BMJ Open

Systematic review of intervention functions, theoretical constructs and cultural adaptations of school-based smoking prevention interventions in low-income and middle-income countries

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To cite: Ba-Break M, Bewick B, Huss R, *et al*. Systematic review of intervention functions, theoretical constructs and cultural adaptations of school-based smoking prevention interventions in low-income and middle-income countries. *BMJ Open* 2023;**13**:e066613. doi:10.1136/bmjopen-2022-066613

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2022-066613).

Received 14 July 2022
Accepted 09 January 2023

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ABSTRACT

Objective To identify the approaches and strategies used for ensuring cultural appropriateness, intervention functions and theoretical constructs of the effective and ineffective school-based smoking prevention interventions that were implemented in low-income and middle-income countries (LMICs).

Data sources Included MEDLINE, EMBASE, Global Health, PsycINFO, Web of Science and grey literature which were searched through August 2022 with no date limitations.

Eligibility criteria We included randomised controlled trials (RCTs) with ≥6 months follow-up assessing the effect of school-based interventions on keeping pupils never-smokers in LMICs; published in English or Arabic.

Data extraction and synthesis Intervention data were coded according to the Theoretical Domains Framework, intervention functions of Behaviour Change Wheel and cultural appropriateness features. Using narrative synthesis we identified which cultural-adaptation features, theoretical constructs and intervention functions were associated with effectiveness. Findings were mapped against the capability-motivation and opportunity model to formulate the conclusion. Risk of bias was assessed using the Cochrane risk of bias tool.

Results We identified 11 RCTs (n=7712 never-smokers aged 11–15); of which five arms were effective and eight (four of the effective) arms had a low risk of bias in all criteria. Methodological heterogeneity in defining, measuring, assessing and presenting outcomes prohibited quantitative data synthesis. We identified nine components that characterised interventions that were effective in preventing pupils from smoking uptake. These include deep cultural adaptation; raising awareness of various smoking consequences; improving refusal skills of smoking offers and using never-smokers as role models and peer educators.

Conclusion Interventions that had used deep cultural adaptation which incorporated cultural, environmental, psychological and social factors, were more likely to be effective. Effective interventions considered improving pupils' psychological capability to remain never-smokers and reducing their social and physical opportunities and reflective and automatic motivations to smoke. Future trials should use standardised measurements of smoking to allow meta-analysis in future reviews.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This systematic review was based on a comprehensive search of randomised control trials (RCTs) in multiple databases and grey literature with no restrictions on dates.
⇒ Double-checking 25% of the included and excluded abstracts and full text for eligibility with a high agreement rate provided the best protection against bias.
⇒ The review used smoking outcomes from 7712 baseline never-smokers and provided multiple explorations of school-based interventional RCTs in terms of cultural appropriateness, theoretical constructs and intervention functions.
⇒ Only 11 trials met the eligibility criteria of this review; probably because of constrained resources to implement long-term high-quality school-based interventional RCTs on smoking prevention in low-income and middle-income countries (LMICs), or barriers to publication facing LMIC authors due to language barriers or inaccessibility to international databases. There was inconsistency among the trials in reporting the changes in smoking status which restricted quantitative synthesis of the findings in this review.

INTRODUCTION

Tobacco use is a global epidemic and its rate, estimated to be 22% among adults, continues to increase annually.[1 2] Smoking is one of the major risk factors for non-communicable diseases (NCD) that cause 70% of the global deaths.[3] Smoking-related mortality, disability and morbidity reduce labour productivity and the potential for income-earning which challenges the economic growth and social development of countries.[4] These harms are

preventable. Therefore preventing smoking and its consequences is a global concern, and over half a trillion US dollars are spent annually on tobacco control measures.[5]

Smokers in low-income and middle-income countries (LMICs) represent 80% of the smokers worldwide.[4] Three-quarters of the global NCD deaths happen in LMICs, mainly (82%) before the age of 70 years.[2 6] The global data indicates poor implementation of effective preventive measures in LMICs compared with high-income countries.[2] Tobacco products are affordable and accessible in many LMICs where tobacco taxation and restriction of tobacco promotion and advertisement are poorly implemented.[4 7 8]

