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RESEARCH ARTICLE

Health Belief Model-Framed Leaflet for Open Waste Burning Knowledge and Attitudes: A One-Group Pretest-Posttest Study

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ABSTRACT

Introduction: Open waste burning threatens peri-urban communities in Indonesia. This study assessed changes in knowledge and attitude and descriptively examined reports of burning and burn marks following an HBM-framed leaflet intervention.

Methods: A quantitative one-group pretest–posttest study was conducted with 100 household heads or adult household representatives in North Palu District, Indonesia, selected purposively from households that had burned waste in the past 6 months. The leaflet was developed using Health Belief Model (HBM) constructs as a content framework; however, these constructs were not measured as separate variables. Knowledge and attitude scores were collected before and one week after a 15–20-minute face-to-face leaflet education session. Knowledge was scored from 0–8, while attitudes ranged from 8–40, with higher scores indicating a stronger rejection of open waste burning and greater support for safer waste management. Paired t-tests were used to estimate changes in mean scores, and behavioural and burn-mark data were analysed descriptively.

Results: Mean knowledge scores increased from 3.11 (SD = 1.30) to 6.94 (SD = 0.97), with a mean difference of 3.83 points (95% CI: 3.52–4.14; $p < 0.001$). The Wilcoxon sensitivity analysis supported the same conclusion for knowledge ($p < 0.001$). Mean attitude scores increased from 22.98 (SD = 2.49) to 32.87 (SD = 2.81), with a mean difference of 9.89 points (95% CI: 9.18–10.60; $p < 0.001$). Descriptively, frequent self-reported burning decreased from 39.0% to 3.0%, and fresh burn marks decreased from 54.0% to 8.0% at one-week follow-up.

Conclusion: The HBM-framed leaflet was linked to short-term gains in knowledge and attitudes about open waste burning. The behavioural and burn-mark results should be seen as preliminary descriptions rather than proof of lasting behaviour change or emission reduction. Controlled long-term studies with objective environmental measurements are needed to establish causal relationships.

Keywords: Open Waste Burning; Health Belief Model; Leaflet; Environmental Knowledge; Community Attitudes

INTRODUCTION

Open waste burning remains a consistent environmental health issue because it releases a complex mix of pollutants directly into residential air without proper combustion control or emission treatment. Global and regional studies indicate that burning domestic waste releases particulate matter, carbon monoxide, volatile compounds, and hazardous air pollutants, with exposure risks increasing when burning occurs close to homes and community activity areas (1,2).

Short-term changes in fine particulate levels can happen quickly around burning sites, while burning municipal solid waste releases specific hazardous pollutants that depend on fuel type and combustion conditions (3,4). Experimental studies of household waste burning also show that both gas- and particle emissions contain toxic chemical species, especially when mixed waste is burned under low-temperature conditions and limited oxygen (5,6). The health risks are not limited to visible smoke. Open burning can emit persistent organic pollutants, ecotoxic compounds, and chemicals attached to particles, including polycyclic aromatic hydrocarbons (PAHs) and other by-products of incomplete combustion (7–9). Waste containing plastics is especially problematic because plastics can produce inhalable toxic aerosols and ash residues, extending exposure beyond the breathing zone (10,11).

In Indonesia, household disposal by burning remains common; the 2023 national health survey reported that burning was still the dominant method of household waste management, accounting for 57.2% (12). Evidence from Semarang shows that household-level open burning contributes to local emissions and health risks, while recent work indicates that different waste materials may generate exposure to metal-bound particulates (13–15). These findings are consistent with broader urban waste-management studies showing that limited collection systems, spatial constraints, and informal disposal practices can sustain waste accumulation and burning in densely populated or peri-urban settlements (16,17). Local research in Palu has also documented gaps in community knowledge and risk perception regarding the environmental and health consequences of waste burning, indicating the need for more accessible and context-specific environmental health education (18).

Health education can support risk communication by translating environmental hazards into understandable, personally relevant, and actionable messages. The Health Belief Model (HBM) is useful for structuring such communication because it links preventive action to perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (19). Studies using HBM across different health contexts show that risk appraisal and perceived benefits can shape preventive intentions and behaviour, although the mechanisms underlying these effects must be interpreted cautiously when the constructs are not directly measured (20–22).

