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Research Article

Preventive Behaviors Against PM_{10} Exposure in Kitchens of Rural Thai Households Using Charcoal for Cooking

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Abstract
Indoor air pollution from particulate matter (PM_{10}) poses a considerable public health hazard, especially in rural areas where traditional cooking fuels like charcoal are prevalent. The objective of this study was to assess preventive behaviors against PM_{10} exposure among households using charcoal for cooking in rural Thailand. A cross-sectional descriptive survey involving 400 participants from 13 rural Thai communities revealed excessive PM_{10} levels and highlighted the limited information available on effective preventive measures. Descriptive statistics, including frequency and percentage, were used for data analysis. Binary logistic regression was employed to determine the correlation between various factors and levels of PM_{10} preventative behaviors. Ninety-eight point three percent of participants exhibited majority understanding of PM_{10} preventive behavior; however, deficiencies persisted in several domains, including comprehension of particle size and the implications of ventilation. Despite this awareness, preventative measures were largely inappropriate (84.0%), with only 14.8% exhibiting effective protective behaviors. The primary preventive strategy was the consistent use of air purifiers (67.2%), while essential practices such as avoiding burning sites, thorough post-exposure cleaning, maintaining household hygiene, and undergoing annual physical examinations were rarely implemented. Association analysis indicated that individuals with congenital illnesses exhibited a substantially higher propensity to undertake high-level PM_{10} preventative actions (aOR = 1.72, 95% CI: 1.12–2.63, p = 0.013). The study emphasizes the need for targeted interventions, including community education, behavioral incentive strategies, and structural modifications such as improved kitchen ventilation.

Keywords: prevention, behavior, PM_{10}, charcoal, cooking, rural homes

1. INTRODUCTION

Air pollution has emerged as an increasing public health issue, particularly in indoor settings, where individuals spend the majority of their time. Numerous studies have assessed particulate matter (PM) concentrations in individual environments as an indicator of exposure over the entire residence [1]-[3]. Even with low dosages and short durations, exposure to PM can lead to impaired pulmonary function, worsening of cardiorespiratory disorders, and cancers [4][5]. Household PM pollution is a leading risk factor for mortality and morbidity, particularly in developing countries [6][7]. The health effects of particulate matter on residents are influenced by their daily activities [8][9].

The northeastern region of Thailand consists mainly of agricultural communities, where the farmers' income primarily depends on annual fluctuations in agricultural output. As a result, most individuals in the northeastern region continue to use charcoal as a cooking fuel in their residences. The charcoal used is either self-produced or obtained at a lower cost than other fuel sources. In Pho Yai Subdistrict of Warin Chamrap District, Ubon Ratchathani Province, Thailand, charcoal is the predominant cooking fuel used by more than 95% of households in this rural area. The concentration of PM in the kitchen area varies depending on design differences [10][11]. Srithawirat et al. found that the average amount of PM_{10} in the kiln zone exceeded both Thailand's National Ambient Air Quality Standards (NAAQS) and the World Health Organization's (WHO) suggestions [12]. Therefore, individuals in these households might experience varied levels of particulate matter exposure. Risk behaviors related to exposure to fine particulate matter depend on numerous factors, particularly individuals' understanding of PM-related risks [13]. Exposure levels change with the seasons, with higher indoor $PM_{2.5}$ and PM_{10} concentrations during the winter [14]. The levels of black carbon were observed to be elevated after using charcoal grills and candles [15]. An earlier investigation by Boonkhao et al.

