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Evaluation of a Mass Media Educational Campaign to Increase Secondary School Students' Awareness of Health Risks of Khat Chewing: A Quasi-Experimental Pre-Post Study in Aden, Yemen

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Background: Khat is a green leaf with amphetamine-like effects. Khat chewing was once a socially acceptable behavior but has come to involve children and affects oral and general health. We evaluated an awareness program addressing the adverse health risks of khat chewing (AHRKC) among secondary school students, in addition to exploring the variables associated with post-intervention awareness.

Material/Methods: A quasi-experimental pre-post study design was used. A total of 450 secondary school students were recruited (intervention, n = 225; control, n = 225) using multistage random sampling. Self-administered questionnaires were used for data collections. For the intervention group, the khat chewing educational program included lectures and seminars, posters, billboards, and brochures. Statistical analyses included chi-squared tests, *t* tests, and logistic regression modelling.

Results: A total of 427 students completed both baseline and follow-up surveys. The overall levels of exposure to anti-khat messages and awareness were significantly higher in the intervention group than in the control group after the program ($P < 0.001$). The multivariable analysis revealed that older students (odds ratio (OR) = 3.35; 95% confidence interval (CI) = 1.11-10.14, $P = 0.031$), students' monthly pocket money (OR = 2.39; 95% CI = 1.04-5.47, $P = 0.018$), and frequent exposure to mass media channels (OR = 2.40; 95% CI = 1.06-5.46, $P = 0.023$) were significantly associated with enhanced awareness of the AHRKC in the intervention group.

Conclusions: The customized educational program improved awareness of AHRKC among secondary school students. Age, pocket money, and message exposure frequency were among the factors that influenced the observed program outcomes.

Clinical trial registration: <https://doi.org/10.1186/ISRCTN36908722>

Keywords: Adolescent • Health Education • Khat • Mass Media • Pre-Post Studies

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Introduction

Khat (*Catha edulis*) is an evergreen shrub belonging to the family Celastraceae. It is found in the “khat belt” area (eg, Ethiopia, Somalia, and Kenya) and the southwest Arabian Peninsula. In Yemen in particular, the chewing of khat leaves is deeply embedded within the sociocultural habits of the region [1-3]. It is chewed for stimulant effects. The psychoactive components, primarily cathinone and cathine, produce effects similar to amphetamines, including increased alertness and euphoria. These stimulatory effects typically peak at 1.5 to 3.5 hours after the initiation of khat chewing and manifest as euphoria, increased alertness, high energy, and promotion of social interaction. However, these effects are subsequently replaced by dysphoria, anxiety, reactive depression, and insomnia [4].

In Yemen and some neighboring regions, khat chewing is practiced for various reasons, including facilitating social interaction, enhancing academic performance among students, and for recreational purposes [5,6]. However, due to its use among diaspora communities originating from East Africa and the Arabian Peninsula, the legal status of khat varies globally. Several countries, including the United Kingdom and the United States, classify khat or its active constituents as controlled or illegal substances due to concerns regarding its psychoactive effects and potential health implications [7]. The literature shows the long-term impacts of khat chewing on socioeconomic status, oral and general health, and associated health risk behaviors, particularly substance use such as tobacco consumption [8-18].

Historically, khat chewing was regulated by social norms that limited its use to certain occasions, specific designated chewing hours, weekends and public holidays, and age restrictions (over 18 years for males and for females only if married). However, these controls have weakened, leading to a marked increase in khat use among adolescents [19]. It is estimated that 15% to 20% of children under the age of 12 years in Yemen have initiated khat chewing [3], and a recent study among school children aged 13 to 19 years reported a prevalence of 42% of khat chewing [20]. Engaging in such a risky health behavior during adolescence often results in habitual khat chewing, with subsequent health and socioeconomic consequences [21].

Health professionals have long advocated raising awareness among khat-consuming communities regarding the increased risks of morbidity and mortality associated with khat chewing [22]. Several prevalence studies have highlighted the need for interventional health awareness efforts, particularly those targeting adolescents [23,24]. Despite these recommendations, the literature remains limited in terms of interventional studies specifically addressing khat chewing among adolescents. As

noted by Sawyer et al, preventing non-communicable diseases and mental health disorders in adulthood can be achieved by addressing risk behaviors during adolescence [25]. The World Health Organisation’s Health-Promoting Schools Framework emphasizes schools as effective platforms for health promotion [26], a strategy that has been successfully applied in adolescent tobacco use prevention programs in various contexts [27,28].

