

HOUSEHOLD FUEL USE, AIR POLLUTION AWARENESS, AND ENVIRONMENTAL BEHAVIOUR DURING WINTER: EVIDENCE FROM NAHIYA 12, KABUL, AFGHANISTAN

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Abstract

Winter air pollution in Kabul, Afghanistan, is a significant environmental and public health concern, largely driven by household reliance on solid fuels for heating in rapidly urbanizing areas such as District 12. This study aimed to evaluate household fuel consumption patterns, examine public awareness of air pollution, and assess environmental behaviours contributing to winter air quality degradation. A cross-sectional study was conducted using a structured 30-item questionnaire covering sociodemographic characteristics, fuel use, awareness, and environmental practices; data were collected from 350 households and analyzed using descriptive statistics and chi-square tests to assess associations between sociodemographic factors and air pollution knowledge and behaviors. Coal (55.7%) and firewood (20.3%) were the primary household fuels, with increased usage during winter. Most respondents reported awareness of air pollution and its health impacts; however, knowledge of monitoring systems, pollution sources, and mitigation strategies remained limited, and adoption of cleaner energy alternatives was low. Education level was significantly associated with both air pollution knowledge and environmental behavior ($p < 0.001$), whereas household income was not significantly associated with these outcomes. The findings demonstrate a gap between awareness and environmental practices, influenced by financial constraints, limited access to clean energy, and increased winter heating demand; targeted interventions are needed to promote affordable renewable energy options, enhance public environmental education, and strengthen institutional engagement.

Keywords: Household fuel consumption, winter air pollution, Solid fuels, Coal and firewood, Public awareness, Environmental behavior, Urban air quality

Introduction

Air pollution is one of the leading environmental and public health challenges worldwide, resulting from the presence of harmful gases, particulate

matter, and aerosols that negatively affect human health and ecosystems (Bist *et al.*, 2022; Chaitanya *et al.*, 2024; Namasivayam *et al.*, 2024). Air pollutants may originate from natural or

anthropogenic sources and are generally classified as primary pollutants, which are directly emitted into the atmosphere, such as carbon monoxide and sulfur dioxide, and secondary pollutants, such as ground-level ozone, which are formed through atmospheric reactions involving primary pollutants (Al-Shidi *et al.*, 2021; Singh *et al.*, 2025). According to the Global Burden of Disease study, air pollution is among the leading risk factors for premature mortality worldwide and contributes significantly to respiratory diseases, cardiovascular disorders, cancer, inflammation, and other adverse health outcomes (Henein *et al.*, 2022; Lindstrom *et al.*, 2022; Mor *et al.*, 2022; Nishida *et al.*, 2022; Sultan-Zoi *et al.*, 2024). Due to its substantial toxicological impacts on human health and the environment, air pollution remains a major global concern, with particularly severe consequences in developing countries such as Afghanistan (de Bont *et al.*, 2022; Sun *et al.*, 2023; Water *et al.*, 2025).

In Afghanistan, rapid population growth, unplanned urban expansion, and increasing pressure on urban infrastructure have contributed to declining air quality, particularly in Kabul, the country's capital and most densely populated city (Development and Undefined, 2024; Khan *et al.*, 2023; Li *et al.*, 2022). Previous studies have identified vehicle emissions, wind-blown dust, domestic heating, diesel generators, and industrial activities as major contributors to Kabul's air pollution (Guttikunda *et al.*, 2023; Sharifi *et al.*, 2024). Among these sources, the widespread use of coal and firewood for household heating and cooking during winter significantly increases emissions of harmful pollutants and contributes to seasonal deterioration of urban air quality (Guttikunda *et al.*,

2023). However, reducing air pollution requires not only emission control measures but also active community participation and behavioral changes (Kiss *et al.*, 2022; Zhang *et al.*, 2022). Public knowledge, perceptions, and attitudes toward air pollution play an important role in shaping individual behaviors, reducing exposure, and supporting mitigation strategies (Thompson *et al.*, 2024). Environmental education, public campaigns, and media engagement are also essential for improving awareness and encouraging participation in air pollution reduction efforts (Fogg-Rogers *et al.*, 2024; Science and Undefined, 2020).

