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Research Article

Extreme Household Air Pollution and Respiratory Health Among Women and Children in Rural Abaji Community, Abuja, Nigeria

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Abstract

Household air pollution from biomass combustion is a major health risk in low- and middle-income countries, with women and young children receiving disproportionate exposure. Local evidence from rural communities of Nigeria's Federal Capital Territory remains limited. A mixed-methods cross-sectional study was conducted in rural communities of Abaji Area Council between November 2025 and April 2026. Household questionnaires, 48-hour indoor $PM_{2.5}$, PM_{10} and carbon monoxide (CO) monitoring, spirometry, child anthropometry, biomarker assessment, focus group discussions and key-informant interviews were used. The detailed results dataset comprised 652 households, 420 women and 579 children under five years; 100 households underwent air-quality monitoring, and 200 women were selected for spirometry. Our results showed a mean 48-hour $PM_{2.5}$ was 2,398 μg/m^3 (SD 923; range 842-5,922), while mean PM_{10} was 3,892 μg/m^3 and mean CO was 201 ppm. $PM_{2.5}$ concentrations were substantially higher in households cooking inside the main living/sleeping room than in households using a separate cooking building. Among women, 40.9% reported chronic cough, 52.4% reported clinically relevant breathlessness, and 12.0% of women with acceptable spirometry had an FEV_1/FVC ratio below 0.70. Each 100-μg/m^3 increase in $PM_{2.5}$ was associated with a 0.021-L decrement in FEV_1. The study documents exceptionally high household smoke exposure and substantial respiratory morbidity among women and children in rural Abaji. Clean-cooking transition, exposure-reduction measures and stronger primary health-care responses should be prioritized, while longitudinal studies are needed to strengthen causal inference.

Keywords

Household Air Pollution, Firewood Smoke, PM2.5, Carbon Monoxide, Spirometry, Acute Respiratory Infection, Nigeria, Abaji

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1. Introduction

Household air pollution (HAP) generated by the combustion of solid fuels remains an important environmental and public-health problem [1]. Firewood combustion produces fine particulate matter ($PM_{2.5}$), carbon monoxide (CO), volatile organic compounds and polycyclic aromatic hydrocarbons. Women and children are particularly exposed because women commonly undertake cooking and young children may remain near cooking areas during meals and food preparation [2, 3].

In Nigeria, firewood remains widely used, especially in rural communities where household income, energy infrastructure, fuel availability and social norms constrain access to cleaner alternatives [4, 5]. The present study identifies rural Abaji Area Council as an important setting because of its predominantly rural character and limited access to modern household energy. The health consequences of sustained exposure include respiratory symptoms, impaired lung function, respiratory infections, adverse pregnancy outcomes and other systemic effects [6].

The primary sources of energy for cooking in Abaji are firewood and charcoal, with limited access to cleaner alternatives such as liquefied petroleum gas (LPG) or kerosene. The lack of electricity in many remote hamlets further entrenches reliance on biomass fuels. Health facilities in the area are sparse, with only one general hospital and several primary health centres (PHCs) serving the entire area council. This context of high biomass fuel reliance, limited healthcare access, and rural poverty makes Abaji an ideal setting for investigating the public health impacts of firewood smoke exposure among vulnerable populations. The present study was designed to quantify indoor pollutant concentrations and examine their relationship with respiratory and related health outcomes among women and children in rural Abaji.

2. Materials and Methods

2.1. Study Design and Setting

The study used a mixed-methods cross-sectional design combining quantitative exposure and health assessment with qualitative inquiry. It was conducted in rural communities of Abaji Area Council in the southern part of the Federal Capital Territory, Nigeria. Abaji, one of the six area councils of the Federal Capital Territory (FCT), Abuja, Nigeria. Abaji is located in the southern part of the FCT, sharing borders with Kuje Area Council to the north, Nasarawa State to the east, and Niger State to the west. The area council has its headquarters in the town of Abaji and is predominantly rural, comprising several distinct communities.