Therefore, this study aimed to assess changes in awareness of khat-related health risks among Yemeni adolescents following exposure to a multi-component school-based educational intervention.

The outcome was the awareness score measured using a structured questionnaire and categorized as high (score 10-14) versus low (score 0-9) using a median split, consistent with prior validated studies reflecting participants’ level of knowledge regarding the health and social consequences of khat chewing (see Methods for questionnaire details and reference). The primary comparison examined the difference in change in awareness scores between the intervention and comparison groups from baseline to follow-up. The hypothesis was that exposure to a mass media educational campaign would be associated with a higher level of AHRKC awareness among intervention students compared with control students, and that this awareness would be associated with selected sociodemographic characteristics.

Material and Methods

Study Design and Setting

This study employed a quasi pre–post experimental (interventional) design with a comparison (control) group and was conducted in the city of Aden, Yemen. The intervention and control groups were assigned at the district level to minimize contamination between groups. Outcome assessment was conducted using self-administered questionnaires, and data analysis was performed independently of the intervention delivery to reduce potential bias.

Given the nature of the educational intervention, blinding of participants to group allocation was not feasible. However, to minimize information bias, students were not explicitly informed of the study hypothesis, and those involved in delivering the educational program were not involved in data collection or statistical analysis. This separation of roles helped reduce performance and assessment bias. Aden City comprises 8 administrative districts. The city was selected as the study setting due to the relative stability of its education system, which made implementation feasible despite the ongoing conflict and humanitarian crisis in Yemen since 2011 [29,30].

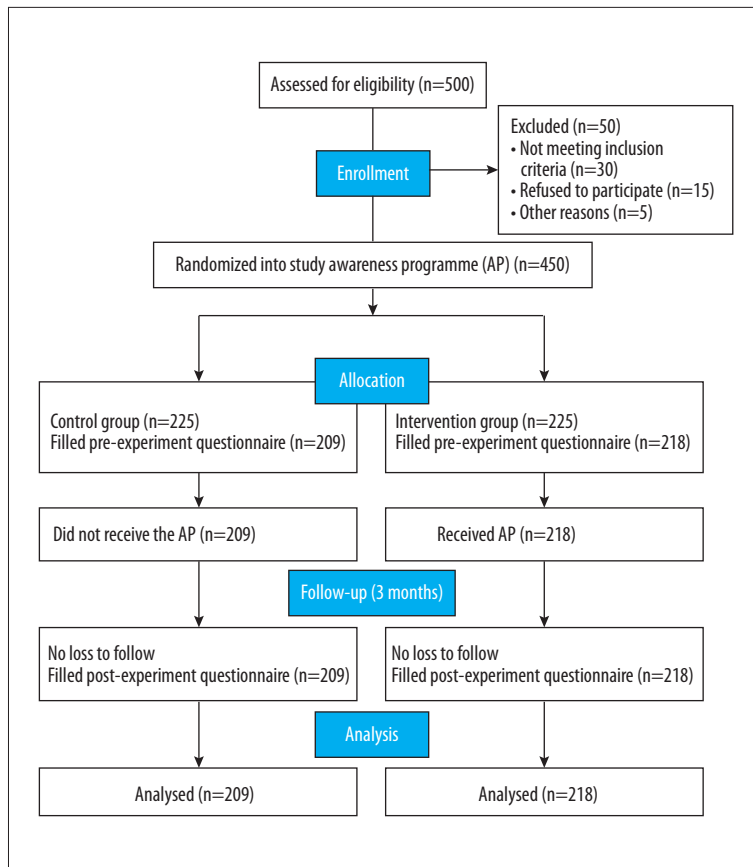


Figure 1. CONSORT flow chart diagram.

