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Assessing the Effects of Indoor Air Pollution Among Rural & Urban Under Five Children – Comparative Study

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Abstract

"Air pollution, marked by the presence of detrimental substances in the Earth's atmosphere, constitutes a major global menace to environmental sustainability and public health. This complex issue arises from a combination of natural processes and anthropogenic factors, with key contributors including industrial discharges, vehicle emissions, agricultural practices, and the burning of fossil fuels and biomass for energy. "This study employed a true experimental one-group pretest-posttest research design, with a sample size of 60 participants selected through purposive sampling. The research was carried out over fourteen days in both urban and rural areas, utilizing self-structured questionnaires. The present study's findings indicate a significant disparity in household air pollution levels between rural and urban areas, with urban areas exhibiting higher concentrations of indoor air pollutants.

Keywords: *Air Pollution, Rural-Urban Comparison, Under-5 Children.*

Introduction

Background

"Air pollution is characterized by the presence of detrimental substances, encompassing gases, particulate matter, and biological molecules, in the Earth's atmosphere. This phenomenon can arise from both natural and anthropogenic sources, posing significant environmental and health risks globally. The major contributors to air pollution encompass emissions from industrial operations, vehicle exhaust, agricultural practices, and the combustion of fossil fuels and biomass for energy purposes."

"Air pollution has evolved into a profound global health emergency, with India bearing a disproportionate burden of this crisis. The country's air pollution levels are amongst the highest globally, posing debilitating risks to both public health and economic stability. Notably, the 2019 World Air Quality Report revealed that India is home to 21 of the world's 30 most polluted urban centres. In these cities, particulate matter concentrations frequently exceed the World Health Organization's (WHO) recommended safe limits by a factor of 10."

In India, numerous studies have explored the relationship between respiratory diseases

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and solid biomass fuel use. One such study, conducted by Laxmi et al. (2012) in Northern India, revealed a significant link between solid biomass fuel use and pulmonary tuberculosis-related mortality and morbidity. This association remained significant even after adjusting for various socio-demographic factors, including age, education, residence, marital status, religion, and region. A separate study in Tiruvallur, South India, identified biomass-based solid fuel as a major risk factor for tuberculosis, surpassing other contributing factors like tobacco smoking, alcohol consumption, and lifestyle habits.

"Research has explored the links between socio-demographic factors, solid cooking fuels, and respiratory illnesses. Studies have found that reliance on solid fuels, such as firewood and cow dung, is widespread (over 60%) and associated with increased risk of COPD, asthma, and TB [3]. Comparative analyses have shown higher solid fuel consumption in rural areas (72.22%) versus urban areas (21.43%), with a strong correlation between solid fuel use and respiratory diseases [4]. Additionally, kerosene consumption has been linked to TB, with PM2.5 showing a weaker association [4, 5]."

"Globally, approximately 2.1 billion individuals rely on solid fuels (including wood, crop waste, charcoal, coal, and dung) and kerosene for cooking, primarily using open fires and inefficient stoves. This population is predominantly low-income and resides in low- and middle-income countries. A significant urban-rural disparity exists in access to cleaner cooking alternatives, with 14% of urban populations using polluting fuels in 2021, compared to 49% of rural populations worldwide."

"Findings from Dyson's inaugural Global Connected Air Quality Data project (2024) revealed that India had the highest average annual PM2.5 levels, with a staggering 55.18 $\mu g/m^3$ of Indoor Average PM2.5. Notably, Tamil Nadu cities exceeded the WHO's daily PM2.5 air quality guideline every month. Furthermore, indoor air pollution accounted for an estimated 2.3 million deaths globally, representing 4% of all deaths, underscoring the urgent need for improved indoor air quality. Among the various sources of air pollution, household air pollution (HAP) stands out as a critical determinant of health, especially for children under the age of five, who are more susceptible to its adverse effects. Indoor air pollution (IAP) poses a significant threat to human health as it encompasses a wide array of contaminants that can infiltrate the air within buildings. These contaminants, which include particulate matter (PM), gases, and biological pollutants, emanate from diverse sources, ranging from combustion processes to household products. Particulate Matter, composed of solid particles and liquid droplets, is a prevalent indoor air pollutant originating from activities such as burning wood, coal, or gasoline, industrial processes, as well as natural events like dust storms and wildfires. Gaseous Pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and sulphur dioxide (SO_2) contribute to indoor air pollution. These gases can emerge from combustion, heating and cooling systems, and various household products. Biological pollutants, encompassing moulds, mildew, bacteria, and viruses, thrive in damp or humid environments like basements, bathrooms, and kitchens. Exposure to IAP has been associated with a range of health issues, including respiratory infections (such as asthma, bronchitis, and pneumonia), heart disease, stroke, cancer, allergic reactions, and sick building syndrome. Vulnerable populations, particularly children and older adults, are at a heightened risk of experiencing adverse health effects due to IAP (7). In 2004, the American Academy of Pediatrics'a Committee on Environmental Health issued a policy statement highlighting the significant link between ambient air pollution and children's health (8). Children's vulnerability to air pollution's adverse effects is heightened due to factors such as increased respiratory rate, immature immune systems, and engagement in physical activities, prolonged outdoor exposure (9), and ongoing lung development during early childhood (10). The combustion of biofuels in rural areas releases hazardous pollutants, including formaldehyde, polycyclic organic matter, carbon monoxide, and particulate matter. Rural women, who often manage cooking and household tasks, are disproportionately exposed to high levels of air pollution. During the COVID-19 lockdown, working-age men and school-going children also experienced increased exposure due to prolonged periods at home. Notably, indoor PM2.5 concentrations in biomass-fueled households were found to be significantly higher - 220 times greater - than outdoor levels in various Indian states.