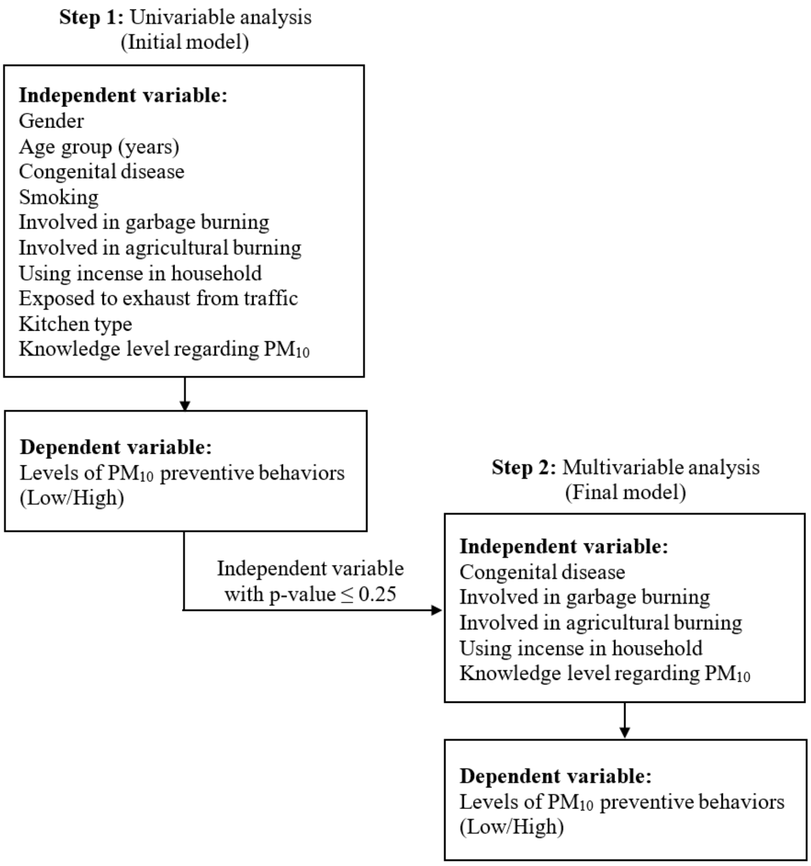

Figure 1. Logistic regression analysis flow chart, from univariable (step 1) to multivariable analysis (step 2).

found that PM_{10} levels were above the limit at all examined locations, including rural Thai homes utilizing charcoal for cooking, both in open and closed kitchens [16]. In enclosed kitchens, measurements reached a maximum of 1,020 µg/m³. However, there is a deficiency of information regarding preventive measures against PM_{10} exposure in the kitchens of rural Thai homes that utilize charcoal for cooking. Furthermore, prior research suggests that enhanced knowledge and risk perception serve as crucial factors in protective activities against air pollution [17][18]. Therefore, the objective of this study was to assess preventative behaviors against PM_{10} exposure among households using charcoal for cooking in rural Thailand.

2. MATERIALS AND METHODS

This research is a cross-sectional descriptive study examining preventive behaviors related to PM_{10} in households using charcoal for cooking in Pho Yai Subdistrict, Warin Chamrap District, Ubonratchathani Province. The study was conducted from June to December 2024.

2.1. Population and Sample

The population includes individuals aged 18 and older residing in households using charcoal as cooking fuel, totaling 1,756 households across 13 villages. The sample group was determined using the population proportion estimation Formula 1 and 2 [19];

$$n = \frac{[NZ^2_{\alpha/2}P(1-P)]}{[e^2(N-1) + Z^2_{\alpha}P(1-P)]} \quad (1)$$

where n is sample size, N is population (1,756 households) ,Zα/2 is the coefficient under the standard normal curve at 95% confidence level, Z (0.025) = 1.96, p is proportion of participants received information regarding preventive measures against dust exposure is 0.84 [20], and e is precision of estimate.

$$n = \frac{1756(1.96^2)(0.84)(1-0.84)}{(0.035^2)(1756-1) + (1.96^2)(0.84)(1-0.84)} = 348.70 \quad (2)$$

The researchers employed incidental sampling to gather data from 400 individuals residing in 13 villages. Interviews were conducted to collect questionnaires from the participants. The inclusion criteria encompass homes residing in Pho Yai Subdistrict, Warin Chamrap District, Ubon Ratchathani Province, with participants aged 18 years and older, specifically focusing on those who serve as the primary cooks within the household.

2.2. Research Tools

The questionnaire consists of three sections, as detailed, general information, This section comprises a closed-ended question with multiple options, including gender, chronic illnesses, smoking history, exposure to PM_{10} from various activities, and kitchen characteristics. Knowledge regarding PM_{10}, This section includes 10 binary questions. The score is interpreted as 0 points for an incorrect answer and 1 point for a correct answer. The cumulative score is ten points. Data are analyzed and categorized into three levels of knowledge: high, moderate, and low. Then, the scores were subsequently categorized into two groups—low and high—using a median threshold value of 8 for further statistical analysis. Preventive

Table 1. Participants's general characteristics (n=400).