Ethical Considerations

Ethics approval for the study was obtained from the Institutional Review Board of the University of Aden (Ref: 20131026). Formal permission was subsequently secured from the Teaching and Education Office in Aden City to access schools and recruit participants. Data collection was conducted between February and early May 2013, in accordance with the ethical principles of the Declaration of Helsinki [31]. All participating students were informed that participation was voluntary, that they could withdraw at any time without penalty, and that their academic performance would not be affected. Confidentiality and anonymity were assured, and all collected data were used exclusively for research purposes. Clear explanations of the study objectives and procedures were provided to the students prior to participation. Written informed consent was obtained from all participating students, and school principals coordinated their efforts to obtain parental permission in accordance with local educational regulations.

Due to logistical and administrative challenges related to the conflict in Yemen, the study was registered retrospectively. Trial registration was completed with the International Standard Randomised Controlled Trials Registry (ISRCTN) <https://doi.org/10.1186/ISRCTN36908722>. Reporting of the study followed

the CONSORT guidelines for non-pharmacological interventions (Figure 1).

Sampling Procedures and Participant Selection

The total number of students in public secondary schools in Aden was 22,447 (Source: Local Education and Teaching Office, 2012-2013, personal communication). These students were distributed across 35 public secondary schools. Prior to the pre-assessment and selection of schools for the study, one of the authors (MK) visited each school to explain the aims of the study and ascertain whether the schools would agree to participate. Based on multistage random sampling, 4 out of a total of 8 districts in Aden City were randomly selected using the lottery box technique. Subsequently, random allocation was used to assign 2 districts to the intervention arm and 2 districts to the control arm. As a result, the districts of Khurmaksar and Shaikh Outhman were the intervention districts, while Al-Mualla and Al-Mansura served as the control districts.

All selected secondary schools were comparable in terms of socioeconomic indicators. Their cultural, religious, educational, and geographic characteristics were similar. Potential spillover effects of the intervention were considered minimal, as the schools were located approximately 4 to 5 kilometers apart.

Students were included in the study if they attended public secondary schools in Aden City, were registered in the second level of study during the 2013/2014 academic year, had resided in Aden for at least 2 years, and were of Yemeni nationality. Students with special needs were excluded due to limited resources to support their participation, and students of non-Yemeni nationality were also excluded. In addition, of the 450 students initially enrolled at baseline (225 in the control group and 225 in the intervention group), 23 (16 from the control group and 7 from the intervention group) were excluded. The post-questionnaire exclusion criteria were: (1) questionnaires with more than 50% missing responses across any section, and (2) questionnaires identified as invalid due to completely uniform non-engaged response patterns in the awareness items. These criteria were applied identically at both baseline and follow-up.

Sample Size Calculation

There were 1140 students (male and female) in the 2 schools selected for the intervention and 1101 students in the 2 schools selected for control. From the districts selected for control or intervention, 1 male and 1 female school were selected using simple random sampling. In the absence of any campaign studies on khat, the reported prevalence of the outcome “Noticing/Recalling Anti-Tobacco Media Messages” in the general youth population (51%) [32] and in the smokeless tobacco population (68%) [33] was used. With a desired confidence level of 95% and a study power of 90%, the study

required a total sample size of 370 participants, with 185 in each of the test and control groups. To account for potential non-response and attrition, the sample size was increased to 450 students (225 intervention, 225 control groups) to compensate for dropouts and preserve the planned statistical power (Chisquares, Inc. Sample Size Calculation for Cross-sectional Studies with Percentage as Outcome [34]).

Intervention Tools and Procedures for Data Collection

Data were collected using a structured, closed-ended, self-administered, Arabic paper-based questionnaire. The questionnaire collected data on socio-demographics, including sex, age group (in years), students’ monthly pocket money allowance, educational track (scientific or literary), place of birth, and awareness of AHRKC (Tables 1, 2, Results Section). The original questionnaire (Table 2) was developed in English by the International Tobacco Control (ITC) Policy Evaluation Project [35], and was translated into Arabic and back-translated to ensure semantic equivalence, following expert review recommended guidelines [36,37] and expert review. It was pre-tested and piloted among 28 second-grade students (male and female) from 2 secondary schools (1 for boys and 1 for girls) in 2 districts in Aden City. This assessment was undertaken to assess the comprehension, ease of administration, and time required to complete the questionnaire. The reliability analysis demonstrated acceptable internal consistency of the questionnaire (Cronbach’s alpha = 0.76). Students and districts involved in the pilot phase were excluded from the

Table 1. Differences between the control (n = 209) and the intervention group (n = 218) in ability to notice media messages before and after the program.