Most open waste-burning research in Indonesia has focused on emissions, exposure, and waste-management systems rather than on intervention content designed to change household-level risk perception. Meanwhile, health education studies often compare media formats without addressing open waste burning as a specific environmental health behaviour. Therefore, this study provides preliminary evidence for an HBM-framed printed leaflet in a peri-urban Indonesian context, while explicitly limiting the HBM claim to the development of the leaflet's content. The study aimed to examine short-term changes in knowledge and attitudes after leaflet education and to descriptively document reported burning practices and burn-mark observations one week after the intervention.

METHODS

This study used a quantitative one-group pretest–posttest design to examine changes in the same respondents before and after a leaflet-based educational session. The design was selected as a preliminary community intervention approach because the study was conducted in a real-world household setting where random allocation and withholding information from a comparable control group were not feasible during the initial local programme. Consequently, the design supports interpretation of short-term within-group changes but does not establish definitive causality.

The study was conducted in residential neighbourhoods of the North Palu District, Palu City, Central Sulawesi, Indonesia. The site was chosen because household waste burning was still common in the community and because the area combines urban access with peri-urban waste-management challenges. Field research and data collection were carried out from 14 March to 27 March 2026, within the validity period of the ethics approval, which ran from 22 February 2026 to 22 February 2027.

Population, sample, and sampling

The source population consisted of 17,720 household heads registered in the North Palu District, as recorded in the 2023 local population records. A minimum sample was estimated using Slovin's formula with a 10% margin of error, which was considered acceptable for a preliminary community-level intervention study with limited operational resources. A total of 100 respondents were included.

Purposive sampling was used because the intervention targeted households directly relevant to the practice under study. Inclusion criteria were: household head or adult household representative responsible for household waste decisions; residence in the study area for at least one year; self-reported history of burning household waste within the previous six months; ability to communicate during data collection; and willingness to complete pretest, education, and posttest procedures. Exclusion criteria were acute illness at the time of data collection, communication limitations that prevented completion of the questionnaire, or unavailability at the follow-up visit.

Leaflet intervention and HBM content framing

The intervention consisted of an A4 tri-fold leaflet printed in full colour, delivered during a 15–20-minute face-to-face education session at each respondent's household. The leaflet was reviewed by two health promotion experts before field use. The HBM was used to organise the educational messages; however, the HBM constructs were not measured as separate variables, so any explanation of the mechanism is inferential and limited to the content framing. Table 1 summarises the mapping of HBM constructs to leaflet content.

Table 1. Mapping of HBM constructs to leaflet content

HBM construct	Leaflet content	Intended educational function
Perceived susceptibility	Smoke can enter the house and expose children, older adults, pregnant women, and household members who stay near burning sites.	Personalises exposure risk and links open burning to typical household proximity.
Perceived severity	The leaflet explains PM2.5 in non-technical language.	Frames open burning as a serious health and environmental hazard rather than a harmless routine.
Perceived benefits	Avoiding burning is linked to cleaner air, less smoke nuisance, safer yards, and improved community comfort.	Explains how stopping or reducing burning offers practical benefits.
Perceived barriers	Common barriers such as limited collection, lack of space, habit, and uncertainty about alternatives are addressed by feasible actions: separating organic and inorganic waste, storing waste safely, composting organic waste, and using collection points.	Reduces the belief that burning is the sole disposal method.
Cues to action	Visual warning icons, a household action checklist, and a reference to Palu Mayor Regulation Number 37 of 2017 are included.	Provides prompts that can remind respondents to avoid burning after the education session.
Self-efficacy	The leaflet provides simple step-by-step household actions that can be performed without specialised equipment.	Builds confidence that respondents can manage waste through achievable actions.

Note. HBM = Health Belief Model; PM2.5 = fine particulate matter with an aerodynamic diameter ≤2.5 μm.

Measures and operational definitions

Knowledge was assessed using eight yes-or-no items, with 1 for a correct answer and 0 for an incorrect or ‘do not know’ response. The total knowledge score ranged from 0 to 8, with higher scores reflecting better understanding of the hazards of open waste burning and safer waste-management strategies. Sample topics included PM2.5 emissions from burning, toxic emissions from plastic waste, respiratory risks from smoke exposure, bans on uncontrolled burning, and alternatives such as waste separation and composting.

Attitude was measured using eight statements on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Total scores ranged from 8 to 40, with higher scores indicating a more supportive attitude towards avoiding open burning and adopting safer household waste management. Example statements addressed agreement that burning waste is harmful, willingness to avoid burning near the house, perceived importance of separating waste, and support for local rules discouraging open burning.