General Characteristics	Number	Percentage (%)
Gender		
Female	315	78.8
Male	85	21.2
Age (years) (Mean = 55.34±11.13, Minimum=22, Maximum=88)		
20-40	30	7.5
41-60	259	64.8
61-80	104	26.0
>80	7	1.7
Congenital disease		
No	239	59.8
Yes	161	40.2
Diabetes	91	56.5
Hypertension	65	40.4
Asthma	3	1.9
Allergies	2	1.2
Smoking history		
Yes	30	7.5
No	362	90.5
Used to smoke	8	2.0
Exposure to dust from other activities (can answer more than 1)		
Involved in garbage burning	175	38.0
Involved in agricultural burning	86	18.7
Using incense in household	48	10.5
Exposed to exhaust from traffic	151	32.8
Kitchen type		
Open	250	62.5
Closed	150	37.5

Table 2. Knowledge level regarding PM_{10}.

Knowledge Levels	Number	Percentage (%)
High	393	98.3
Moderate	3	0.7
Low	4	1.0

behavior regarding PM_{10},This section includes 10 items presented in a question format with three response options: always, sometimes, and never. Scoring if the inquiry is positive, answer "always" with 3 points, "sometimes" with 2 points, and answer "never" for 1 point. For negative questions, the scoring is inversely applied to the aforementioned three components. The behavior scores are categorized into three levels: appropriate, moderate, and behavior requiring improvement. Then, the PM10 preventive behavior scores were then categorized into low and high categories using a median score of 22 as the threshold for further statistical analysis.

2.3. Research Tool Quality Assessment

The questionnaire had a content validity evaluation conducted by three experts, who were professors from the College of Medicine and Public Health at Ubon Ratchathani University. These specialists focus on risk assessment, public health, and air pollution, and the Item-Objective Congruence (IOC) Index ranged from 0. 67to 1.00. Reliability testing was conducted with a sample of 30 individuals from rural regions in Surin Province, Thailand. The two components of the questionnaire that underwent reliability testing were Knowledge regarding PM_{10}, Kuder-Richardson statistics, the KR-20 computation, yielded a value of 0.72 ,which is deemed acceptable. Preventive behavior regarding PM_{10} ,The Cronbach Alpha Coefficient was used for reliability assessment, yielding a reliability value of 0.7 ,which is deemed satisfactory [21].

2.4. Data Collection

Interviews were conducted with 400 individuals who served as household representatives in 13 villages in Pho Yai Subdistrict, Ubon Ratchathani Province, to gather general information, knowledge of PM_{10} ,and preventive behaviors. Samples were gathered by researchers proficient in interviewing, who refrained from guiding respondents to avoid bias in data collection.

2.5. Data Analysis

Quantitative data were evaluated using mean and standard deviation, whereas qualitative analysis was conducted using descriptive statistics such as frequency and percentage distribution. Univariable binary logistic regression was initially utilized to determine the relationship between each independent variable (10 variables in total) and the low/high levels of PM_{10} preventive behaviors. Variables with a p-value $\leq$ 0.25 (including 5 variables namely congenital disease, involvement in garbage burning, involvement in agricultural burning, incense usage in the household, and knowledge level regarding PM_{10} preventive behaviors) were then included in the multivariable analysis as shown steps of analysis in Figure 1. This step ensured the inclusion of only the most pertinent variables, thus enhancing the robustness and reliability of the findings. As a result, only a single adjusted logistic regression model was presented in the multivariable analysis, reflecting the detailed analysis previously described. The results are presented as crude odds ratio (cOR) and adjusted odds ratio (aOR) with 95% confidence intervals (95% CI). A significance level of p-value 0.05 was employed. All statistical analyses were conducted using SPSS for Windows version 22 (IBM Corp, Armonk, NY).

2.6. Ethical Consideration

This study was approved by the Human Research Ethics Committee of Ubon Ratchathani University) code UBU-REC-175/2567, November 13, 2024 .(The effective period is from November 13, 2024, to November 12, 2025.

3. RESULTS AND DISCUSSIONS

The participants had the following

Table 3. Knowledge regarding PM_{10} (n=400).