Items	Baseline			Three-month follow-up		
	Control N (%)*	Intervention N (%)*	P value**	Control N (%)*	Intervention N (%)*	P value**
Q1. Noticing anti-khat chewing messages (how often)?						
Never	38 (18.2)	45 (20.6)	0.263	77 (36.8)	4 (1.8)	< 0.001
Once	55 (26.3)	43 (19.7)		39 (18.7)	18 (8.3)	
Often	116 (55.5)	130 (59.6)		93 (44.5)	196 (89.9)	
Q2. Noticing messages about risks associated with khat chewing and encouraging people to quit in the following places						
Posters	113 (54.1)	128 (59.8)	0.233	67 (24.7)	204 (93.5)	< 0.001
Billboards	45 (21.5)	63 (29.4)	0.062	34 (16.3)	186 (85.3)	< 0.001
Educational displays	68 (32.5)	70 (32.7)	0.969	46 (22.0)	186 (85.3)	< 0.001
Morning announcements#	89 (42.6)	100 (46.7)	0.391	76 (36.4)	184 (84.4)	< 0.001
Brochures	106 (50.7)	105 (49.1)	0.734	60 (28.7)	190 (87.2)	< 0.001

* The reported response was the correct answer (Yes) in each statement; ** Chi-square test; # School radio; Bold values are significant at $P < 0.05$.

Table 2. Differences in students' awareness of health effects of khat between the control (n = 209) and the intervention (n = 218) groups before and after the program.

Questions	Baseline			Three-month follow-up		
	Control N (%)*	Intervention N (%)*	P value**	Control N (%)*	Intervention N (%)*	P value**
Constipation	115 (55.0)	117 (53.7)	0.054	104 (49.8)	204 (93.6)	< 0.001
Loss of appetite	139 (66.5)	126 (57.8)	0.051	131 (62.7)	211 (96.8)	< 0.001
Insomnia	168 (80.4)	164 (75.2)	0.165	158 (75.6)	212 (97.2)	< 0.001
Hypertension	67 (32.1)	40 (18.3)	0.001	72 (34.3)	183 (84.3)	< 0.001
Gastritis	70 (33.5)	74 (33.9)	0.999	54 (27.4)	167 (78.8)	< 0.001
Anxiety	98 (47.8)	91 (42.5)	0.207	107 (51.2)	201 (92.2)	< 0.001
Hyperglycemia	44 (21.1)	57 (26.1)	0.258	48 (23.1)	176 (80.7)	< 0.001
Periodontal and gum	94 (45.0)	88 (40.4)	0.289	94 (45.0)	205 (94.0)	< 0.001
Oral cancer	80 (38.6)	60 (27.5)	0.01	71 (34.1)	202 (92.7)	< 0.001
Neurological disorders	108 (51.9)	98 (45.0)	0.165	88 (42.1)	200 (91.7)	< 0.001
Heart stroke	53 (25.5)	36 (16.5)	0.024	47 (22.5)	168 (77.1)	< 0.001
Impotence in male	41 (19.7)	46 (21.1)	0.704	73 (34.9)	174 (80.0)	< 0.001
Psychosis	115 (55.3)	106 (48.6)	0.186	75 (35.9)	172 (78.9)	< 0.001
Brain stroke	41 (19.9)	27 (12.4)	0.041	32 (15.4)	130 (61.0)	< 0.001

* The reported response was the correct answer (Yes) in each statement; ** Chi-square test. Bold values signify significant at $P < 0.05$.

main study. Following approval from school directors, social science and health teachers were recruited to facilitate study implementation. Additionally, 9 trained youth volunteers from the Yemeni Health Voluntary Organisation assisted with questionnaire distribution and collection during the baseline and follow-up phases.

