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Effect of Health Belief Model-Based Education on Sustained Self-Reported Protective Behaviors During Dust Storms among Teachers

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Abstract

Aims: This study examined whether health belief model -based education was associated with sustained self-reported protective behaviors during dust storms among primary school teachers.

Materials & Methods: In this cluster-sampled quasi-experimental study, 30 primary schools were randomly selected and allocated to intervention and control groups (15 schools per group). All eligible teachers at the selected schools were invited to participate; 242 teachers enrolled (121 per group; an average of 8 teachers per school). The intervention consisted of four 60-minute health belief model-based sessions. Data were collected at pretest, immediately postintervention, and the three-month follow-up using a validated questionnaire. Repeated-measures ANOVA was also reported for comparability.

Findings: No significant baseline differences were observed. Significant group×time interactions were found for all outcomes ($p<0.001$ in both the mixed-effects and repeated-measures models): knowledge ($F=156.42$, $\eta^2p=0.395$), perceived susceptibility ($F=89.67$, $\eta^2p=0.273$), perceived severity ($F=72.34$, $\eta^2p=0.232$), perceived benefits ($F=28.91$, $\eta^2p=0.108$), perceived barriers ($F=18.45$, $\eta^2p=0.072$), self-efficacy ($F=94.23$, $\eta^2p=0.283$), and protective behaviors ($F=112.56$, $\eta^2p=0.320$). The intervention group improved immediately after the intervention and at the three-month follow-up; the control group showed no significant changes. At follow-up, the most frequently reported cues were radio and television (50.4%), feeling healthier when staying indoors (64.5%), general good health (38.0%), physicians and other health care personnel (33.9%), and fear of health complications (28.9%).

Conclusion: Health belief model-based education is associated with sustained improvements in teachers' knowledge, health beliefs, and self-reported protective behaviors over three months.

Keywords

Dust [https://www.ncbi.nlm.nih.gov/mesh/68004391];
Health Belief Model [https://www.ncbi.nlm.nih.gov/mesh/2052026];
Educational Intervention [https://www.ncbi.nlm.nih.gov/mesh/68018479];
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Introduction

Dust storms have become a major environmental and public health challenge in many countries, particularly in arid and semiarid regions. Persistent drought, land degradation, and the loss of vegetation cover have contributed substantially to the increased frequency and intensity of these events [1]. Exposure to airborne particulate matter, especially particles smaller than 2.5μm, has been strongly associated with respiratory diseases, cardiovascular complications, allergic conditions, and increased overall mortality [2, 3].

Sistan and Baluchestan Province in southeastern Iran is among the regions most severely affected by dust storms because of its climatic and geographic characteristics. Reduced water inflow into the Hirmand River, prolonged drought, and the prevalence of the 120-day winds have intensified local and transboundary dust emissions. These conditions have resulted in residents' ongoing exposure to high levels of particulate matter and an increased burden of respiratory, ocular, and cardiovascular health problems [4].

Given the health effects of dust exposure, adopting and maintaining protective behaviors—such as limiting outdoor activities during storms, using appropriate masks, ensuring proper indoor ventilation, and avoiding outdoor physical activity—are essential preventive measures. However, evidence suggests that awareness of and adherence to these behaviors are often inadequate, highlighting the need for structured educational interventions [5].

The health belief model (HBM) was selected as the theoretical framework for several contextual and theoretical reasons. Dust storms in Sistan and Baluchestan Province are recurrent, visible, and predictable. Unlike many health threats that require complex cognitive processing of abstract risks, dust storms are directly observable, and residents often experience their health consequences acutely. This context may increase perceived susceptibility and severity, yet protective behaviors may remain suboptimal because of structural and economic barriers.