Although previous research in Kabul has mainly focused on air quality measurements and emission sources (Afghan *et al.*, 2022), limited attention has been given to understanding household fuel-use patterns, public awareness, and environmental behaviors at the community level, particularly within specific urban areas such as individual Nahiyas (Ward *et al.*, 2022). Therefore, this study aimed to assess household fuel consumption patterns, evaluate public awareness of air pollution, and examine environmental behaviors associated with winter air pollution in District 12 of Kabul, Afghanistan.

Study Area

This study was carried out in Nahiya 12, Kabul, an urban residential nahiya of Kabul City, Afghanistan. According to UN-Habitat, Kabul is characterized by rapid urban expansion, high residential density, and a significant proportion of unplanned settlements, with restricted access to essential urban amenities (UN-Habitat, 2019). District 12 is located across the Logar River to the east of District. Districts 22 and 21 share an

eastern border. District 19 borders the district on the north, while the Kabul River borders it on the south. The region has an excellent primary link to the city center since it is located between the two roadways that connect Kabul and Nangarhar Provinces. Located in the center of District 12, Pule Charkhi Prison is one of the most well-known urban characteristics.

District 12 reflects these broader urban characteristics, consisting of a mixture of planned communities and informal housing areas. Infrastructure limitations are common, especially with regard to energy availability and housing quality and Residential buildings are closely spaced (UN-Habitat, 2019). Urban household energy choices are influence by such condition, particularly in winter.

Kabul experiences cold winter situation, making heating a basic necessity need in homes. Due to restricted access to modern energy services, residents in urban residential areas like District 12 frequently rely on locally accessible fuels for heating and cooking (UN-Habitat, 2019). These actions make residential fuel usage more significant as a household level contributor to winter air pollution.

District 12 was selected as the research site because it represents a typical urban residential environment in Kabul where household fuel use and winter weather conditions combine. Consequently, the region provides an appropriate environment for examining the connection between exposure to winter air pollution and home fuel usage.



Fig. 1: Map of Kabul Nahiyas

Material and Method

Sample Size and Sampling Technique

A cross-sectional survey design was employed in this study using a structured 30-item questionnaire consisting of four sections: socio-demographic characteristics, knowledge, behavior, and practice.

Sample Size Determination

The sample size was determined using Cochran's formula (1977) for estimating proportions in large populations.

$$n = \frac{Z^2 \cdot p(1 - p)}{d^2}$$

Where:

n = required sample size

Z = Z-value at 95% confidence level.

p = estimated proportion of households using solid fuels.

d = margin of error.

Where Z = 1.96, p = 0.5, and d = 0.05.

The calculated sample size was 384.

However, due to time and resource constraints, 350 households were included in the study. Although this still provides adequate statistical reliability for descriptive analysis.

Sampling Technique

A systematic random sampling technique was used to select households within District 12. Initially, the region was divided into residential blocks, and households. In every block, a beginning household was chosen at random. Next, based on a predetermined sample interval (e.g., every third or fifth house, depending

on density), every k-th family was chosen. This strategy guaranteed: Improved geographical coverage of the research region and decreased selection bias in contrast to convenience sampling. Simple random sampling was used in places where systematic selection was impractical, such as informal settlements.

Data Collection

Data collection was conducted from December 2025 to February 2026 among 350 households in District 12, Kabul, using face-to-face interviews with a standardized questionnaire. The questionnaire was designed to obtain information on socio-demographic characteristics (age, education, gender, and occupation), household fuel use (types of fuel used for residential purposes, heating, and cooking, as well as consumption patterns), awareness and perception of air pollution, and environmental behavior and practices. A three-point Likert scale was used to assess respondents' knowledge, ranging from high to low. Practices were documented using binary (yes/no) responses, while behavioral questions focused on the types and quantities of fuels used, such as wood, coal, plastic, and gas. The questionnaire's main goal was to gather pertinent information about respondents' knowledge, behaviors, and practices in connection to the research objectives. It was pre-tested to guarantee clarity, consistency, and reliability.