Pre-Intervention Phase

In this phase, participating students in the control and intervention groups were given the same questionnaire. The first section of the questionnaire comprised sociodemographic variables (eg, age, sex, and student monthly pocket money allowance as a proxy for the socioeconomic status of the family) (Table 3). The second section investigated students' awareness of anti-khat media messages using questions presented in Table 1. The first question was 'During the last 30 days, how often have you noticed anti-khat chewing media messages in the following: posters, billboards, brochures, wall magazines, TV, and school radio announcements?' Responses were categorized as 'never', 'once', or 'often'. The second question was 'In the last 30 days, have you noticed or heard advertising or information that discusses the risks associated with khat chewing or encourages quitting in any of the following places: posters,

billboards, brochures, educational displays, TV, and school radio?' The respondents had 'yes' or 'no' options to answer each question. Those who answered 'yes' scored 1, and those who answered 'no' scored 0. The third section assessed awareness of 14 adverse health risks associated with khat chewing. Responses were coded as 1 = yes and 0 = no/don't know. Awareness scores ranged from 0 to 14 and were categorized into low awareness (0-9) and high awareness (10-14) using a median split, consistent with prior studies [35].

Intervention and Post-Intervention Phases

The intervention started immediately after baseline data collection and consisted of a 3-month mass media educational campaign. The intervention included lectures and seminars, billboards, posters, brochures, educational displays, documentary films, and school radio announcements. Given the absence of television facilities in most Aden schools, educational documentary films were used as a substitute. Morning assembly announcements and student-led activities were also incorporated. Educational sessions were delivered by the lead author (MK) and a public health specialist, with each session lasting approximately 35 minutes. At the conclusion of the intervention, all educational materials were provided to the control

Table 3. Sociodemographic characteristics of the participants in the control (n = 209) and the intervention groups (n = 218) at the baseline.

Variables	Control N (%)	Intervention N (%)	P value*
Age group			0.801
≤ 17	149 (71.3)	153 (70.2)	
18 and above	60 (28.7)	65 (29.8)	
Sex			0.003
Male	137 (65.6)	75 (34.4)	
Female	72 (34.4)	143 (65.6)	
Field of study			0.108
Scientific	153 (73.2)	144 (66.1)	
Literary	56 (26.8)	74 (33.9)	
Pocket money/month#			0.077
≤ 3000 YR (~USD 14)	103 (49.5)	126 (58.1)	
More than 3000 YR (~USD 14)	105 (50.5)	91 (41.9)	
Place of birth#			0.583
Urban	124 (59.6)	135 (62.2)	
Rural	84 (40.4)	82 (37.8)	

* Chi-square test: Bold values signify significant at $P < 0.05$, YR, Yemeni Rials; USD, United States Dollars (2013 exchange rate ~ 215 YR = 1 USD); # missing data for 1 participant in both groups.

schools to ensure ethical equity. Post-intervention data collection was conducted using the same questionnaire 3 months after the baseline assessment.

Statistical Analysis

The data were analyzed using SPSS version 22. Descriptive statistics were used to summarize participant characteristics. Chi-square tests assessed differences in categorical variables (eg, sociodemographics) between groups, while independent *t* tests evaluated mean differences in awareness and media exposure scores. Normality was confirmed using the Shapiro-Wilk test ($P > 0.05$). Baseline and follow-up data were analyzed as independent samples (not linked at the individual level) and ‘change’ reflected group-level mean differences between timepoints. Bivariate analyses examined associations between sociodemographic variables and post-intervention awareness as outcome (high = score ≥ 10 [yes]; low = score 0-9 [no]). Multivariable logistic regression analysis was performed to identify factors independently associated with post-intervention awareness (categorized as ‘yes’ or ‘no’) of AHRKC. Statistical significance was set at $P < 0.05$.

Results

The Socio-Demographics of Participants

Of the 450 students initially enrolled at baseline (225 in the control group and 225 in the intervention group), 23 were

excluded due to questionnaires with more than 50% missing responses or lack of relevance to the study outcomes (16 from the control group and 7 from the intervention group). This resulted in a final analytical sample of 427 participants (209 control and 218 intervention). **Table 3** presents the sociodemographic characteristics of the study sample. The mean age of the participants was 17.33 ± 0.95 years, with an age range of 15 to 22 years. Except for sex, no statistically significant differences were observed in sociodemographic characteristics between the control and intervention groups.