No.	Knowledge regarding PM_{10}	Right answer	
		Number	Percentage (%)
1	PM_{10} consists of particles with a diameter not exceeding 10 microns.	355	88.8
2	Numerous reasons contribute to dust production, including charcoal used as cooking fuel, emissions from power plants, vehicular exhaust, deforestation through burning trees, waste incineration, and cigarette smoke.	396	99.0
3	PM_{10} can induce inflammation and irritation in the respiratory system.	394	98.5
4	Prolonged exposure to high concentrations of PM_{10} may impair lung function and increase the risk of asthma, allergies, and emphysema.	396	99.0
5	Short-term exposure to PM_{10} may result in conjunctivitis, ocular irritation, xerophthalmia, erythema of the eyes, and nasal discomfort.	388	97.0
6	Vulnerable population that must exercise particular caution regarding PM_{10} include the elderly, pregnant women, young people, and individuals with chronic illnesses.	392	98.0
7	Wearing a mask while cooking fuel might decrease PM_{10} exposure.	378	94.5
8	Keeping doors and windows closed helps mitigate the effects of exposure to PM_{10}.	342	85.5
9	The severity of health effects depends on the dust concentration, exposure duration and frequency, nature of the activity undertaken, and individuals' characteristics.	392	98.0
10	Individuals experiencing chest tightness, dyspnea, chest discomfort, or severe exhaustion requiring rest should seek immediate medical consultation.	396	99.0

characteristics: The majority of participants were female, accounting for 78.8% of the sample. The average age of the participants was 55.34 years, with a standard deviation of 11.13 years. Most individuals (59.8%) reported no history of congenital diseases. A significant proportion (90.5%) identified as non-smokers. Additionally, 38.0% of participants reported exposure to PM_{10} from other sources, such as the burning of garbage. The participants prepared food in 62.5% of open kitchens and 37.5% in closed kitchens (Table 1).

3.1. The Knowledge Level Regarding PM_{10}

The study's findings on knowledge regarding PM_{10}, categorized into high, moderate, and low levels, indicated that 98.3 %of the participants had a high level of knowledge (Table 2). The study revealed that the participants recognized many contributors to dust, including charcoal used as cooking fuel, power plants, vehicular emissions, deforestation, waste incineration, and cigarette smoke. They thought that long-term exposure to high levels of PM_{10} could damage lung function and increase the risk of asthma, allergies, and emphysema. They also thought that symptoms like chest tightness, shortness of breath, chest pain, or fatigue that required standing up straight should be evaluated by a doctor immediately, and 99.0% of the respondents answered correctly. As shown by the fact that 11.2% and 14.5% of the respondents gave incorrect answers, the participants did not know that PM_{10}refers to particles with a diameter of no more than 10microns and that closing doors and windows can lower exposure to PM_{10} (Table 3).

The study found that 98.3% of the participants exhibited extensive knowledge of PM_{10}. The heightened level of general knowledge among them is remarkable. Consistent with prior research, this study also found that workers have a high degree of knowledge about preventing illnesses caused by stone dust (96.3%) [22]. They accurately identified multiple sources of PM_{10}, including charcoal used for cooking, power generation facilities, automobile emissions, deforestation, garbage incineration, and cigarette smoke. They acknowledged the health consequences of chronic PM_{10} exposure, such as diminished lung function and heightened risks of asthma, allergies, and emphysema. However, there were gaps in some areas of knowledge. For example, 11.2% of the participants did not know that PM_{10} refers to particles with a diameter of 10 microns or less, and 14.5% were unaware that closing doors and windows can lower PM_{10} exposure. These knowledge gaps indicate the need for focused educational initiatives. It would greatly benefit community health if people understood the importance of using specific preventative strategies, such as understanding the size of particles and taking actions around the house to minimize exposure.

3.2. PM_{10} Preventive Practices among Participants

Self-protective behaviors about PM_{10} were categorized into three levels: good, moderate, and needs improvement. The majority of the participants exhibited a moderate level of behavior at 84.0%, while 14.8% demonstrated a good level (Table 4). Participants implemented appropriate self -protection measures against PM_{10}, particularly the consistent use of air purifiers at home (67.2%). However, they did not take enough precautions, such as staying away from areas with heavy burning or cooking fuel use, washing their hands and faces thoroughly after being exposed to dust pollution, keeping their homes clean, and getting annual medical exams. Specifically, 98.5%, 98.0%, and 96.0% of the participants reported doing these actions only sometimes or not at all (Table 5).