Burning practice was reported descriptively using three categories: often, sometimes, and never. Field observation of burn marks was conducted in the household yard or immediate waste-disposal area and classified as new marks, old marks, or none. New marks referred to visibly recent ash, fresh charred residue, or recently blackened soil; old marks referred to residual or older burn traces without signs of recent burning. The observational categories were used to complement self-report data, not to establish inferential evidence of behavioural change.

The knowledge and attitude questionnaires were tested among 30 respondents outside the main sample. Item validity was assessed using item-total correlations, and all retained items had Pearson correlation values above the r-table value of 0.361. Internal consistency was acceptable, with Cronbach's alpha values above 0.70 for both scales.

Data collection procedures

Trained enumerators conducted door-to-door visits. Respondents received information about the study, provided written informed consent, completed the pretest questionnaire, and participated in the leaflet education session. The posttest was administered seven days after the intervention using the same knowledge and attitude measures. Self-reported burning frequency and field observations of burn marks were recorded at both pretest and posttest using a standardised observation sheet.

Data analysis

Descriptive statistics were used to summarise demographic characteristics, reported burning practices, and burn-mark observations. Behavioural and observational variables were not analysed inferentially because the categories were meant to describe only short-term indicators, and the study lacked a control group.

For knowledge and attitude scores, pretest–posttest differences were examined using paired analyses. Normality of difference scores was assessed using the Shapiro-Wilk test. The paired t-test was used to estimate mean differences and 95%

confidence intervals because mean change was the primary estimand. Because the knowledge-score difference was not normally distributed, a Wilcoxon signed-rank sensitivity analysis was conducted to assess whether the statistical conclusion remained consistent under a nonparametric approach. Statistical interpretation followed the principle that nonparametric sensitivity analysis is appropriate when distributional assumptions may influence inference (23). All analyses were carried out using SPSS version 26. Cohen's d for paired comparisons was calculated as dz, using the mean difference between the final and initial test results divided by the standard deviation of the paired difference scores.

Ethical approval

This study met the ethical standards for human health research, as outlined in the WHO 2011 Standards and the CIOMS 2016 Guidelines. The Research Ethics Approval letter was issued by the Palu Polytechnic Health Ministry Ethics Committee, with registration number 000859/KEPK POLTEKKES KEMENKES PALU/2026, and is valid from 22 February 2026 to 22 February 2027.

RESULTS

The findings are presented in the following sequence: respondent characteristics, descriptive behavioural and environmental observation findings, normality assessment, and pretest–posttest comparisons of knowledge and attitude scores. Respondent characteristics are described to provide contextual information on the social background of the study population, as educational level, occupation, and household roles may influence access to environmental health information and waste management practices. The behavioural and observational data are reported descriptively, while changes in knowledge and attitude scores are examined using paired statistical analysis, with additional caution in interpretation given the one-group pretest–posttest design. Table 2 presents the demographic profile of the respondents.

Table 2. Demographic characteristics of respondents

Characteristics	Category	Frequency	%
Gender	Female	58	58
	Male	42	42
Education	Not in education / Primary school	26	26
	Lower secondary school	29	29
	Upper secondary school	18	18
	Higher education (Diploma/Bachelor's degree)	27	27
Occupation	Trader / Entrepreneur	29	29
	Farmer / Fisherman / Labourer	26	26
	Office Employee (Civil Servant / Private Sector)	24	24
	Housewife / Not Working	21	21

Source: Primary Data, 2026

As shown in Table 2, most respondents were women (58.0%). The largest educational group comprised respondents who had completed lower secondary school (29.0%), followed by those with higher education (27.0%). The largest occupational group was traders/entrepreneurs (29.0%), followed by farmers/fishermen/labourers (26.0%).

Table 3 presents reported burning practices and burn-mark observations. These data are descriptive and should not be interpreted as inferential evidence of behavioural effectiveness.

Table 3. Descriptive distribution of reported burning practice and burn-mark observation

Variable	Category	Pretest n (%)	Posttest n (%)	Interpretation
Reported frequency of burning waste	Often	39 (39.0)	3 (3.0)	Short-term descriptive decrease
	Sometimes	46 (46.0)	25 (25.0)	Short-term descriptive decrease
	Never	15 (15.0)	72 (72.0)	Short-term descriptive increase
Burn-mark observation	New marks	54 (54.0)	8 (8.0)	Short-term descriptive decrease
	Old marks	31 (31.0)	61 (61.0)	Residual indication of previous burning
	None	15 (15.0)	31 (31.0)	Short-term descriptive increase

Source: Primary data, 2026.