In developing countries, indoor pollution from domestic cooking stoves poses a significant concern due to inadequate ventilation and widespread use of inefficient stoves and biofuels. Studies have revealed benzene concentrations ranging from 44-167 μg/m3 associated with kerosene stove usage (11). Historically, benzene was extensively used as a solvent in various industrial applications, including paints, adhesives, and cleaning agents. Although stricter occupational exposure limits have led to reduced benzene use in many areas (12), its presence remains a concern in certain regions, such as some African countries.

Urban exposure to indoor air pollution is influenced by the construction of tightly sealed buildings, decreased ventilation, use of synthetic materials, and the presence of chemical products, insecticides, and household items. Indoor air pollution in urban areas can stem from both internal and external sources, encompassing pollutants such as lead, carbon monoxide, nitrogen dioxide, tobacco smoke, 4 and biological contaminants. High PM2.5 Exposure in Working-Age Rural women exhibits the highest PM2.5 exposures, primarily due to biomass cooking-related emissions. Lockdown Impact on Exposure, Despite the lockdown, working-age women maintained the highest exposures, with increases observed in working-age men (24%) and school-going children (18%). "Indoor air pollution, primarily caused by biomass fuel combustion for cooking and heating, is a significant risk factor for childhood pneumonia. Biomass fuels, including wood, straw, and animal dung, are inefficient and polluting, posing health risks. Children's increased metabolic rate, ongoing organ development, and higher surface-to-body mass ratio make them more vulnerable. Indoor pollution exposure can have intergenerational consequences, affecting fetal development and leading to neurological and behavioural issues, such as autism and ADHD, later in life."

Need for the Study

"Globally, approximately 2.1 billion individuals, nearly a third of the worldwide population, rely on open flames or inefficient stoves fueled by polluting energy sources, including kerosene, biomass, and coal. This widespread practice leads to severe household air pollution, accounting for an estimated 3.2 million annual deaths as of 2020, with 237,000 of those deaths occurring among children under five. The combined impact of ambient and household air pollution culminates in a staggering 6.7 million premature deaths annually."

“Exposure to household air pollution is a significant risk factor for non-communicable diseases, including stroke, ischemic heart disease, COPD, and lung cancer. Women and children, often responsible for cooking and fuel collection, bear the brunt of health impacts due to polluting fuels and technologies. Transitioning to clean fuels and technologies is crucial to mitigate household air pollution and protect public health. Alternatives like solar, electricity, biogas, LPG, natural gas, alcohol fuels, and improved biomass stoves can achieve the WHO's emission standards, offering a pathway to reduced health risks."

Children under the age of five are particularly susceptible to the adverse effects of air pollution due to their developing respiratory and immune systems. The levels and sources of household air pollution can vary significantly between rural and urban settings. Respiratory issues, such as asthma and infections, which are linked to household air 6pollution, can profoundly impact the health of young children. Additionally, rural and urban areas often differ in socioeconomic characteristics, influencing the types and levels of air pollution present. By evaluating the effectiveness of measures aimed at mitigating household air pollution, the study contributes to the broader goal of fostering long-term public health benefits, especially for vulnerable populations. Conducting a comparative study on household air pollution among children under five in rural and urban areas is essential for generating evidence-based insights. These insights will inform targeted interventions designed to enhance the overall health and well-being of this vulnerable demographic variable (16).

Materials and Methods

Objective of the Study

1. To assess the effect of household air pollution in rural settings.
2. To assess the effect of household air pollution in an urban setting.
3. To compare the effect of household air pollution in rural and urban settings.
4. To associate the effect of household air pollution in urban and rural settings with demographic variables.

Hypothesis: **H1:** There is a significant difference in the levels of household air pollution between rural and urban areas, with urban areas experiencing higher concentrations of indoor air pollutants**.** **H2:** The implementation of interventions to reduce household air pollution will result in a statistically significant improvement in air quality in both rural and urban areas. ***Study design:*** True experimental one-group pretest and posttest research design. ***Study setting:*** Urban Poonamallee and Rural Meppur village. ***Sampling Technique and Sampling size:*** Using a purposive sampling technique investigator recruited 60 study participants. ***Data Collection Procedure:*** After ethical clearance from local authorities in the chosen rural and urban communities. Informed consent was obtained from parents or guardians of participating Children. Emphasizing the voluntary nature of participation, Demographic information, household characteristics, and initial health assessments of the children was collected during the first phase of data collection. Data on household air pollution levels, including sources of pollution and duration of exposure, was recorded using environmental monitoring devices in the homes of participating families. Respiratory health outcomes of children, including symptoms, lung function tests, and incidence of respiratory infections, was assessed during subsequent visits.