Over the past four decades, school-based interventions have been used to prevent adolescents from smoking initiation in many countries.[9] The effectiveness of school-based smoking prevention interventions (SBSPI) was evaluated in many randomised control trials (RCTs) and reviewed in some systematic reviews to identify factors influencing the effectiveness.[10–21] However, only three reviews were focused on LMICs, one is limited to African countries and included non-RCTs,[22] one explored smoking cessation only[23] and one was not a systematic review.[24] To enhance the effectiveness of SBSPIs in LMICs, it is important to understand factors that influence their effectiveness and consider these factors during the design and implementation process. Therefore, the current systematic review was conducted to develop an understanding of what influenced the effectiveness of SBSPIs that were implemented in LMICs in terms of theoretical constructs, intervention functions and cultural appropriateness.

The following theoretical perspectives were used to review the included trials: (1) the middle layer of the Behaviour Change Wheel (BCW)[25] to specify intervention functions. (2) The Theoretical Domain Framework (TDF)[26] was adapted using the classification of smoking prevention curriculum[27] and used to explore the theoretical constructs of interventions. (3) The findings from the steps above were matched against the inner layer of BCW, the capability, opportunity, motivation and behaviour (COM-B) model. (4) Kreuter *et al*, [28] and Castro *et al*,[29] classifications were used to assess approaches, dimensions and strategies of cultural appropriateness. These theoretical perspectives were used to allow comprehensive exploration of the cultural appropriateness, intervention functions and theoretical constructs that were commonly applied in effective SBSPIs in LMICs to enhance the capability, opportunity and motivation of pupils to avoid smoking initiation.

This review is important because no other systematic review has been conducted that (a) reviews RCTs of SBSPIs implemented in LMICs to prevent smoking initiation among adolescents; (b) explores cultural appropriateness of interventions; (c) identifies theories and behaviour change approaches that influence effectiveness. This systematic review aims to identify approaches and strategies used to ensure cultural appropriateness, intervention functions and theoretical constructs of the effective and ineffective SBSPI that were implemented in LMICs.

METHODS

Search strategy and trial selection

We searched the MEDLINE, EMBASE, PubMed, Global Health, PsycINFO, CINAHL, Web of Science, POPLINE, Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, ICTRP International Clinical Trials Registry Platform (WHO, International), TRIP, Database of Abstracts of Reviews of Effects (DARE), WHO Regional Databases, Cochrane Database of Systematic Reviews, ProQuest Middle East & Africa Database, Education Resources Information Centre (ERIC), Applied Social Sciences Index And Abstracts (ASSIA), Tobacco control 1992-, ProQuest dissertations and theses, Electronic Thesis Online Services (ethos), DART –Europe- E – theses portal, South African thesis and dissertation (SATD), A Stop Smoking In School Trial (ASSIST), Action on Smoking and Health (ASH), Centre for Tobacco Control Research, the Cochrane Tobacco Addiction Group's Specialised Register, Trials Register of Promoting Health Interventions (TRoPHI). The search was conducted from inception to August 2022 using terms relating to SBSPI, with no date restrictions (see online supplemental file 1). Articles were filtered later for the country of implementation. We checked article bibliographies and ran individual MEDLINE and Web of Science searches for 60 authors who researched this topic in LMICs. The World Bank classification of countries by income[30] was used.

We searched for all RCTs evaluating SBSPI in LMICs. Trials were included, if interventions targeted adolescents (10–17 years old) and adolescents were individually randomised, or as classes or schools were randomised as clusters RCTs with a minimum of 6 months follow-up after intervention completion. Trials were excluded, if no control group was included or smoking rates before and after interventions were not measured and reported. We excluded trials that merely targeted teachers or parents or only reported changes in pupils' awareness or intention to smoke. Studies targeting smoking alone or together with other risky behaviour and independent from what the control group received were included providing they aimed at preventing smoking initiation. The main outcome was pupils that remain in never-smokers. Using biochemical validation of self-reported smoking status was recorded but not required for inclusion.

The search was restricted to articles published in English and Arabic. Three interventions were excluded because the full text was only available in Portuguese, Chinese or Spanish languages. Another excluded trial[31] met all the inclusion criteria except one, as pupils were only followed for 4 months after intervention completion.