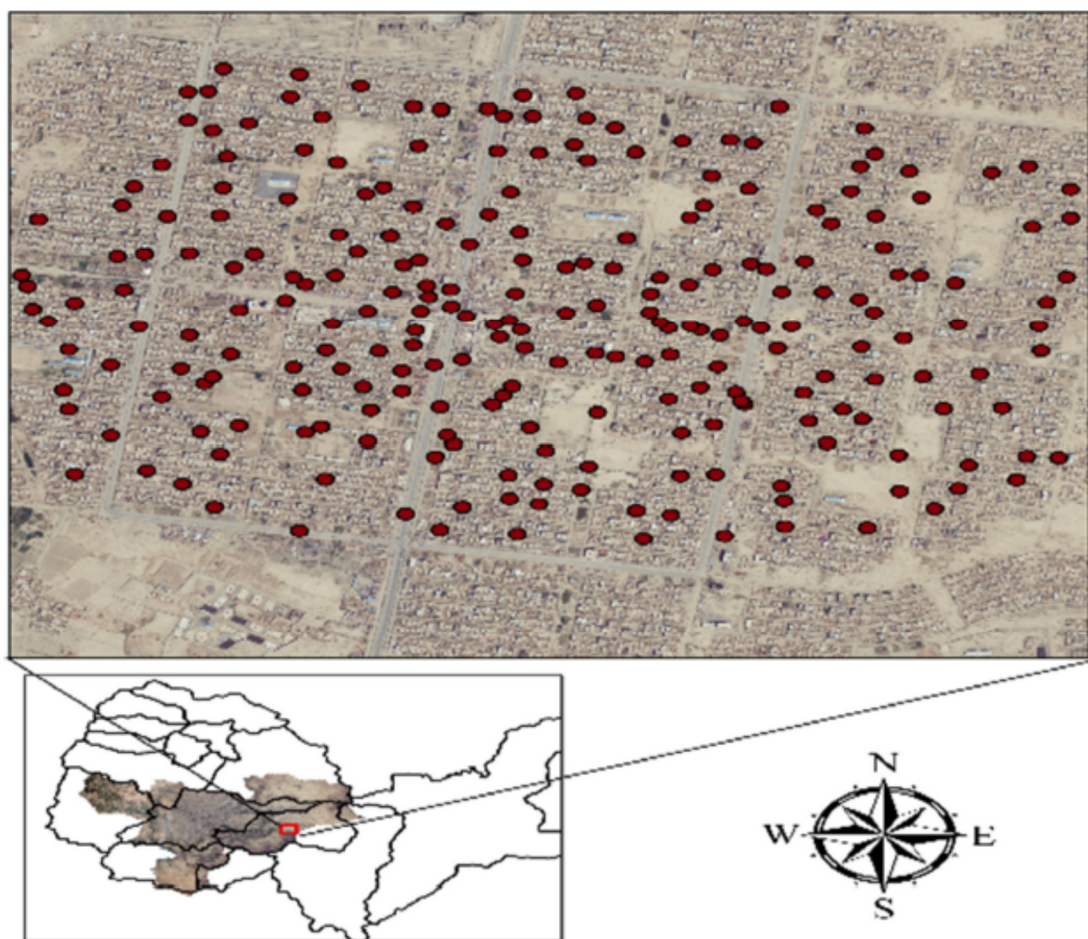


Fig.2. Locations of the sampling sites on the map of district 12, Kabul

Statistical Analysis

The collected data were input and arranged using Microsoft Excel and analyzed using IBM SPSS Statistics software.

Socio-demographic characteristics, air pollution awareness, environmental behaviors and household fuel use patterns, were all summarized using descriptive statistics, such as frequencies and percentages. Tables and figures are used to display the results.

The chi-square (χ^2) test of independence in SPSS was used to evaluate associations between specific categorical variables. Statistical significance was defined as a p-value of less than 0.05. The chi-square test was

applied to assess associations between education level and air pollution knowledge, education level and environmental behavior, household income and air pollution knowledge, and household income and environmental behavior.