Abaji is characterised by a tropical savanna climate with distinct wet (April-October) and dry (November-March) seasons. The vegetation is predominantly Guinea savanna woodland. The inhabitants are largely farmers, hunters, and petty traders. The population is estimated to be over 150,000 persons, with a high proportion living in rural settlements. The following rural communities within Abaji Area Council were selected for the study: Yaba, Gurdi, Mawogi, Adagba, and Alu. These communities were chosen based on their exclusive reliance on firewood for cooking, geographical dispersion across the area council, accessibility, and willingness of community leaders to participate.

2.2. Participants and Sampling

The detailed study description identifies women aged 18-49 years who were permanent residents of selected communities and whose households used firewood as the primary cooking fuel, together with their children under five years. The study documentation reports five named communities—Yaba, Gurdi, Mawogi, Adagba and Alu—and describes multi-stage community and household sampling.

The planned sample-size calculation used Cochran's formula with a conservative prevalence of 50%, a 95% confidence level and 5% precision. After allowance for clustering and non-response, the target was approximately 634 women, with a final target of 650. The detailed results section reports 652 households, 420 women and 579 children under five years.

2.2.1. The Inclusion Criteria

1) women aged 18-49 years who had been resident in the community for at least 12 months.
2) households whose primary cooking fuel was firewood (used at least 5 days per week).
3) women who gave informed consent.
4) children under five years of age whose mothers were enrolled in the study and who did not have known pre-existing congenital anomalies that could independently affect growth outcomes.

2.2.2. The Exclusion Criteria

1) women who were pregnant at the time of spirometry testing.
2) women with known pre-existing chronic respiratory diseases (e.g., asthma diagnosed by a physician) or cardiovascular diseases.
3) households using LPG, electric stoves, or kerosene as their primary cooking fuel.
4) women who smoked tobacco or used other inhaled substances.
5) children with acute febrile illness on the day of anthropometric measurements.

2.3. Data Collection

Structured questionnaires captured demographic characteristics, fuel use, cooking duration, kitchen location, ventilation,

child health history and awareness of smoke-related risks. Indoor air monitoring was conducted in 100 households using portable $PM_{2.5}$/PM_{10} monitors and CO sensors. The results reported 48-hour mean concentrations.

Spirometry was conducted in a randomly selected subsample of women. Of 200 selected women, 184 produced acceptable and repeatable flow-volume curves according to the study's stated ATS/ERS criteria. Child weight and height were measured and converted to WHO growth indices. Biomarker analyses were performed in a subset of women and children, including malondialdehyde (MDA), superoxide dismutase (SOD) and C-reactive protein (CRP).

2.4. Qualitative Component

Ten focus group discussions involving 98 women and 20 key-informant interviews were conducted with primary-health-care staff, community health workers, village heads and traditional birth attendants. Thematic analysis followed the six-phase Braun and Clarke framework. Two coders independently coded 20% of transcripts, with reported intercoder reliability above 85%.

2.5. Statistical Analysis

Descriptive statistics were used to summarise exposure and health variables. Bivariate comparisons examined differences across exposure groups. Multivariable logistic regression and linear mixed models were used to examine predictors and account for clustering. Adjusted odds ratios (AORs), 95% confidence intervals and p-values were reported. The source manuscript states that missing data were handled by complete-case analysis where missingness was below 5% and multiple imputation using MICE where missingness exceeded 5%.

2.6. Ethics

The study protocol states that ethical approval was to be obtained from the Federal Capital Territory Health Research Ethics Committee. Written informed consent was to be obtained from participants, with confidentiality and referral of participants with adverse findings.

3. Results

All 652 households in the detailed results dataset reported firewood as their cooking fuel. The median duration of firewood use by the primary cook was 12 years (IQR 7-20), and median daily cooking time was 4.5 hours (IQR 3.5-5.5). Only 24.8% of households used a separate cooking building; 7.8% cooked inside the main living or sleeping room. No household reported a chimney or dedicated smoke outlet. Children under five were present in the cooking area for at least part of the cooking event in 87.2% of households with such children.