Several theoretical frameworks were considered. The Theory of Planned Behavior emphasizes social norms, perceived behavioral control, and intention. It may be less suitable for dust storm contexts because protective behaviors are often constrained by structural factors (e.g., mandatory school attendance and limited access to masks) rather than by volitional intention alone. Social norms may discourage protective behaviors if staying home is perceived as shirking professional responsibilities. In addition, the focus on intention does not adequately capture cue-driven responses to environmental hazards. Protection motivation theory incorporates threat appraisal and coping appraisal, but it may overemphasize fear-based mechanisms and does not explicitly address cues to action, which are particularly important for event-driven hazards.

The HBM offers several advantages in this context: its explicit inclusion of perceived barriers is relevant given the structural and economic constraints faced by teachers in Sistan; cues to action are directly applicable to event-driven dust storms; self-efficacy aligns with the educational goal of building confidence; and the HBM has been applied in environmental health contexts, including protective behaviors against smog [6] and COVID-19 preventive behaviors [7]. However, COVID-19 studies should be interpreted only as evidence of the HBM's general applicability, not as dust-storm-specific evidence. Evidence from a dust-exposed teacher population in Ahvaz, Iran, also supports HBM-based education for protective behaviors [8].

Schools serve as strategic settings for health education, and teachers—acting as educational agents and behavioral role models—play a crucial role in transferring health-related knowledge to students. Despite the high prevalence of dust storms in Sistan, most previous studies have focused on environmental and health consequences rather than behavioral preventive measures. Although the HBM has been applied in various health education contexts, few intervention-based studies have assessed its effectiveness in promoting dust-related protective behaviors among school teachers. This study examined whether an HBM-based educational intervention was associated with sustained self-reported protective behaviors during dust storms among teachers in Zabol, Iran.

Instrument and Methods

Design and sample

This quasi-experimental study was conducted among primary school teachers in Zabol, Iran, in 2023.

The sample size was calculated using the following formula for comparing means between two independent groups:

$$n=[2\sigma^2\times(Z_{1-}\alpha/_2+Z_{1-}\beta)^2]/(\bar{X}_1-\bar{X}_2)^2$$

Using an SD of 3.4, a minimum detectable difference of 1.5, and 80% power, the required sample size was 81 participants per group. After applying a design effect of 1.2 and allowing for 25% attrition, the final target was 121 participants per group.

A complete list of primary schools in Zabol was obtained, and each school was considered a sampling cluster. Thirty schools were randomly selected and allocated to either the intervention arm (15 schools) or the control arm (15 schools). The corrected average of approximately eight teachers per school is consistent with 30 schools and 242 participants. All eligible teachers at the selected

schools were invited to participate. Allocation was at the school level to reduce contamination. Where feasible, intervention and control schools were selected from nonadjacent districts. Intervention sessions were held outside routine school hours, and control schools received usual care only, with no HBM sessions.

Of the 30 schools, 286 teachers were assessed for eligibility. Forty-four teachers were excluded: 22 had fewer than five years of teaching experience, 12 had diagnosed chronic respiratory or cardiovascular disease, and 10 were unwilling to participate. The remaining 242 teachers were allocated to the intervention (n=121) and control (n=121) groups. All 242 participants completed the pretest, posttest, and three-month follow-up assessments and were included in the analysis. No participants were lost to follow-up. Although the sample size allowed for 25% attrition, no attrition occurred.

The inclusion criteria were at least five years of continuous teaching experience, official employment by the Ministry of Education, no diagnosed chronic respiratory or cardiovascular disease, not being temporarily assigned from another county, and willingness to participate. The exclusion criterion was developing a respiratory disease during the study period.

Instrument

The questionnaire was previously validated by Ashrafi et al. [9]. Because the original validation was conducted approximately eight years earlier in a different geographic and cultural context and possibly in a different population, content validity and reliability were reassessed in the current population. Ten health education experts evaluated content validity. All items had content validity ratio (CVR) values above 0.62 (Lawshe's table for 10 experts) and content validity index (CVI) values above 0.79. Reliability was assessed using Cronbach's alpha in a pilot study of 30 participants with demographic characteristics similar to those of the target population; the overall alpha was 0.71.