Result

Socio-demographic Characteristics of Respondents

Table 1 presents the socio-demographic characteristics of the 350 respondents. The majority of participants were aged 18–24 years (55.1%), followed by those aged 25–34 years (34.3%). Respondents aged 35–40 years, 41–50

years, and above 50 years represented 5.1%, 4.0%, and 1.4% of the sample, respectively. Regarding educational status, 54.6% of respondents had school-level education, 28.0% had graduate-level education or above, 11.1% had undergraduate education, and 6.3% had no formal education. The majority of respondents were male (93.7%), while females accounted for 6.3%. The largest occupational groups were private-sector employees (31.1%), students (26.0%), and

government employees (16.8%). Regarding monthly household income, the majority of households reported relatively low income levels. The largest proportion of households (38.6%) had a monthly income of 5,000–10,000 Afghani (Afg), followed by those earning 1,000–5,000 Afg (30.9%). Overall, 69.5% of households reported monthly incomes below 10,000 Afg, while only 8.3% reported incomes between 20,000 and 50,000 Afg.

Table1. Socio-demographic characteristics of respondents (n=350)

Variables	Category	Frequency(n)	Percentage (%)
Age	18-24	193	55.1
	25-34	120	34.3
	35-40	18	5.1
	41-50	14	4
	>50	5	1.4
Education	No formal education	22	6.3
	School level	191	54.6
	Undergraduate	39	11.1
	Graduate & above	98	28.0
Gender	Male	328	93.7
	Female	22	7.3
Occupation	Unemployed	42	12
	Student	91	26
	Government employees	59	16.8
	Private sector	109	31.1
	Self-employed	35	10
	Skilled labor	14	4
Monthly household income (Afg)	1,000–5,000	108	30.9
	5,000–10,000	125	38.6
	10,000–20,000	78	22.3
	20,000–50,000	29	8.3

The results indicate that the majority of respondents were young adults aged 18–24 years, representing more than half of the sample. Most participants had at least school-level education, and the sample was predominantly male. In terms of occupation, private-sector employees and students constituted the largest

groups. Regarding socioeconomic status, the majority of households reported relatively low monthly incomes, with 69.5% earning below 10,000 AFN. These characteristics suggest that the study population mainly consisted of young, moderately educated individuals from predominantly low-income households.

Table 2. Association between household income and air pollution-related knowledge/behavior (n=350)

Association between household income and Air Pollution Knowledge							Association between household income and Behavior to Air Pollution					
Household Income	Yes /n, (%)	No/ n,(%)	Total number	χ^2	df	p-value	Yes /n, (%)	No/ n,(%)	Total number	χ^2	df	p-value
1,000–5,000	70 (64.9%)	38 (35.1%)	108	≈ 0.50	3	≈ 0.92	56(52.1%)	52(47.9%)	108	≈ 3.01	3	$p \approx 0.39$
5,000–10,000	82 (65.6%)	43 (34.4%)	125				72(57.5%)	53(42.5%)	125			
10,000–20,000	48 (61.5%)	30 (38.5%)	78				45(57.1%)	33(42.9)	78			
20,000–50,000	19 (65.5%)	10 (34.5%)	29				20(67.9%)	9(32.1%)	29			

The results indicate that there was no statistically significant association between household income and knowledge of air pollution ($\chi^2 \approx 0.50$, df = 3, $p \approx 0.92$). Although respondents across all income groups showed relatively similar levels of knowledge, with the majority in each category reporting awareness, the differences were not statistically meaningful.

Similarly, there was no statistically significant association between household income and behavior related to air pollution ($\chi^2 = 3.01$, df = 3, $p \approx 0.39$). While slight variations in behavior were observed among different income groups, these differences were not significant, indicating that income level did not substantially influence respondents' behavioral practices regarding air pollution.

Table 3. Association between education level and air pollution-related knowledge/behavior (n=350)

Association between Education Level and Air Pollution Knowledge							Association between Education Level and Behavior to Air Pollution					
Education Level	Yes /n, (%)	No/ n, (%)	Total number	χ^2	df	p-value	Yes /n, (%)	No/ n, (%)	Total number	χ^2	df	p-value
No formal education	7(30%)	15(70%)	22	≈ 42.81	3	<0.001	8(36.3%)	14(63.7%)	22	≈ 20.8	3	<0.001
School level	94(49.3%)	97(50.7%)	191				95(49.7%)	96(50.3%)	191			
Undergraduate	25(63.5%)	14(36.5%)	39				26(66%)	13(34%)	39			
Graduate & above	84(83.5%)	14(14.4%)	98				80(81.2%)	18(18.8%)	98			

The chi-square analysis revealed a statistically significant association between education level and knowledge of air pollution ($\chi^2 = 42.81$, df = 3, $p < 0.001$). The results indicate that respondents with higher levels of education demonstrated greater awareness of air pollution

compared to those with lower educational attainment.