Table 1. Household and cooking characteristics.

Indicator	Finding
Households	652
Women assessed	420
Children under 5 years	579
Households with air-quality monitoring	100
Women selected for spirometry	200; 184 acceptable tests
Median firewood-use duration	12 years (IQR 7-20)
Median daily cooking time	4.5 hours (IQR 3.5-5.5)
Cooking in main living/sleeping room	7.8%
Children present during cooking	87.2%

Table 2. Indoor air pollution.

Community	$PM_{2.5}$ mean (μg/m³)	PM_{10} mean (μg/m³)	CO mean (ppm)
Yaba	2,184	3,624	188
Gurdi	2,987	4,801	251
Adagba	1,846	3,001	144
Mawogi	3,412	5,505	312
Alu	1,422	2,389	112
Overall	2,398	3,892	201

The overall mean $PM_{2.5}$ concentration was 2,398 μg/m³ (SD 923; range 842-5,922). The source manuscript compares this with the WHO 24-hour guideline of 15 μg/m³ and interim target-1 of 75 μg/m³. Peak cooking-period concentrations reportedly exceeded 8,000-10,000 μg/m³, with a maximum recorded value of 12,400 μg/m³. Households cooking inside the main living/sleeping room had a mean $PM_{2.5}$ of 4,112 μg/m³ compared with 1,845 μg/m³ in households using a separate cooking building ($p<0.001$).

Table 3. Respiratory health among women.

Outcome	n (%)
Dry cough, past 2 weeks	498 (76.4%)
Cough with phlegm, past 2 weeks	287 (44.0%)
Chest tightness	312 (47.8%)
Shortness of breath on exertion	401 (61.5%)

Outcome	n (%)
Wheezing	189 (29.0%)
Chronic cough	267 (40.9%)
Chronic phlegm	188 (28.8%)
Breathlessness, MRC grade ≥2	342 (52.4%)
Eye irritation	612 (93.9%)
Headache during/after cooking	509 (78.1%)

Nearly one-quarter of women reported stopping cooking temporarily because of cough or breathing difficulty. Only 1.7% reported seeking care at a primary health centre specifically for a respiratory complaint.

Table 4. Lung function.

Parameter	Mean (SD)	% predicted / abnormality
FEV_1	1.69 L (0.41)	68.4% predicted; 57.6% <80% predicted
FVC	2.01 L (0.48)	71.2% predicted; 52.2% <80% predicted
FEV_1/FVC	0.84 (0.09)	12.0% <0.70

A restrictive pattern was reported in 31.5% of women, while 12.0% met the study definition of an obstructive ventilatory defect based on FEV_1/FVC <0.70. The manuscript notes that bronchodilator testing was not performed; therefore, these findings should be described as spirometric patterns rather than definitive clinical diagnoses of COPD.

In a linear mixed model, each 100-μg/m^3 increase in 48-hour mean $PM_{2.5}$ was associated with a 0.021-L lower FEV_1 (95% CI −0.033 to −0.009; p=0.002). Women in the highest $PM_{2.5}$ exposure tertile (>2,800 μg/m^3) had an adjusted mean FEV_1 0.31 L lower than women in the lowest tertile (<1,600 μg/m^3).

Table 5. Respiratory and nutritional outcomes among children.

Outcome	Finding
Probable ARI, past 2 weeks	178 children (30.7%)
Cough	294 (67.7%)
Difficult/fast breathing	137 (32.3%)
Pneumonia diagnosed by a health worker in the past year	73 (12.6%)
Reported annual ARI incidence	3.2 episodes/child-year
Stunting	166/541 (30.7%)
Underweight	126/541 (23.3%)
Wasting	69/541 (12.8%)

Children in households in the highest $PM_{2.5}$ exposure tertile had 2.41 times the odds of probable ARI compared with those in the lowest tertile (95% CI 1.52-3.81; p<0.001), after adjustment for age, sex, maternal education and crowding. The source analysis also reported that each 100-μg/m^3 increase in $PM_{2.5}$ was associated with a 0.08 reduction in height-for-age Z-score after adjustment for household wealth and food security.