Normality testing and the analytic decision are shown in Table 4.

Table 4. Shapiro–Wilk normality test for pretest–posttest score differences

Variable	Difference tested	W statistic	p-value	Analytic decision
Knowledge	Posttest − pretest	0.958	0.003	Mean difference reported; Wilcoxon sensitivity analysis added
Attitude	Posttest − pretest	0.979	0.106	Paired-sample t-test used

Source: Primary data, 2026.

Changes in knowledge and attitude scores are presented in Table 5.

Table 5. Changes in knowledge and attitude scores before and after leaflet education

Variable	Score range	Pretest mean (SD)	Posttest mean (SD)	Mean difference	95% CI	Cohen's d	p-value
Knowledge	0–8	3.11 (1.30)	6.94 (0.97)	3.83	3.52–4.14	2.46	<0.001*
Attitude	8–40	22.98 (2.49)	32.87 (2.81)	9.89	9.18–10.60	2.75	<0.001

Note. *The Wilcoxon signed-rank sensitivity analysis for knowledge also supported a statistically significant pretest–posttest increase ($p < 0.001$). CI = confidence interval; SD = standard deviation. Source: Primary data, 2026. Cohen's d represents d_z for paired data, standardised by the standard deviation of the paired difference scores.

Knowledge scores increased from a mean of 3.11 (SD = 1.30) before education to 6.94 (SD = 0.97) one week after education. The mean difference was 3.83 points (95% CI: 3.52–4.14; $p < 0.001$). Because the knowledge-score difference was not normally distributed, a Wilcoxon signed-rank sensitivity analysis was also conducted and supported the same statistical conclusion ($p < 0.001$).

Attitude scores increased from a mean of 22.98 (SD = 2.49) to 32.87 (SD = 2.81). The mean difference was 9.89 points (95% CI: 9.18–10.60; $p < 0.001$). The large standardised mean differences indicate substantial within-group changes in the measured scores, but they should not be interpreted as proof of causal effectiveness because this study had no control group.

DISCUSSION

Principal findings

This study found statistically significant short-term increases in knowledge and attitude scores one week after a face-to-face HBM-framed leaflet education session. The findings indicate that the leaflet was associated with improved cognitive and affective responses to open waste burning in this peri-urban community. However, because the study used a one-group pretest–posttest design, the findings should be interpreted as before-and-after associations rather than definitive evidence that the leaflet alone caused the observed changes.

How the HBM-framed leaflet may have supported knowledge and attitude change

The leaflet may have supported knowledge improvement by turning invisible hazards into concrete, locally recognisable messages. Perceived susceptibility was addressed by explaining that smoke can enter homes and affect children, older adults, and other household members; perceived severity was addressed by simplifying information on PM2.5, toxic organic pollutants, and plastic-burning emissions. This risk translation is important because environmental health literacy depends not only on exposure information but also on residents' ability to connect that information to familiar household practices (24,25).

The shift in attitude can also be understood through the HBM framework used in the leaflet. Perceived benefits were framed in terms of cleaner air, reduced smoke nuisance, and safer household surroundings, while perceived barriers were addressed through practical alternatives such as sorting, storage, composting, and the use of collection points. This interpretation is consistent with HBM-based studies showing that perceived benefits, barriers, susceptibility, and self-efficacy can shape prevention-oriented intentions across different health and environmental contexts (26–28).

The leaflet also served as a cue to action by combining brief warnings, images, a household checklist, and a reference to Palu Mayor Regulation Number 37 of 2017. The inclusion of step-by-step actions was intended to support self-efficacy because residents might recognise the danger of burning but still continue the practice if they do not believe feasible alternatives exist. However, this study did not measure HBM constructs separately; thus, the HBM mechanism remains a plausible explanation of the intervention content rather than an empirically tested mediation pathway.

Role of printed visual media in peri-urban environmental health education

Printed leaflets remain relevant in settings where digital access, digital literacy, or sustained internet use may be inconsistent. Comparative education studies suggest that leaflets can boost recall and knowledge when the information is brief, visually organised, and available for repeated reading, although digital and audiovisual media might be more effective in other situations (29–32). In this study, the face-to-face explanation may have reinforced the leaflet messages by allowing respondents to ask questions and relate the message to their own waste practices.

Visual organisation is especially important when discussing technical terms like PM2.5, dioxins, and PAHs. Systematic evidence on visual-based health literacy efforts shows that graphics can lower cognitive load and help audiences with different

educational backgrounds better understand risk information (33). This is relevant to the current sample, where respondents had varied educational and occupational backgrounds.