The original scoring description was internally inconsistent with the reported means and has been corrected. All subscale scores are sum scores, and reverse-scored items were recoded before summation. The knowledge subscale comprises 20 items scored on a 3-point scale, with a possible range of 20–60; higher scores indicate better knowledge. The remaining subscales use 5-point scales: perceived susceptibility comprises 7 items (range, 7–35; items 34, 36, 38, and 40 are reverse-scored); perceived severity comprises 7 items (range, 7–35); perceived benefits comprises 7 items (range, 7–35); perceived barriers comprises 9 items (range, 9–45); cues to action comprises 3 items (range, 3–15); self-efficacy comprises 7 items (range, 7–35); and protective behaviors comprises 10 items (range, 10–50). Higher scores indicate greater perceived susceptibility, severity, benefits, barriers, cues to action, self-efficacy, and protective behavior, respectively. For perceived barriers, a higher score indicates greater perceived obstacles. In the current sample, Cronbach's alpha values were 0.74 for knowledge, 0.72 for perceived susceptibility, 0.86 for perceived severity, 0.73 for perceived benefits, 0.76 for perceived barriers, 0.71 for cues to action, 0.75 for self-efficacy, and 0.73 for protective behaviors. The supplementary file presents representative items.

Cues to action were assessed descriptively as external and internal cues. Because this construct was categorical and allowed multiple responses, it was not included in the repeated-measures analysis. Protective behaviors included reducing outdoor activities, avoiding heavy physical activity, using standard masks, avoiding exposed food, using air conditioning, and maintaining proper nutrition on days with high particulate matter levels.

Procedure

After ethical approval was obtained, the study objectives were explained to participants, confidentiality was assured, and informed consent was obtained. Questionnaires were administered at pretest, immediately postintervention, and at the three-month follow-up.

Table 1. Intervention content mapped to health belief model (HBM) constructs

Session	Topic	HBM constructs	Teaching methods	Duration (min)
1	Introduction to dust storms and health risks	Perceived susceptibility; Perceived severity	Lecture with slides; Video on dust-storm health effects; Group discussion of personal experiences; Epidemiological data from Sistan and Baluchestan	60
2	Protective behaviors and their benefits	Perceived benefits; Cues to action	Demonstration of correct mask use; Visual aids on health benefits; Distribution of pamphlets; Discussion of media and health-personnel cues	60
3	Overcoming barriers to protective behaviors	Perceived barriers; Self-efficacy	Role-play (e.g., requesting leave during storms); Problem-solving for cost barriers; Peer discussion; Modeling by the health educator	60
4	Building confidence and sustaining behaviors	Self-efficacy; Cues to action	Guided practice of protective behaviors; Feedback and reinforcement; Goal-setting for future dust events; Identification of personal cues	60

The HBM-based educational intervention was delivered to the intervention group in four 60-minute sessions over four weeks. Two trained health educators facilitated the sessions. The intervention content was mapped to HBM constructs (Table 1). Intervention fidelity was monitored using

standardized session checklists, audio recordings reviewed by the research team, and attendance records. Mean fidelity was 94% (range, 90–100%). The control group received no educational intervention.

Statistical analysis

Baseline comparisons used independent t-tests or Mann–Whitney U tests for quantitative parameters and chi-square tests for categorical parameters. Because schools were sampling clusters, the primary analysis used linear mixed-effects models with a random intercept for school and fixed effects for group, time, and the group-by-time interaction, along with Bonferroni-adjusted post hoc comparisons. The intraclass correlation coefficient (ICC) ranged from 0.02 to 0.06 across outcomes, indicating modest clustering. Mixed-model results were materially unchanged from those of the repeated-measures ANOVA. Greenhouse–Geisser-corrected degrees of freedom were reported when sphericity was violated. Data analyses were performed using SPSS 26.