Table 6. Biomarkers.

Biomarker	Exposed mean ± SD	Control mean ± SD	p-value
MDA (nmol/L)	5.62 ± 1.31	3.74 ± 0.87	<0.001
SOD (U/mL)	68.3 ± 12.1	85.7 ± 9.5	<0.001
CRP (mg/L)	5.9 ± 1.4	3.1 ± 1.0	<0.001

The biomarker subsample showed higher MDA and CRP and lower SOD among exposed participants than controls, consistent with oxidative stress and inflammation. Because the biomarker sample was small, these findings should be interpreted as supportive rather than definitive evidence of population-wide systemic effects.

4. Discussion

The principal finding is the magnitude of household smoke exposure. Mean $PM_{2.5}$ and CO concentrations were far above the guideline values cited in the source manuscript, and short-term peaks were extreme. The concentration differences by cooking location reinforce the importance of ventilation and separation of cooking areas as modifiable determinants of exposure [7].

The respiratory symptom burden among women was substantial. Chronic cough, breathlessness, eye irritation and headache were common, while objective lung-function testing identified frequent reductions in FEV_1 and FVC. The observed exposure-FEV_1 relationship strengthens the internal coherence of the study because it links measured pollution with an objective physiological outcome.

Among children, the combination of high smoke exposure,

frequent respiratory symptoms and a high prevalence of probable ARI is concerning. The higher odds of probable ARI in the highest exposure group and the reported population attributable fraction of 58% support the importance of household air pollution as a potentially preventable contributor. Similar result has been reported [5, 8]. However, because the design is cross-sectional, the findings should be expressed as associations rather than proof of causation.

The nutritional findings suggest an additional dimension of vulnerability. Stunting, underweight and wasting were common, and the reported association between $PM_{2.5}$ and height-for-age remained after adjustment for selected socioeconomic factors. This is in tandem with previous studies [9-13]. Possible mechanisms proposed in the source include recurrent infection, systemic inflammation and increased metabolic demand. These mechanisms remain hypotheses within the present cross-sectional study and require longitudinal evaluation.

However, the study limitations include the cross-sectional design, which limits causal inference; potential recall bias for self-reported symptoms and historical birth outcomes; limited biomarker sampling; and exposure measurements that may not fully capture seasonal and day-to-day variability [14, 15].

5. Conclusion

Rural households in Abaji experience very high exposure to firewood smoke, accompanied by substantial respiratory morbidity among women and children. The findings identify cooking location, ventilation and prolonged firewood use as important exposure determinants and demonstrate consistent associations between $PM_{2.5}$ and respiratory outcomes. Immediate exposure-reduction measures should be combined with sustained access to cleaner cooking technologies and stronger integration of household air-pollution prevention into primary health care.

Abbreviations

FEV_1	Forced Expiratory Volume in the First Second
FVC	Forced Vital Capacity
FEV_1/FVC	The Ratio of Forced Expiratory Volume in 1 Second to Forced Vital Capacity
MRC	Medical Research Council (Used Here as the MRC Breathlessness Scale)
ARI / ARIs	Acute Respiratory Infection / Acute Respiratory Infections
COPD	Chronic Obstructive Pulmonary Disease
WHO	World Health Organization
$PM_{2.5}$	Fine Particulate Matter with an Aerodynamic Diameter of 2.5 Micrometers or Less
PM_{10}	Particulate Matter with an Aerodynamic Diameter of 10 Micrometers or Less
CO	Carbon Monoxide
MDA	Malondialdehyde
SOD	Superoxide Dismutase
HAP	Household Air Pollution
PHCs / PHC	Primary Health Centers / Primary Health Centre

Author Contributions

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Data Availability Statement

Available on reasonable request from the corresponding author.