Similarly, a statistically significant association was observed between education level and behavior toward air pollution ($\chi^2 = 20.8$, df = 3, $p < 0.001$). Participants with higher education levels

exhibited more positive environmental behavior, whereas those with lower levels of education showed comparatively poorer practices.

Household Fuel Types and Energy

Sources

The distribution of household fuel types used for residential activities, heating, and cooking is presented in Figer 1. Coal was the most commonly used household fuel (55.7%), followed by

wood (20.3%) and plastic (13.7%). The use of gas and electricity accounted for 6.6% and 4.0%, respectively. For space heating, coal was the dominant fuel (51.1%), followed by wood (31.7%). Gas (7.4%), plastic (6.6%), and electricity (2.6%) were less frequently used for heating. For cooking purposes, gas was the most commonly used fuel (60.0%), followed by wood (24.0%).

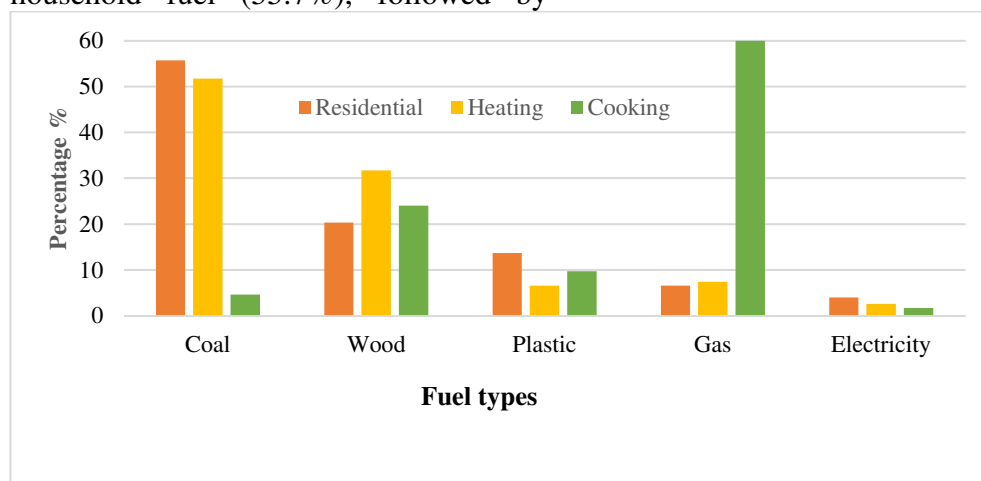


Fig. 3: Distribution of Household Fuel Types by Use

The findings show that most of household use coal and firewood as fuel, particularly for heating. Smaller proportion of households used cleaner energy sources such as gas and electricity, indicating continued dependence on solid fuels.

Quantity of Household Fuel Consumption

Annual and winter fuel consumption patterns are presented in Figure 4 and 5. For firewood consumption, 45.7% of

households reported annual consumption between 81–160 kg, while 28.6% consumed 161–400 kg annually. During winter, 34.6% of households consumed 81–160 kg and 25.4% consumed 161–400 kg of firewood. For coal consumption, 34.3% of households reported annual consumption of 81–160 kg, while 31.4% consumed less than 80 kg. During winter, 31.1% consumed less than 80 kg and 26.8% consumed 81–160 kg of coal.