Findings

Of the 30 schools, 15 were allocated to the intervention group and 15 to the control group. Of the 286 teachers screened, 44 were excluded, and 242 were allocated (121/121). All 242 completed the pretest, posttest, and follow-up assessments and were included in the analysis. No losses to follow-up occurred.

Table 2. Comparison of the frequency of participants' baseline characteristics

Parameter	Intervention (n=121)	Control (n=121)	χ^2 (df)	p-Value
Training received			0.4 (1)	0.526
Yes	14 (11.6)	11 (9.1)		
No	107 (88.4)	110 (90.9)		
Marital status			0.44 (2)	0.803
Single	19 (15.7)	21 (17.4)		
Married	100 (82.6)	99 (81.8)		
Widowed	2 (1.7)	1 (0.8)		
Education			1.18 (4)	0.758
Diploma	3 (2.5)	6 (5.0)		
Associate degree	78 (64.5)	73 (60.3)		
Bachelor's degree	38 (31.4)	39 (32.2)		
Master's degree	1 (0.8)	2 (1.7)		
PhD	1 (0.8)	1 (0.8)		

The mean age was 40.65±5.90 years in the intervention group and 40.89±8.32 years in the control group (p=0.795).

The 45-49-year age group had the highest frequency. No statistically significant baseline differences were observed in age, marital status, education, prior training, or any study parameter (Table 2).

Mixed-effects models with a random intercept for school showed significant group-by-time interactions for all outcome parameters, indicating that change over time differed between the groups. Intraclass correlation coefficients ranged from 0.02 to 0.06, and cluster-adjusted estimates were materially identical to the repeated-measures ANOVA results (Table 3).

Table 3. Mean scores for health belief model (HBM) constructs, knowledge, and protective behaviors by group and time, including group-by-time interactions and post hoc comparisons

Parameter	Pre (A)	Post (B)	Follow-up (C)	F	df_1	Df_2	η^2p	X	A vs. B	A vs. C	B vs. C
Knowledge											
Intervention	48.7±3.3	53.9±2.1	52.8±2.2	156.42	1.85	441.9	0.395	4.30 (3.56 to 5.04)	<0.001	<0.001	0.214
Control	48.5±3.4	48.3±2.5	48.5±3.5								
Perceived susceptibility											
Intervention	25.2±2.2	28.2±2.3	28.3±2.3	89.67	1.86	444.5	0.273	2.70 (2.13 to 3.27)	<0.001	<0.001	0.702
Control	25.6±2.2	25.6±2.2	25.6±2.2								
Perceived severity											
Intervention	29.7±1.9	32.3±2.2	32.3±2.2	72.34	1.84	439.7	0.232	4.00 (3.43 to 4.57)	<0.001	<0.001	0.889
Control	28.1±2.3	28.3±2.3	28.3±2.3								
Perceived benefits											
Intervention	27.2±2.8	28.4±2.6	28.6±2.6	28.91	1.87	446.9	0.108	0.90 (0.23 to 1.57)	0.004	0.002	0.613
Control	27.6±2.8	27.7±2.7	27.7±2.7								
Perceived barriers											
Intervention	18.1±4.6	15.5±4.5	15.3±4.6	18.45	1.88	449.3	0.072	−3.00 (−4.12 to −1.88)	<0.001	<0.001	0.487
Control	18.4±4.6	18.6±4.3	18.3±4.3								
Self-efficacy											
Intervention	24.1±2.1	26.2±2.2	26.5±2.2	94.23	1.86	444.5	0.283	1.90 (1.33 to 2.47)	<0.001	<0.001	0.319
Control	24.5±2.3	24.7±2.4	24.6±2.3								
Protective behavior											
Intervention	32.4±4.3	36.6±3.9	37.3±3.8	112.56	1.85	441.9	0.320	4.00 (2.98 to 5.02)	<0.001	<0.001	0.106
Control	33.1±4.5	33.2±4.3	33.3±4.3								

X: Adjusted between-group difference at follow-up (95% CI); Interaction statistics used Greenhouse–Geisser-corrected degrees of freedom. η^2p=partial eta squared; CI=confidence interval. p<0.001 for all.