Groups Noticing Anti-Khat Mass Media Messages Before and After Program

Table 1 presents non-significant differences between the intervention and control groups in their ability to notice anti-khat mass media messages in posters, billboards, educational displays, TV, school radio, and brochures at baseline. However, significant improvement was seen following the program in the ability to notice anti-khat mass media messages in the intervention group compared to the control group in the following locations/platforms: posters (93.5% vs 24.7.1%), billboards (85.3% vs 16.3%), educational displays (85.3% vs 22%), brochures (87.2% vs 28.7%), and school radio (84.4% vs 36.4%) ($P < 0.001$).

Groups’ Awareness of Khat Health Risks Before and After the Program

Table 2 indicates that the overall awareness of khat health risks was similar in the intervention and control groups at

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Table 4. Differences and changes in the scores of mass media channels and students' awareness in the control (n = 209) and the intervention (n = 218) groups before and after the program.

Items score	Control (n = 209) Mean (95% CI)	Intervention (n = 218) Mean (95% CI)	Mean difference Mean (95% CI)	P value*
Mass media scores				
Before mass media exposure	2.01 (1.83-2.21)	2.18 (2.00-2.36)	0.17 (0.17-0.17)	0.239
After mass media exposure	1.29 (1.11-1.47)	4.30 (4.16-4.44)	3.01 (2.98-3.04)	< 0.001
Change in mass media exposure scores	-0.72 (-0.82 - -0.62)	2.12 (2.07-2.17)	2.84 (2.80-2.88)	< 0.001
Awareness Scores				
Awareness before	5.89 (5.49-6.29)	5.18 (4.79-5.75)	-0.71 (-0.71-0.71)	0.012
Awareness after	5.52 (5.05-5.99)	11.95 (11.67-12.23)	6.43 (6.30-6.56)	< 0.001
Change in awareness scores	-0.37 (-0.42-0.32)	6.77 (6.69-6.85)	7.14 (7.01-7.27)	< 0.001

* Independent t test; (95% CI): 95% Confidence interval; Bold values a significant at $P < 0.05$.

Table 5. Significant factors associated with students' awareness of khat chewing's adverse health risks in the intervention group (n = 218).

Variables	Fully adjusted model		
	OR	95% CI	P value*
Age			
≤ 17	3.35	1	0.031
≥ 18		1.11-10.14	
Pocket money			
More than 3000 YR (~USD 14)	2.39	1	0.018
≤ 3000 YR (~USD 14)		1.04-5.47	
Exposure to anti-khat media channels			
No	2.40	1	0.023
Yes		1.06-5.46	

* Logistic regression; (1) Reference category; OR, odd ratio; 95% CI, 95% confidence interval; YR, Yemeni Rial; USD, United States Dollars (2013 exchange rate ~ 215 YR = 1 USD). Bold values signify significance at $P < 0.05$.

baseline. Following the program, significant improvement in awareness was observed in the intervention group compared to the control group ($P < 0.001$).

Groups' Scores of Mass Media And Awareness Before and After the Programme

Table 4 presents the mean score for students after the exposure to anti-khat media messages. The mean score was 2.01 points for the control group and 2.18 points for the intervention group, with a mean difference of 0.17 ($P = 0.239$). Significant improvements were seen after the program in the intervention group's mean score (4.30 points) compared to that of the control group (1.29 points), with a mean difference of 3.1 ($P < 0.001$). The mean total awareness score in the control group at baseline was 5.89 points and 5.18 points for the intervention group, with a mean difference of -0.71 ($P = 0.012$).

Moreover, within the program, the mean awareness score in the intervention group increased by 11.95 points compared to the control group's mean awareness score of 5.52 points, with a mean difference of 6.43 ($P < 0.001$).

Factors Associated With Students' Awareness of Khat Chewing's Adverse Health Effects

Table 5 presents the results from multivariable regression analysis, showing the association between awareness of the health risks of khat chewing and sociodemographic variables, along with the exposure level to anti-khat mass media messages in the intervention group. Regression analysis revealed that only 3 factors were significantly associated with awareness of adverse health effects: students' age of over 18 years (OR = 3.35; 95% CI = 1.11-10.14, $P = 0.031$), students' pocket

money allowance (OR = 2.39; 95% CI = 1.04-5.47, $P = 0.018$), and exposure to anti-khat media messages (OR = 2.40; 95% CI = 1.06-5.46, $P = 0.023$).