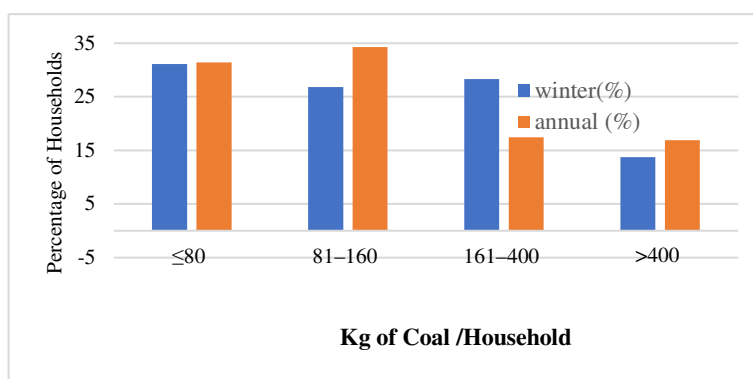
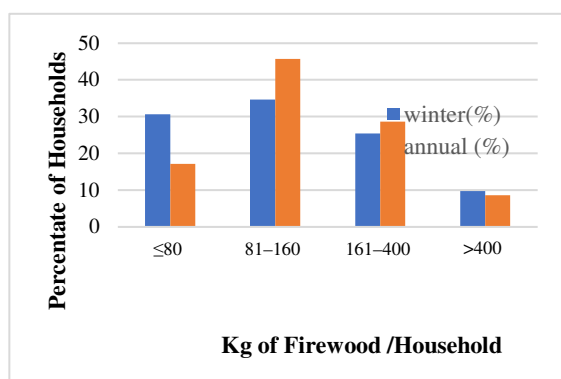


Fig. 4: Seasonal firewood consumption Fig. 5: Seasonal Coal consumption

Awareness and Perception of Air Pollution

Table 4 presents respondents' awareness and perception of air pollution. About 45.5% of respondents had a high level of awareness, while 31.5% and 23.0% had medium and low awareness levels, respectively. Most respondents reported that air pollution was higher during winter

(85.1%) and that low-quality fuels increase pollution (88.8%). Residential areas and heating activities were identified as pollution sources by 57.4% and 52.2% of respondents, respectively. Most respondents reported limited awareness of air quality monitoring devices (94.1%) and information provided by NEPA (79.1%).

Table 4. Awareness and perception of air pollution

Question	High (%)	Medium (%)	Low (%)
Awareness of air pollution	45.5	31.5	23.0
Air quality improved recently	73.4	18.9	7.7
Residential area contributes to pollution	57.4	28.0	14.6
Heating activities cause pollution	52.2	32.9	14.9
Cooking activities cause pollution	7.7	16.3	76.0
Pollution higher in winter	85.1	—	14.9
Low-quality fuel increases pollution	88.8	10.3	1.0
Air quality monitoring devices available	1.6	4.3	94.1
NEPA provides pollution information	8.3	12.6	79.1

The findings show that while a considerable percentage of respondents expressed medium to high awareness of air pollution, there was still a lack of specific understanding about institutional functions and monitoring methods. This suggests a gap between general awareness and specific environmental knowledge.

Environmental Behavior and Willingness

Table 5 presents environmental behaviors and willingness to adopt cleaner

practices. Most respondents reported previous use of clean fuels (80.0%) and willingness to use clean fuels in the future (96.1%). A high proportion of respondents reported using or planning to use low-pollution technologies (98.0%). However, willingness to use solar energy was reported by 11.0% of respondents, and 24.0% reported cooperation with environmental authorities.

Table 5. Environmental behavior and willingness

Statement	Yes (%)	No (%)
Used clean fuel in the past	80.0	20.0
Willing to use clean fuel in future	96.1	3.9
Uses/plans to use low-pollution devices	98.0	2.0
Willing to use solar energy	11.0	89.0
Received information from NEPA	86.0	14.0
Cooperates with environmental department	24.0	76.0
Would use harmful fuel if cheaper	19.0	81.0
NEPA has taken measures to reduce pollution	91.5	8.5

Most respondents expressed willingness to adopt environmentally friendly and cleaner energy sources. However, actual adoption of renewable energy options, such as solar energy, remained low, indicating possible economic or infrastructural barriers. However, the actual uptake of renewable energy sources, like solar energy, remained low, suggesting potential infrastructural or financial obstacles.

Discussion

This study demonstrated a strong dependence on solid fuels, particularly coal and firewood, among households in District 12, Kabul. The findings indicate that household energy choices remain largely influenced by the availability, affordability, and accessibility of fuels, especially during the winter season when heating demand increases. Similar trends have been noted in developing countries, where households still utilize solid fuels due to limited access to environmentally friendly and cleaner energy alternatives (Guttikunda *et al.*, 2023; Water *et al.*, 2025). The widespread burning of coal and firewood indicated in this study represents an important household air pollution concern because the burning of solid fuels is associated with the release of harmful pollutants and increased health risks (Guttikunda *et al.*, 2023). Prior

studies in Kabul have also determined vehicle emissions, along with domestic heating, generators, dust, and industrial activities, as important factors to urban air pollution sources (Guttikunda *et al.*, 2023; Sharifi *et al.*, 2024).