Analysis

This data was analyzed by descriptive and inferential statistical methods using IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA) Statistical package. The background variables of the participants were described as frequency, percentage, mean and standard deviation. The effectiveness of the intervention was calculated by one-way ANOVA with Bonferroni's t-test. The chi square used to find the association, $p<0.05$ or less taken as statistically significant.

Results

Demographic variables and their percentage, both urban (30) 50% and rural (30) 50%, were evenly distributed. Regarding age group majority fall from 4-5 years (24) 40%, most of the samples were Female children (34) 57% rather than Male children, among parent education level 42% were secondary school (25) than college and university (23) 38%, most of the children were accompanying with Parents (36) 60% rather than Grandparent (24) 40%, Most of the children were no history of any allergic reactions (34) 57%.

Table 1. To Assess the Comparative Effectiveness of Educational Programs on Indoor Air Quality

Location	Mean	Standard Deviation
Rural	8.7	6.3
Urban	11.2	3.8

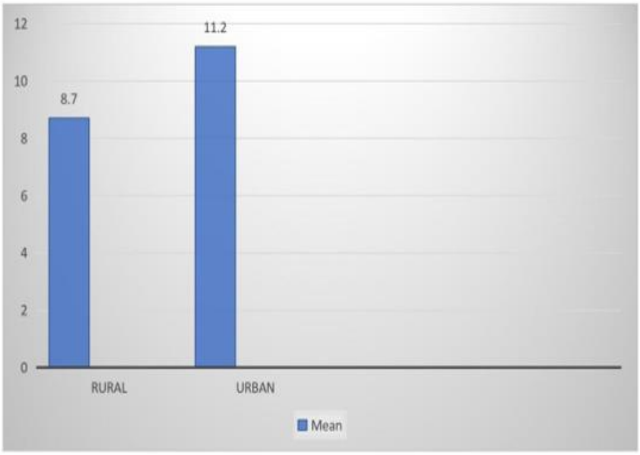

Figure 1. Factors Contributing to Household Air Pollution among Young Children in Urban and Rural Areas

The higher mean in urban areas implies, on average, a greater exposure to household air pollution among children under 5 years old in urban settings compared to rural areas. The lower standard deviation in urban areas indicates a more consistent or homogeneous level of household air pollution among children less than 5 years old, while the higher standard deviation in rural areas suggests a more diverse range of pollution levels.

In the analysis of demographic variables, specifically age, parental educational status and family income, distinct statistical tests were conducted to assess potential differences among groups. For age, a One-way ANOVA test revealed a significant difference ($F = 3.752$, $p = 0.023$) among the groups. However, a subsequent chi-squared test for independence did not show a significant association ($\chi^2 = 5.031$, $df = 3$, $p = 0.170$), indicating that while there are variations in age across groups, these differences are not statistically significant.

Discussion

The reported correlation coefficient (r) of 1.95 between Rural and Urban variables suggests a strong positive correlation, indicating a nearly perfect positive linear relationship. This exceptionally high correlation coefficient implies an extremely strong positive association between the two variables.

"A cross-sectional study conducted by Yadav et al. (2021) explored the relationship between various risk factors and tuberculosis (TB) incidence. The results indicated a positive correlation between smoking frequency and TB prevalence, with daily smokers exhibiting the highest prevalence rate (37.66%). Moreover, households relying on solid biomass-based cooking fuels had a significantly higher TB incidence (57.05%) compared to those using alternative fuels (42.95%). Other significant factors included house type, with semi-pucca houses showing a higher TB prevalence (49.86%) than pucca houses (40.53%), and household sleeping arrangements, with a higher TB prevalence observed in households with fewer sleeping rooms (<2) (74.45%) versus those with more rooms (5-6) (2.30%). Additionally, tobacco users had a higher TB incidence (59.73%) compared to non-users (40.27%) (17)."

Conclusion

The present study's findings indicate a significant disparity in household air pollution levels between rural and urban areas, with urban areas exhibiting higher concentrations of indoor air pollutants.

The study underscores the detrimental impact of solid biomass-based cooking fuels on household environments, compounded by additional risk factors such as house type, availability of rooms, tobacco use, and others, which are strongly linked to tuberculosis. A collaborative effort between governmental and non-governmental organizations is necessary to raise awareness about the adverse effects of biomass-based cooking fuels and promote cleaner alternatives.

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Ethical Approval

The Institutional Scientific Review Board under the Saveetha College of Nursing (SCON), Saveetha Institute of Medical and Technical Sciences (Deemed to be University), approved a study with the reference 688/2021/ISRB/SCON dated 25th August 2021.

Conflict of Interest

The author announces no conflict of interest.

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