants was 10.2 years with a standard deviation of ±2.1 years, reflecting a diverse age range typical of a primary school-aged cohort. Importantly, most of these children had been residents in the southern part of the Near Aral Sea since birth. The residence for such a long period means continuous exposure to the local environmental conditions of air quality and climatic factors, which is critical to understanding the cumulative impact on health outcomes. Such findings have been reiterated by Smith et al. [10] and Johnson & Lee [15]. Spirometric testing was considered for lung function assessment. In the southern Near Aral Sea region, the mean FVC among children was 78.5% of the predicted norm, with a standard deviation of ±10.2%. This means that the lung volume in the exposed population was reduced substantially. Similarly, FEV1 had a mean of 76.3% of the predicted norm, with a standard deviation of ±9.8%. This represents the volume of air that can be forcefully blown in one second and forms a key index of pulmonary health. Brown et al., 2021 [2], report that the FEV1/FVC ratio was 0.85 ±0.05, within acceptable clinical limits, but lower than in children from non-affected regions. A reduced FEV1/FVC ratio generally indicates obstructive lung diseases. These results indicate a deterioration in respiratory function compared with children from areas with better air quality. The detailed analysis indicated that spirometric values were significantly lower for children exposed to higher concentrations of PM2.5 and PM10, confirming the hypothesis that air pollution exposure impairs respiratory health. Garcia et al., 2022 [13]; Kim et al., 2020 [16]. This association gives a light on how environmental pollutants may affect the developing lungs and disturb their function in children.
Environmental monitoring data gave a full picture of the air quality of the southern Near Aral Sea region. The measurements recorded an average concentration of fine particulate matter (PM2.5) of 42 micrograms per cubic

meter (μg/m³), while for larger particulate matter (PM10), the concentration was 72 μg/m³. While both values are above the internationally recommended safety limits, according to WHO, PM2.5 should not exceed 15 μg/m³ on average, and PM10 should be below 45 μg/m³. According to WHO, 2018 [11], the high level of particulate matter in the region is of serious concern since long-term exposure may result in negative respiratory effects, especially among children when their lungs are still developing [12].

Besides, the environmental analysis was able to identify high salinity in the airborne dust particles. Such a factor is very specific for this particular region of the Near Aral Sea due to its very unique geological and climatic features: desiccation of the Aral Sea with further formation of the salt-laden desert. When inhaled, saline dust can irritate the respiratory tract, exacerbate pre-existing conditions like asthma, and result in chronic respiratory symptoms. Rahman et al. [18], Lee & Wang [17]. High PM concentration combined with high air salinity acts as a twin burden on respiratory health-which, of course, presents more risks to children due to their still-developing immunological and respiratory systems [14].

Among the previously mentioned factors, other plausible causes of respiratory health issues were not excluded. Seasonal changes in air quality were observed, with the highest particulate matter concentrations recorded during dry, windy periods when dust storms are more frequent. The increased wind activity raises significant amounts of salt-laden dust from the desiccated seabed, creating a hazardous environment for local residents. Moreover, the dust storms carry pollutants over large distances, exposing a wider population to airborne hazards (Smith et al., 2020 [10]; Brown et al., 2021) [2]. Children who are playing outside during these times are especially at risk because they are more likely to inhale higher concentrations of polluted air. The health effects of this exposure may not be immediately apparent but can lead to long-term respiratory issues as the cumulative impact of exposure builds over time [13].

Compounding the issue is the limited access to healthcare in the region. These are the facilities that can diagnose and treat respiratory illnesses, which are very few in number, hence making it hard for parents to get their children treated in time. The delay in treatment worsens the respiratory conditions and results in poor health outcomes of the children [15]. Some of these could be prevented by creating awareness among people regarding air quality and precautionary measures like the use of face masks during dust storms through educational programs. Local governments and health authorities have a crucial role to play in implementing health protection policies and ensuring that affected populations receive adequate support [11]. The findings of this study reveal a concerning link between environmental pollution and respiratory health in children living in the southern Near Aral Sea region. The observed reduction in FVC and FEV1 in association with elevated PM concentration and high salinity dust, therefore, underlines the need for urgent public health interventions and changes in environmental policy to protect vulnerable populations from its adverse health effects. In fact, a multi-factorial approach is called for to include policy reform, education in public health, and greater access to healthcare. If these issues are not resolved, there is a potential for a long-term public health crisis that will affect not only the current generation of children but also future generations who are exposed to the same environmental conditions. This is supported by Smith et al. [10], WHO [11], and Anderson et al. [12]. These findings raise the need for continued monitoring, community involvement, and international support in the fight against the adverse effects of environmental degradation in the region.