Discussion

This study addresses a specific gap in the literature by evaluating a multi-channel, school-based health awareness intervention targeting khat-related health risks among adolescents in Yemen. While previous research has primarily focused on the prevalence and health consequences of khat use, there is limited evidence from interventions designed to improve awareness in this population. The present study therefore contributes as a contextual validation and translation of multi-component media-based health education to prevent khat use. Importantly, the study examined this approach within clearly defined boundary conditions, including a school-based setting, an adolescent population, the use of multiple communication channels, and a defined follow-up period. As such, the study contributes to the emerging literature on khat-related health education by examining awareness outcomes following a multi-component school-based intervention in a real-world educational setting.

The findings of the study supported the proposed hypothesis and suggest that school-based mass media educational approaches can improve health awareness among adolescents. However, in the absence of directly comparable studies, we relied on the relevant literature on similar interventions to discuss the findings of the present study.

Students in the intervention group reported significantly higher recognition of anti-khat messages across multiple media channels, including posters, billboards, brochures, educational displays, and school radio announcements. This pattern suggests that repeated exposure through multiple communication platforms can play an important role in reinforcing health messages. Similar observations have been reported in adolescent tobacco prevention research, where multi-component media campaigns were associated with increased message recall and awareness [35,38]. Although behavioral outcomes were not assessed in the present study, increased awareness is an important preliminary step in health promotion efforts targeting substance use.

The present study found that responses of students from the control and intervention groups to awareness questions were comparable at baseline. However, significant improvement was seen in the awareness of the intervention group compared to the control group. This finding agrees with another study conducted among Nigerian university students, which reported that awareness of the health risks of smoking increased

after implementation of an intervention program [39]. A randomized controlled trial conducted on Australian adolescents used a multi-component mass media approach and revealed that a mixed program was successful in enhancing adolescents' awareness of the dangers of smoking [40]. Moreover, approximately 60% of students in both the control and intervention groups in the current investigation were aware that khat chewing can lead to sleeplessness, loss of appetite, constipation, and psychosis. These findings are consistent with the existing literature [12,41-43].

The current study also found that the average scores for mass media exposure were higher in the intervention group than in the control group. In addition, exposure to anti-khat chewing media messages was associated with a significant increase in awareness of the health risks of khat chewing in the intervention group compared to the control group. This was similar to the findings of a study conducted among adult smokers in Malaysia, which revealed that respondents in the intervention group had higher awareness scores than those who were not exposed to media messages [44]. Obaid et al in the United Arab Emirates aimed to reduce adolescents' their desire to initiate smoking, showing that a health education intervention program increased students' awareness scores and alleviated their desire to smoke [45]. These findings highlight the potential role of educational interventions in addressing behaviors associated with significant health risks. In the context of khat use, such interventions may be particularly important given the reported effects of khat chewing on oral microbial flora and its association with alterations in proinflammatory cytokines and hepatic and renal responses [47].

The current investigation revealed that awareness of the adverse health effects of khat chewing among adolescents in the intervention group was significantly associated with age, monthly pocket money allowance, and level of exposure to mass media channels. This finding suggests that targeted interventions focused on younger age groups, children with higher pocket money allowances, and those with limited access to preventive information could be useful in controlling khat and substance use. In 2018, Booker et al demonstrated that early social media interaction at the age of 10 years was associated with a decline in protective behavior and well-being [48]. Older adolescents have better cognitive functions, which increases their awareness of health risks. We also found that school children with lower pocket money allowances were more likely to be aware of AHRKC. This suggests that adolescents with more pocket money tend to be less concerned about AHRKC. Higher pocket money allowances have been previously identified as a predictor of tobacco use [49].

Notably, the findings of this study are consistent with previous research on anti-tobacco campaigns, which have revealed that

audiovisual media messages can significantly increase awareness of the health risks associated with tobacco use. Studies conducted among Indian adults and European schoolchildren have demonstrated that exposure to these types of media messages is strongly associated with greater awareness of the dangers of smoking, thereby suggesting that similar strategies could be effective in raising awareness of khat-related health risks among adolescents [50,51].