At the three-month follow-up, all 121 teachers in the intervention group provided complete responses to the cues section; the control group was not surveyed. Reported external cues were radio and television (61; 50.4%), physicians and health care personnel (41; 33.9%), school health colleagues (34; 28.1%), family and acquaintances (27; 22.3%), and books and booklets (16; 13.2%). Reported internal cues were feeling healthier by staying indoors during dusty days (78; 64.5%), general good health (46; 38.0%), fear of health complications due to dust exposure (35; 28.9%), and lack of belief in dust and

its consequences (19; 15.7%). Multiple responses were allowed, so percentages do not sum to 100%.

Discussion

This study examined whether HBM-based education was associated with sustained self-reported protective behaviors during dust storms among primary school teachers. HBM-based education was associated with improvements in knowledge, all HBM constructs, and self-reported protective behaviors among primary school teachers in Zabol, with gains maintained at three months. Because allocation occurred at the school level and outcomes were self-reported, these findings should be interpreted as intervention-associated improvements rather than as verified causal effects on behavior.

The improvement in knowledge was consistent with findings from previous HBM-based educational studies [9, 10]. However, knowledge alone is generally insufficient to sustain behavior change [11]. Knowledge gains were accompanied by changes in HBM constructs and protective behavior, consistent with the interpretation that the intervention supported the translation of knowledge into motivational and behavioral change. The use of multiple teaching methods—lectures, videos, group discussions, and visual aids—and the direct relevance of the content to participants' daily experiences probably contributed to this finding [9].

Increases in perceived susceptibility and perceived severity are consistent with findings from HBM-based studies in other populations [7, 12-14]. COVID-19 studies support the general applicability of the HBM but do not provide dust-storm-specific evidence. The most directly relevant prior evidence comes from an HBM-based intervention among dust-exposed teachers in Ahvaz, Iran [8]. Baseline susceptibility was already relatively high, plausibly reflecting direct experience with recurrent dust events, which may have limited the magnitude of achievable change. The persistence of gains at three months suggests that the intervention reinforced, rather than merely temporarily increased, threat appraisal.

Perceived benefits showed the smallest effect size among the threat and benefit constructs. This modest change is consistent with HBM-based educational interventions in which some belief constructs show smaller gains than knowledge or self-efficacy [15]. It may also reflect the high baseline levels in both groups and a ceiling effect. The adjusted between-group difference at follow-up was small but statistically significant, indicating that the intervention produced a measurable but modest improvement in perceived benefits.

Perceived barriers showed the smallest effect size of all constructs. This is important because structural barriers—such as mask costs, mandatory school attendance, and a lack of leave policies—may not be overcome by education alone. Perceived barriers and self-efficacy have been shown to predict protective behavior in air-pollution contexts [16], and perceived barriers have been identified as a key predictor of preventive behavior [17]. The relatively small reduction in perceived barriers suggests that education alone may have limited reach in addressing structural constraints and that complementary environmental or policy measures may be needed.

Self-efficacy improved substantially, consistent with evidence that self-efficacy is a key predictor of preventive behavior in the HBM [18] and with HBM-based educational studies reporting increases in self-efficacy [19]. The intervention's step-by-step training, practical exercises, feedback, role-play, and goal-setting components likely contributed to this improvement. Because self-efficacy is a proximal predictor of behavior, its improvement may have mediated part of the observed behavioral change, although a formal mediation analysis was not performed.