The observed increase in firewood and coal use during winter emphasize the important role of seasonal heating needs in household fuel consumption patterns. In cold seasons, households often increase their dependence on accessible fuels to maintain indoor thermal comfort, particularly in areas where access to efficient clean energy and heating systems sources is limited. Similar seasonal reliance on solid fuels has been reported in other urban areas where household heating activities contribute to increased air pollution risks during winter (Sun *et al.*, 2023). The reported increase in solid fuel use during winter indicates a period of potentially higher household air pollution risk, although this study did not directly measure air pollutant concentrations,

The results also indicated that participants generally had moderate to high its health impacts and awareness of air pollution; however, important knowledge gaps remained regarding institutional information, air quality monitoring systems, and specific household pollution sources. This suggests that awareness of air pollution as

a general environmental problem does not always translate into detailed understanding of effective mitigation strategies or pollution sources. Prior research has indicated the importance of, perception, public knowledge, and attitudes in influencing environmental behaviors and supporting pollution reduction efforts (Thompson *et al.*, 2024). Environmental education, public communication, and access to reliable information are therefore important components of household air pollution mitigation strategies (Fogg-Rogers *et al.*, 2024).

A further important finding of this study was the significant association between education level and both knowledge and behavior related to air pollution. Individuals with higher levels of education demonstrated greater awareness of air pollution and more positive environmental practices compared to those with lower educational attainment. This highlights the role of education as a key determinant in shaping environmental knowledge and responsible behavior. Educated individuals are more likely to access, interpret, and apply environmental information, which may lead to improved decision-making regarding household energy use and pollution reduction practices. Similar findings have been reported in previous studies, where education was identified as a strong predictor of environmental awareness and pro-environmental behavior (Faisal *et al.*, 2021; Hoffmann *et al.*, 2021; UNEP, 2019). These findings suggest that strengthening environmental education and public awareness programs could significantly improve household-level practices and contribute to reducing air pollution exposure.

A notable finding of this study was the gap between respondents' willingness to adopt cleaner practices and their actual household fuel-use patterns. Although most participants expressed willingness to use cleaner fuels and low-pollution technologies, many households continued to depend on coal and firewood, particularly during winter. This difference between environmental attitudes and practices may be influenced by economic limitations, fuel availability, infrastructure constraints, and household energy needs. Similar attitude-behavior gaps have been reported in environmental health studies, where willingness to adopt sustainable practices is often restricted by affordability and accessibility of alternatives (WHO, 2025; Zhang *et al.*, 2021).

The findings highlight the need for integrated strategies to reduce household air pollution risks in Kabul. Policies should focus on improving access to affordable clean energy options, promoting efficient household heating technologies, strengthening environmental education, and increasing collaboration between communities and environmental institutions. Community participation is essential because household energy choices and daily practices play an important role in reducing pollution-related risks (Kiss *et al.*, 2022; H. Zhang *et al.*, 2022).

This study has several limitations. First, the cross-sectional design limits the ability to establish causal relationships between household fuel use and air pollution risks. Second, information on fuel consumption, awareness, and behaviors was obtained through self-reported questionnaires, which may introduce recall or response bias. Third, the study was conducted in District 12 of

Kabul; therefore, the findings may not fully represent all households in Kabul or other regions of Afghanistan.

Conclusion

This study investigated household fuel consumption patterns, public awareness, and environmental behaviors associated with winter air pollution in District 12, Kabul, Afghanistan. The findings revealed continued dependence on solid fuels, particularly coal and firewood, for household heating during winter. Although respondents showed high awareness of air pollution and its health impacts, a gap remained between awareness and actual environmental practices, including limited adoption of cleaner energy alternatives. Education level was significantly associated with air pollution-related knowledge and environmental behavior, highlighting the importance of environmental education in promoting sustainable practices. Reducing household air pollution requires improving access to affordable clean energy, strengthening awareness programs, enhancing institutional communication, and encouraging public participation in sustainable energy transitions.

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