Among participants, a significant percentage regularly use air purifiers at home (67.3%), whereas other protective measures, such as avoiding high-exposure areas, maintaining post-exposure hygiene, ensuring indoor cleanliness, and participating in annual medical examinations, are rarely observed.

Table 4. PM_{10} preventive behavior levels among participants (n=400).

PM_{10} preventive practice levels	Number	Percentage (%)
Good	59	14.8
Moderate	336	84.0
Improved	5	1.2

Table 5. PM_{10} preventive behavior among participants (n=400).

No.	PM_{10} preventive behavior	Regularly Percentage (%)	Sometimes Percentage (%)	Not at all Percentage (%)
1	Wear a mask when using charcoal as a cooking fuel.	21.7	60.3	18.0
2	Use an air purifier in the residence.	67.2	18.0	14.8
3	Avoid areas with significant combustion or cooking fuel presence.	1.5	58.3	40.2
4	Secure windows and doors in the residence whenever cooking fuel smoke is present.	14.5	44.5	41.0
5	If you experience a persistent cough, constant phlegm, and red eyes, there is no need to shield yourself from PM_{10} exposure.*	23.3	51.7	25.0
6	Maintain a consistently clean household.	2.0	31.5	66.5
7	Individuals with chronic conditions such as asthma, allergies, or emphysema can stay in an area with dust.*	28.2	35.0	36.8
8	Undergo annual health examinations regularly.	4.0	30.5	65.5
9	Thoroughly cleanse your hands and face exposure to dust pollution.	2.0	24.8	73.2
10	Remain in a designated smoking area without perceiving it as a health risk.*	24.5	43.5	32.0

(*) Indicates a negative inquiry.

These gaps in preventive practices may expose participants to dust, which could adversely affect their health [23][24]. The regular use of air purifiers is a beneficial measure, as it helps mitigate indoor air pollution via these appliances [25][26]. However, the minimal participation in additional protective measures is concerning, as comprehensive approaches are necessary for effective defense against PM_{10}. In conclusion, while using air purifiers is helpful, it is also important to adopt a comprehensive approach to protect oneself from PM_{10}. This includes changing lifestyle habits and becoming more aware of environmental factors. Public health campaigns must prioritize educating individuals on the hazards of PM_{10} exposure and the advantages of comprehensive preventative measures, promoting a more proactive approach to health protection.

3.3. Factor Associated with PM_{10} Preventive Behavior

The association analysis found that participants with congenital diseases were significantly more likely to exhibit high levels of PM_{10} preventive behavior than those without such conditions (aOR = 1.72, 95%CI: 1.12-2.63; p = 0.013). Conversely, those involved in agricultural burning (aOR = 0.52, 95%CI: 0.30-0.91; p = 0.023), using incense in the household (aOR = 0.43, 95% CI: 0.21-0.88; p = 0.021), and having a high level of knowledge regarding PM_{10} preventive behavior (aOR = 0.34, 95%CI: 0.17-0.67; p = 0.002) were identified as factors that significantly reduced the likelihood of exhibiting high levels of PM_{10} preventive behavior. Meanwhile, other factors did not show a significant association with the level of PM_{10} preventive behavior among the participants (Table 6).

The investigation identifies several variables affecting individuals' participation in preventive measures against PM_{10} exposure. Participants with congenital diseases are significantly more likely to adopt high levels of PM_{10} preventative measures than those without such conditions. This heightened attention may arise from greater health susceptibility, leading to more proactive protective measures. Conversely, specific actions and beliefs correlate with a diminished probability of participating in advanced PM_{10} preventative behaviors. For example, individuals engaged in agricultural burning are less likely to have elevated levels of PM_{10} preventative behavior. The contradiction may stem from the normalization of exposure dangers present in their environment, resulting in complacency towards protective measures. The use of incense in domestic settings also correlates with a reduced likelihood of engaging in high-level preventive behaviors. This may be due to a lack of awareness of how burning incense contributes to indoor air pollution, causing individuals to underestimate the associated health risks. The present study reveals a contradictory yet significant finding: whereas 98.3% of participants exhibit extensive knowledge about PM_{10}, this awareness failed to transform into persistent preventive actions. Merely 14.8% exhibited effective protective measures, suggesting that information alone is inadequate to motivate action. This occurrence aligns with current literature that highlights the complexity of health behavior modification, particularly in environmental health settings. According to Mokhtari et al. [18], the Health Belief Model's internal motivators, cues to action, and perceived barriers all play a crucial role in mediating the relationship between knowledge and behavior. For instance, individuals may not take action even though they are aware of the risks posed by PM_{10} unless they feel personally vulnerable or have access to supporting infrastructure, such as vented kitchens or reasonably priced protective clothing.Therefore, expanding knowledge alone is not enough for an intervention to be effective. For effective preventative action against PM_{10} exposure in rural communities, behavioral models must be incorporated into health promotion efforts.