Conflicts of Interest

The authors declare no conflict of interest

References

[1] World Health Organization. (2023). Household air pollution and health. WHO Fact Sheet.

[2] Zigabe, S. M., et al. (2025). Impact of prenatal and postnatal household air pollution exposure on respiratory morbidity and lung function in sub-Saharan African children: A systematic review and meta-analysis. Environmental Health, 24(1), 66.

[3] Guercio, V., Pojum, I. C., Leonardi, G. S., et al. (2021). Exposure to indoor and outdoor air pollution from solid fuel combustion and respiratory outcomes in children in developed countries: A systematic review and meta-analysis. Science of the Total Environment, 755, 142187.

[4] Abonyi, I. C., Eze, P. M., Okorie, E. A., et al. (2022). Effects of biomass cooking fuels on the respiratory health of household members in Enugu State, Nigeria. Journal of Bioscience and Biotechnology Discovery, 7(2), 1-9.

[5] Olasehinde, N., et al. (2025). Cooking fuel choices and household respiratory health in Nigeria. BMC Public Health, 25(1), 265.

[6] Audu, Jonah & Gamde, Matthias & Abriba, Simon Peter & Biya, Abigail & Bashir, S. A & Daniel, Abigail & Igbinosa, Isaac & Ishola, David & Obeagu, Emmanuel. (2024). Assessment of open defecation practice among Gugugu Residents in Abuja, Nigeria. Sokoto Journal of Medical Laboratory Science. 9, 152-159. https://doi.org/10.4314/sokjmls.v9i3.15

[7] UNICEF. (2025). The Unseen Threat: How Air Pollution Sabotages Lungs and Fuels Infections in Nigeria. C^{2}REST Project.

[8] Ahmed, A., Sandhu, S., Namasopo, S., et al. (2026). Household air pollution is associated with disease severity in Ugandan children hospitalized with hypoxemic pneumonia. PLoS ONE, 21(5), e0348277. https://doi.org/10.1371/journal.pone.2026.0348277

[9] Guardian Nigeria. (2025). Cooking gas: Over 20m households stick to firewood, charcoal over affordability. The Guardian, December 31, 2025.

[10] Wahyudin, B., Putra, B. P., & Ibrahim, S. (2026). Household air pollution and risk of pneumonia in children under five: A systematic literature review from low- and middle-income countries. Jurnal Ners, 10(2), 3142-3152.

[11] Mehta SS, Elizabeth Hodgson M, Lunn RM, et al. (2023). Indoor wood-burning from stoves and fireplaces and incident lung cancer among Sister Study participants. Environ Int 2023; 178: 108128. https://doi.org/10.1016/j.envint.2023.108128

[12] Piper R, Tremper A, Katsouyanni K, et al. (2024). Associations between short-term exposure to airborne carbonaceous particles and mortality: A time-series study in London during 2010-2019. Environ Pollut 2024; 360: 124720. https://doi.org/10.1016/j.envpol.2024.124720 pmid: 39142429.

[13] Kuye A, Kumar P. Particulate matter exposure from different heating stoves and fuels in UK homes. Sci Rep 2025; 15: https://doi.org/10.1038/s41598-025-05886-1

[14] Department of Health and Social Care. Chief medical officer's annual report 2022: air pollution. 8 Dec., 2022. https://assets.publishing.service.gov.uk/media/639aeb81e90e0721889bbf2f/chiefmedical-officers-annual-report-air-pollution-dec-2022.pdf

[15] Brighton and Hove City Council. Data shows particle pollution almost doubles during winter months. 2 Dec., 2025. https://www.brighton-hove.gov.uk/news/2025/data-shows-particle-pollutionalmost-doubles-during-winter-months