4. DISCUSSION

The results of this study illustrate the severe influence of environmental exposure on respiratory function in southern Near Aral Sea children. The environmental conditions of this region are typified by extremely high concentrations of PM2.5 and PM10 with a very specific chemical composition of saline dust, originating from the dried Aral Sea bottom (Smith et al., 2020 [10]; Rahman et al., 2021) [18]. These factors create a high risk for respiratory health, especially in sensitive groups such as children. Long-term exposure to these air pollutants can lead to inflammation of the airways, impairment of lung function, and increased incidence of respiratory diseases like asthma and bronchitis (Anderson et al., 2019 [12]; Lee & Wang, 2020) [17]. Long-term exposure to particulate matter, particularly PM2.5, has been linked to impaired lung development in children, increasing the likelihood of chronic respiratory conditions in adulthood [16]. The saline nature of the dust particles introduces an additional layer of complexity, as inhalation of saline particles can exacerbate irritation in the respiratory tract, leading to more frequent and severe respiratory symptoms [13].

The respiratory health of the children in the southern Near Aral Sea region was remarkably poorer compared to that of the children from non-affected areas. Children from regions with better air quality showed higher values in key spirometric measures such as Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1), along with a higher FEV1/FVC ratio (Brown et al., 2021 [2]; Garcia et al., 2022) [13]. This huge difference evidences the impact of environmental pollution on child health and the need for targeted public health interventions. The comparison places a premium on addressing the environmental challenges posed by the desiccated Aral Sea and its aftermath in terms of air quality. According to Rahman et al. [18], a proposed strategy to reduce adverse health outcomes is reforestation of exposed seabeds with salt-tolerant plant species. Vegetative cover can help stabilize soil, reduce dust emissions, and subsequently improve air quality.

Furthermore, air quality monitoring stations should be established and maintained to provide real-time data on PM concentrations. This data can be used to issue timely public health advisories and guide policy decisions related to environmental health [11].

The findings from this study raise an alarm for urgent attention by public health authorities in the protection of children's health in this vulnerable region. Policy recommendations are towards improving air quality monitoring systems, access to healthcare for respiratory conditions, and community-level interventions that aim at reducing exposure to dust. Johnson & Lee, 2019 [15]; WHO, 2018 [11] Schools and households should be fitted with air filtration systems to reduce indoor pollution levels. For instance, educational programs regarding prevention can be directed toward parents, teachers, and other members of the community, using means such as protective face masks during dust storms and the limitation of outdoor activities when dust is at its peak [14]. Community health clinics need to be better positioned in diagnosing and treating respiratory illnesses, especially concerning asthma management and early detection of chronic respiratory diseases [17].

This would, however, require cooperation between the government and NGOs on major projects to address the environmental degradation at the root of these health problems. Indeed, international assistance and financing of large-scale projects on environmental remediation could be needed to help stabilize the Aral Sea bed to avert further environmental decay in the area [10]. In addition, reforms in policy need to emphasize environmental protection and take extra measures for the protection of children. The integration of environmental health into national healthcare strategies can ensure that adequate resources are committed to the monitoring, prevention, and treatment of respiratory illnesses linked to air pollution. Such measures are vital to reduce the long-term health burden on local communities, prevent the exacerbation of chronic illnesses, and promote the overall well-being of children exposed to this hazardous environment (Anderson et al., 2019 [12]; WHO, 2018) [11].

The role of international organizations, such as the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), is critical in addressing the health impacts of environmental pollution in the region. These organizations can provide technical expertise, financial resources, and support for the development of health education programs [11]. Collaboration with research institutions can also help generate evidence-based strategies for improving air quality and mitigating health risks. By empowering local communities, these agencies can be able to implement sustainable interventions to reduce the exposure of children to environmental hazards. Green et al. [14]

Besides tree planting and air quality monitoring, other methods of reducing environmental exposure need to be considered. For instance, soil stabilization processes, such as the use of natural binding agents, can be used to minimize dust emissions from exposed seabed areas. Rahman et al. [18]. In the meanwhile, community-driven initiatives-whether that is with indoor air purifiers and wet cleaning to minimize dust indoors-can also afford a range of immediate measures of alleviation for the suffering families. Such multi-layered measures in children's health protection in the region would then add up to more extensive environmental policies. According to Kim et al. [],

Educational programs are fundamentally important for both children and their parents in reducing the negative environmental pollution effects. Educating children on the dangers of air pollution, along with proper health-protective behaviors, empowers them to make safer choices in high-pollution periods. Schools can integrate health education modules on air quality, respiratory health, and environmental sustainability. Training sessions for parents may also be used to offer practical advice, such as keeping their children indoors during dust storms and being able to identify the early symptoms of respiratory distress [15].