This study has value, as it questioned individuals who predominantly prepare food at home, who are at the greatest risk of exposure to PM_{10} from charcoal used as a cooking fuel. If the group comprehends and effectively implements dust prevention measures, they might serve as a model for dust mitigation within the household. The study's limitations encompass the reliance on self-reported behavior and the possibility of recall bias; also, the use of accidental sampling may yield data that lacks complete accuracy, making the results not reflective of the community.

Table 6. PM_{10} preventive behavior by related factors.

Factors	Univariate		Multivariate	
	cOR (95%CI)	***p*-value**	**aOR (95%CI)**	***p*-value**
Gender				
Female	1.0			
Male	0.89 (0.55–1.43)	0.617		
Age group (years)				
20-40	1.0			
41-60	0.79 (0.37–1.68)	0.533		
61-80	0.79 (0.35–1.79)	0.577		
>80	1.33 (0.25–7.01)	0.734		
Congenital disease				
No	1.0		1.0	
Yes	1.96 (1.31–2.94)	0.001*	1.72 (1.12–2.63)	0.013*
Smoking				
Never	1.0			
Current smoker	0.70 (0.32–1.51)	0.363		
Former smoker	1.21 (0.30–4.90)	0.792		
Involved in garbage burning				
No	1.0		1.0	
Yes	2.36 (1.58–3.54)	<0.001*	1.56 (0.99–2.46)	0.054
Involved in agricultural burning				
No	1.0		1.0	
Yes	0.40 (0.24–0.67)	0.001*	0.52 (0.30–0.91)	0.023*
Using incense in household				
No	1.0		1.0	
Yes	0.42 (0.21–0.81)	0.010*	0.43 (0.21–0.88)	0.021*
Exposed to exhaust from traffic				
No	1.0			
Yes	1.26 (0.84–1.90)	0.261		
Kitchen type				
Open	1.0			
Closed	0.99 (0.66–1.49)	0.979		
Knowledge level regarding PM_{10}				
Low	1.0		1.0	
High	0.31 (0.16–0.59)	<0.001*	0.34 (0.17–0.67)	0.002*

*Significant at p-value ≤ 0

4. CONCLUSIONS

This study contributes novel insights into the gap between high knowledge and insufficient preventive behavior against PM_{10} exposure in rural Thai households using charcoal for cooking. Despite 98.3% of participants demonstrating a majority understanding of the health risks associated with PM_{10}, only 14.8% engaged in comprehensive protective actions. Most relied primarily on air purifiers while neglecting crucial practices like hygiene, ventilation, and exposure avoidance. The findings reveal that factors such as congenital illness positively influence behavior, whereas agricultural burning, incense use, and even higher knowledge unexpectedly correlate with reduced preventive actions. To effectively reduce PM_{10} exposure, communities should organize workshops on its health impacts and prevention, encourage the use of enclosed, well-ventilated kitchens, and conduct regular screenings for related diseases. Local governments must regulate key pollution sources such as waste burning and vehicle emissions. Additionally, community programs should promote behavioral changes, including consistent household cleanliness, personal hygiene practices like washing hands and face after exposure, and routine annual health checkups. Further research should employ qualitative methodologies, such as mixed-method community engagement studies, to collaboratively develop culturally tailored interventions with community stakeholders, hence enhancing adherence and sustainability. Also, compare the levels of PM_{10} and the risks of exposure in different kitchen designs (like open versus closed and ventilated versus unventilated) and the materials used in both rural and urban areas.

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Conflicts of Interest

The authors declare no conflict of interest.

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DECLARATION OF GENERATIVE AI

Not applicable.

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