One researcher (MB-B) independently screened all titles, abstracts and full-text articles for inclusion and exclusion criteria. A random sample (25%) of all titles and abstracts of included and excluded studies was

independently reviewed by two other researchers (AA and HA), with an agreement rate of 90%.

Data extraction and management

Data were independently extracted by two researchers (MB-B and AA). Any disagreement was resolved through collective discussion and consensus, or referral to other researchers (HE, BB and HA).

A data extraction form was first piloted in 25% of the trials then used to extract data from each intervention about the following aspects: (1) intervention's functions, aim, study design, number of arms, theoretical constructs, contents (for both interventions and controls) and smoking prevention curriculum (what). (2) Details of the intervention and control groups: number, age, gender, ethnicity, rates of attrition and response (who). (3) Intervention's delivery methods, deliverers and their training (how). (4) Years (when) and country of implementation, the setting and school types (where). (5) Number of main and booster sessions, frequency of contact, duration of interventions and follow-up after intervention completion (how many). (6) Intervention's country of origin and cultural appropriateness, risk of bias, any reported facilitators, challenges and quality of implementation (how well). (7) Justification for using schools in this context (why). (8) Definition and numbers of never-smokers at baseline and follow-up among intervention and control groups.

The review specified the application of each of the following nine BCW intervention functions in each arm: education, persuasion, incentivisation, training, enablement, coercion, restriction, environmental reconstruction and modelling. The theoretical construct of each arm was explored using the following 17 TDF theoretical domains[26]: knowledge; physical and psychological skills; memory, attention and decision process; behavioural regulation; managing environmental context and resources; social influences management; beliefs about consequences; beliefs about capabilities; optimism; intentions; professional/social role and identity; personal goals/target setting; reinforcement; and emotion management. The knowledge and skills domains were subgrouped using Griffin and Botvin[27] classification of smoking prevention curriculum to specify types of information and skills delivered. Each trial was explored to identify the involved approaches (top-down or bottom-up), dimensions (deep or surface) and strategies for cultural appropriateness (linguistic, peripheral, evidential, constituent-involving, sociocultural and cultural tailoring), using the Kreuter *et al*,[28] and Castro *et al*[29] classifications.

A designed checklist was used to identify the presence or absence of each of the 17 theoretical domains, the 9 intervention functions and the smoking prevention curriculum as well as the 2 dimensions, the 3 approaches, the 6 strategies and the 3 stages of cultural appropriateness in each arm of the included trials. Selecting more than one dimension, approach, strategy for cultural appropriateness, theoretical domain, function and curriculum per trial was allowed. Tables were used to summarise key findings and facilitate comparison across trials. To ensure effective data extraction and coding, the reviewers referred to the definitions and examples of each theoretical domain and intervention function. Additionally, open discussion with other expert reviewers was conducted prior to data extraction to clarify boundaries between different intervention functions and domains.

The Cochrane risk of bias tool[32] was used, independently by two researchers with 90% agreement rate, to assess whether trials had high, low or unclear risk of selection bias (random sequence generation and allocation concealment), detection bias, attrition bias and reporting bias. High risk of bias is selected, if the available data indicate plausible bias that reduces confidence in the results, while unclear risk of bias is selected if the available data was insufficient to judge. Authors were contacted if data were missing or unclear in the published articles, but missing data were not imputed.

Data synthesis

A narrative synthesis of the findings[33] was used in this review as the heterogeneity across the included trials in defining, measuring, assessing and presenting outcomes hindered pooling the findings and conducting a meta-analysis. It is recommended to calculate effect size in systematic reviews to facilitate comparing the effectiveness of intervention when different statistical tests and parameters were used across studies.[34–37] Therefore, RevMan software (V.5.1) was used to calculate the effect size of each of the included trials. A visual inspection of a funnel plot was used to assess publication bias risk (see online supplemental file 2.

The following steps were employed in data synthesis: (1) key findings extracted from all trials were summarised in tables. (2) A narrative descriptive summary of the intervention functions, theoretical constructs, smoking prevention curriculum, cultural appropriateness and effectiveness of the included trials was produced. (3) Patterns among interventions in each of these aspects were examined. (4) interventions' effectiveness was discussed in relation to variance or similarity between trials in each of these aspects. (5) Lastly, the findings were discussed using the matrices that link COM-B model with each of TDF and the intervention functions, as these matrices were developed to facilitate discussing and designing behaviour change interventions.[25] The review concluded how effective SBSPIs in LMICs enhanced the capability, opportunity and motivation of pupils to avoid smoking initiation.