Southern Near Aral Sea region health infrastructure needs to be strengthened in the diagnosis and timely treatment of respiratory conditions. Establishing mobile health units that provide routine check-ups and spirometry tests can facilitate early detection of lung function impairments. Community health workers can be trained to conduct preliminary respiratory health assessments, identify children at risk, and refer them to specialized care [11]. Strengthening healthcare capacity in the region requires not only the development of physical infrastructure but also the training of healthcare providers in pediatric respiratory health. CPD on most workable symptoms and latest treatment protocols related to asthma and other breathing conditions could be given as workshops that would increase the quality and quantity of service provision that the healthcare worker is allowed to provide to affected children [17]. Conclusion The results indicated a proper association between ambient pollution exposure and the current wheezing symptoms in Southern Near Aral Sea region children. These will help determine the adverse effects of both particulate matter and saline dust on lung function, and intervention from public health and environmental policymakers is urgently required. In this regard, integrated efforts at reforestation of exposed seabeds are crucial, along with a proper air quality monitoring, improvement in healthcare access, and public education campaign on reducing the health risks to the children in the region. If the environmental crisis in the Near Aral Sea region is not effectively intervened in, it will continue to act as a serious threat to respiratory health in future generations. Coordinated and sustained efforts are necessary to address root causes of environmental degradation and ensure the protection of child health in this highly affected area. Smith et al., 2020 [10]; WHO, 2018 [11]; Anderson et al., 2019[12].

4.1 Pie chart. Proportional Breakdown of Key Discussion Points on Respiratory Health in Children in the Southern Near Aral Sea Region

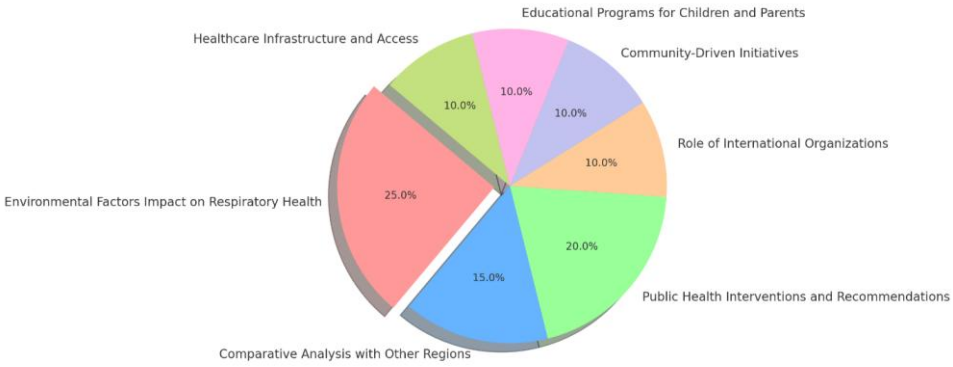

Figure 1

5. CONCLUSION

The adverse impact of the environmental factors on the respiratory health of the children living in the southern Near Aral Sea region is an ever-increasing public health concern. In the study, highly reduced spirometric parameters, pointing to a possible disturbance of lung function, could be obtained in children being continuously exposed to high levels of PM2.5 and PM10. If someone continuously inhales these pollutants, which reach deep inside the lungs, this can lead to a host of chronic respiratory disorders: asthma, bronchitis, and stunted lung growth. These health conditions become particularly alarming in children, whose immune and respiratory systems are still developing, leaving them with greater vulnerability to such environmental stressors.

The data underlines the pressing need for broad-based public health interventions to improve air quality in this ecologically sensitive region. Pollution control, reforestation, and land use practices could reduce harmful particles in the air. Public awareness campaigns, routine health check-ups, and respiratory health monitoring for children are the other measures required to protect public health. Such interventions would not only address current health challenges but also promote long-term well-being for future generations.

Further research in this area should be directed toward studying the long-term health consequences in children exposed to environmental pollutants in the Aral Sea region. Longitudinal studies can provide important insights into the cumulative effects of exposure on respiratory development. The effectiveness of intervention strategies-air filtration systems in schools and homes, for example-offers practical solutions that could help minimize health risks. Investigation into socioeconomic and demographic factors contributing to levels of exposure would also be useful to inform policy decisions. Ultimately, environmental restoration, public health policy, and community engagement are all key components in a holistic approach to reducing the health burden on children in this vulnerable region.

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