These findings provide valuable implications for public health policy and practice in Yemen. Given the role of mass media in improving young adults' awareness of the health risks of khat chewing, policymakers should integrate evidence-based communication strategies as a part of a national anti-khat framework. Recommended intervention measures include mandatory health warning labels at where khat is sold, as well as sustained mass media campaigns through television, school radio and digital platforms. Also, school-based health education programs can be integrated within the secondary school curriculum, in alignment with the World Health Organization's Health-Promoting Schools Framework [52,53]. Engagement of community leaders, public figures and families may further reinforce these strategies.

Despite the strengths of this study in terms cost-effectiveness, simplicity of implementation, targeting high risk adolescents at schools (real-world environment), and increasing awareness of the risks of khat chewing, there are a number of noteworthy weaknesses. The generalizability of this study's findings is limited: the results primarily apply to similar public secondary school settings in Aden or other contexts where khat chewing is prevalent and culturally embedded. Notably, the findings should not be extrapolated to settings where khat is illegal or absent, as the sociocultural dynamics and baseline awareness levels differ substantially.

In addition, the sample was weighted to overrepresent females, which may have biased the findings. However, limited research in the topic highlights the significance of the obtained findings, even for settings extending beyond the boundaries of the current study. Additionally, the data were collected in 2013, and delays in dissemination were attributable to the ongoing conflict and logistical challenges in Yemen. While the age of the data may raise concerns, khat chewing remains a prevalent public health issue, and older datasets continue to inform contemporary research and policy, as demonstrated by the continued use of legacy national surveillance data (eg, National Health and Nutrition Examination Survey 2011/2012 in public health literature [54,55]). Another limitation from the current study is that self-reported measures may be subjected to social desirability bias. However, these are commonly used tools in similar public health studies and provide valuable insights into perceptions and awareness. Efforts were made to ensure

anonymity, reducing the likelihood of bias in participants' responses, and to maintain the strictest level of participant anonymity, which is crucial in sensitive studies like the present one, the authors opted not to relate individual pre- and post-test responses. While this approach prioritises privacy, it limits the ability to track changes on an individual level. Future studies could explore alternative methods that balance anonymity with the ability to track individual progress. Namely, future studies should use individual-linked data to enable appropriate repeated-measures analyses (eg, mixed-effects models or paired analyses) to yield more precise estimates of within-student change. Another limitation is that the study included only 4 district clusters (2 intervention and 2 control districts), which may limit the strength of causal inference despite the random allocation procedure. Finally, the short duration of the programme may have precluded the maturation effect inherent in before-and-after experimental designs [56]. However, the relatively short follow-up period limited the ability to assess the long-term sustainability of the observed changes in awareness, highlighting the need for future studies with extended follow-up durations. Such studies could provide a more comprehensive understanding of whether improvements in awareness are sustained over time and whether periodic reinforcement of educational messages is necessary to maintain awareness and support efforts to prevent khat chewing among adolescents. In addition, as khat is classified as a controlled substance in many counties [7] but remains culturally normal and legally permitted in others [8-18], the generalizability of the present findings is limited by the sociocultural and legal context of the study setting. Therefore, caution is required when applying the results to different contexts.

Conclusions

Given the limitations of this study, it can be concluded that the mass media campaign and educational program were associated with increased awareness of the adverse health risks of khat chewing among secondary school students over the 3-month follow-up period. The observed associations were influenced by factors such as age, pocket money, and message exposure frequency. However, the findings should be interpreted with caution due to potential sources of bias, including selection bias, sex imbalance, reliance on self-reported data, exclusion of participants with incomplete questionnaires, and unmeasured potentially confounding variables such as parental education and peer influence. These factors highlight the complexity of evaluating awareness-based educational interventions. In addition, the applicability of the findings is primarily limited to public secondary school settings in Aden/Yemen and similar contexts using comparable educational and mass media delivery channels. Future research should include larger and more representative samples, reduce demographic imbalances,

incorporate more robust and objective measures of awareness, and use longitudinal designs to examine whether the observed awareness gains are sustained over time.

Department and Institution Where Work Was Done

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Institutional Review Board Statement

The study was approved by the Institutional Review Board of University of Aden (Ref. 20131026). This was followed by a formal request to the director of the Teaching and Education Office in Aden City to allow access to schools to enrol participants for this study.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Data Availability Statement

The data supporting this study are subject to privacy and are therefore not publicly available. They may, however, be obtained from the first author upon reasonable request.

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Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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