At the same time, the findings should not be used to claim that printed materials are universally superior to digital media. Rather, the contribution of this study is more specific: a locally tailored printed leaflet, delivered face-to-face and framed in terms of behavioural constructs, was associated with short-term changes in knowledge and attitudes in a peri-urban Indonesian setting where open burning remains common.

Interpretation of reported burning practice and burn-mark observation

The descriptive reduction in the frequency of self-reported burning and fresh burn marks is encouraging, but it must be interpreted with caution. These variables were not tested inferentially, were assessed only one week after education, and may reflect short-term attention to the study rather than sustained behavioural change. Self-reported pro-environmental behaviour is also vulnerable to social desirability bias, especially when respondents know that the practice is discouraged (34).

Burn-mark observations provide useful contextual information because they do not rely solely on verbal reports. However, these observations are not direct measures of emissions, burning volume, or sustained household waste management. The reduction in fresh burn marks could also reflect temporary changes in waste collection, weather, inspection awareness, researcher presence, or delayed burning rather than full cessation of the practice. Such research participation effects are consistent with the broader literature on behavioural reactivity to observation (35).

Therefore, the behavioural findings should be described as short-term descriptive indicators that accompany changes in scores. Making stronger claims regarding reduced burning, reduced emissions, or stable behaviour would require a control group, longer follow-up, repeated unobtrusive observations, waste-volume documentation, and ambient air-quality monitoring.

Scientific and policy implications

The study provides preliminary empirical evidence for integrating environmental health literacy with a behavioural theory framework in household waste-burning education. This is relevant because open burning is sustained not only by a lack of knowledge but also by limitations in waste services, social norms, perceived convenience, and the absence of practical alternatives. A leaflet alone should therefore be seen as a communication component within a broader waste-management strategy rather than as a stand-alone solution.

For local implementation, the leaflet could be used by environmental health officers, community health workers, or neighbourhood leaders as an advocacy and counselling tool. Its use should be combined with household waste separation, support for composting, reliable refuse collection, and consistent enforcement of local regulations. Broader reviews of waste mismanagement and plastic burning highlight that awareness campaigns are unlikely to succeed without accessible disposal options and system-level support (36).

Limitations and cautions

This study has several limitations. First, the one-group pretest–posttest design does not control for history, maturation, repeated testing, or researcher-attention effects. Second, purposive sampling limits generalisability beyond households with a recent history in the North Palu District. Third, HBM constructs were used to frame leaflet content but were not measured separately; therefore, the study cannot demonstrate which HBM construct contributed most strongly to the observed score changes. Fourth, behavioural and burn-mark variables were assessed descriptively after only one week, so they cannot demonstrate sustained behavioural transformation. Fifth, self-reported burning practices may be affected by social desirability bias, whereas burn-mark observation cannot quantify burning volume, pollutant concentrations, or exposure reductions. Finally, the study did not include objective environmental measurements, such as PM2.5, black carbon, or monitoring of toxic organic pollutants.

Recommendations for future research

Future studies should use controlled or cluster-randomised designs to compare HBM-framed leaflets with standard counselling, digital education, or combined communication strategies. A longer follow-up is needed to assess knowledge retention, attitude stability, and persistence of non-burning behaviour. Future instruments should measure HBM constructs directly, allowing mediation pathways to be analysed rather than inferred from intervention content. Research should also integrate objective environmental and waste-management indicators, including repeated burn-site observations, waste-volume records, service-availability data, and ambient PM2.5 or black carbon measurements. Such evidence would allow stronger conclusions about whether education contributes to reductions in actual burning and local pollutant exposure.

CONCLUSION

The HBM-framed leaflet education was associated with statistically significant short-term increases in knowledge and attitudes regarding open waste burning among household heads or adult household representatives in North Palu District. Descriptive findings also showed reductions in the frequency of self-reported burning and in the number of fresh burn marks at the one-week follow-up. These behavioural observations should be interpreted as preliminary short-term indications, not as evidence of sustained behaviour change or emission reduction. The study supports the potential use of locally tailored printed leaflets in environmental health education, but stronger causal claims require controlled, longitudinal studies that directly measure HBM constructs, household waste practices, and objective environmental outcomes.

DECLARATIONS

Author contributions: Mustafa: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. Amsal, Ros Arianty: Investigation, Validation, Supervision. Idayani Sangadjisowohy, Siti Jubaida Lutiah: Resources, Formal analysis, Writing – review & editing.

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