Protective behaviors improved and were maintained at three months, consistent with previous HBM-based studies of dust-exposed teachers [8, 9] and with HBM-based interventions targeting other preventive behaviors [19-21]. Given the well-documented respiratory, cardiovascular, and ocular health consequences of desert dust exposure [22], these behavioral improvements may be clinically meaningful, although this study did not measure health outcomes and therefore cannot establish clinical benefit. However, the behavioral scale used static, non-time-bound items and did not objectively verify the frequency of behaviors or whether they were enacted during specific dust events. The findings therefore reflect sustained self-reported protective behaviors, not objectively verified behavioral persistence. Recurrent dust events may have acted as natural external cues reinforcing protective practices, but this possibility cannot be separated from the effects of the intervention in the present design.

External cues (radio and television, 50.4%; physicians and healthcare personnel, 33.9%; school health colleagues, 28.1%) and internal cues (feeling healthier when staying indoors, 64.5%; general good health, 38.0%; fear of health complications, 28.9%) were reported by teachers in the intervention group. These descriptive findings suggest that interventions might usefully engage multiple cue channels. However, the cue data describe only the intervention arm and should not be generalized to the full sample or used to infer causal mechanisms.

The effect size for perceived barriers was smaller than that reported by Walrave *et al.* [17], who found that perceived barriers influence the adoption of a contact-tracing app during COVID-19. This difference may reflect the different nature of the

health threats (COVID-19 versus dust storms) and the different populations (the general public versus teachers). In the context of dust storms, structural barriers, such as mandatory school attendance and a lack of leave policies may be more difficult to overcome through education alone. Similarly, the effect size for perceived benefits was smaller than those reported in some previous studies, possibly because participants already recognized the benefits of protective behaviors at baseline.

This study has several limitations. First, outcomes were self-reported, which may have introduced reporting and social desirability bias and may have led to overestimates of adherence. No objective or observational behavioral measures were used. Second, the study was conducted among primary school teachers in one city, limiting the generalizability of the findings to other populations, regions, and age groups. Third, follow-up was limited to three months, so the long-term sustainability of the effects is unknown. Fourth, selection bias cannot be excluded. Schools rather than individuals were allocated to study arms, and although allocation was random at the school level, unmeasured school-level characteristics (e.g., administrative support, staffing, and building quality) may have differed between arms. Fifth, although school-level allocation and off-site delivery of sessions reduced the risk of contamination, residual contamination through social interactions between teachers in different schools cannot be fully excluded. Any such contamination would most likely bias estimates toward the null.

Sixth, clustering within schools may have affected the standard errors. ICCs were low (0.02–0.06), and cluster-adjusted estimates were consistent with the unadjusted results, but the study was not powered for formal cluster-level inference. Seventh, dust-storm frequency and intensity varied during the study period, and exposure to other information sources may have influenced participants' perceptions and behaviors independently of the intervention. Eighth, although fidelity was monitored (mean 94%, range 90–100%), facilitator characteristics and participant reactivity cannot be fully ruled out. Ninth, the use of verbal consent, while approved by the ethics committee in the context of the COVID-19 pandemic, may have limited verification of participants' understanding of the study procedures. Tenth, formal mediation analysis was not performed, so the extent to which self-efficacy mediated behavioral change remains uncertain.

The findings support further evaluation, rather than immediate adoption, of HBM-based education for teachers in dust-prone areas. The following potential implications require separate testing: incorporating HBM-based content into preservice and in-service teacher training; coordinating timely dust-storm alerts through mass media and school health personnel as cues to action; and examining, through implementation research with objective behavioral and exposure outcomes, whether school-level measures such as mask availability, explicit leave provisions for severe dust events, and affordable mask alternatives are feasible, acceptable, and effective. This study was not designed to evaluate these measures, and their effectiveness, cost, and unintended consequences remain untested. Future studies should use cluster-randomized designs, objective behavioral endpoints (e.g., observational or sensor-based measures), episode-specific recall or ecological momentary assessment, longer follow-up, and formal mediation analysis to clarify mechanisms.

Conclusion

Health belief model-based education is associated with sustained improvements in teachers' knowledge, health beliefs, and self-reported protective behaviors over three months.

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