Patient and public involvement

We conduct this review to contribute to the global effort to better control smoking-related morbidity and mortality worldwide and in LMICs. The review is a step toward designing school-based interventions to prevent Egyptian adolescents from smoking initiation. This review is implemented in response to questions from schools'

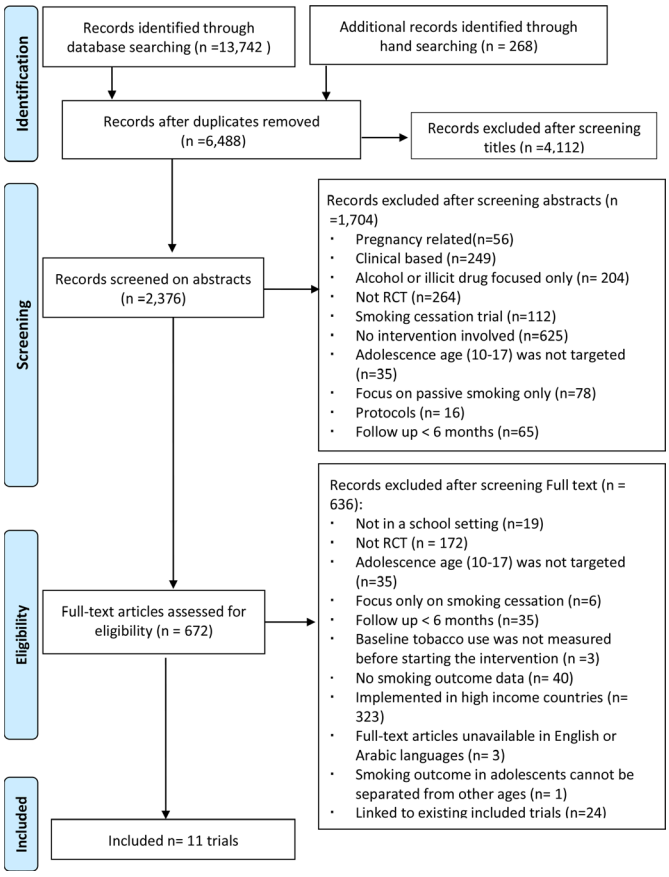

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram for searching school-based smoking prevention interventions in low-income and middle-income countries. RCTs, randomised controlled trials.

children and teachers who inquired what other schools do to prevent smoking initiation among pupils. This study reviewed the available research and did not include primary data collection to involve the public. The findings will be disseminated to relevant stakeholders in LMICs through emails, virtual conferences and webinars.

RESULTS

Out of the 13 742 articles retrieved, 675 potential studies were identified after screening titles and abstracts. Of these, 11 clustered RCTs met the eligibility criteria and are included in this review (figure 1); representing 39 455 never-smoked pupils aged 11–15 years (table 1 summarises participants' characteristics). Women represented at least 45% of the sample in all trials, except in one[38] they were 11%.

Interventions characteristics

The included trials were conducted in the following LMICs: three in China, two each in India, and South Africa and one each in Romania, Thailand, Indonesia and Mexico. Each trial comprised 1-intervention arm with the exception of two that comprised 2-intervention arms and one included 3-intervention arms, so in total the review included 15-intervention arms (see table 2 for trials characteristics). All trials included at least one control group who received a regular school curriculum. In one trial[39] the control group received the same but delayed intervention after intervention completion. Contents of school curriculum in relation to smoking prevention were discussed only in four trials.[39–42] These trials indicated absence of smoking prevention contents or activities in school curriculum, of these two trials[39 42] also reported absence of anti-smoking school policy. All trials focused primarily on preventing smoking initiation but one.[39] Four trials[38 40 43 44] also involved smoking cessation and other substances-use, respectively. All interventions focused on face-to-face activities inside schools. Four trials[39 40 42 45] also implemented activities outside schools. Booster-sessions were delivered in four trials only.

Primary-outcomes

To assess the effectiveness of each intervention, adolescents' smoking behaviour were compared in the intervention and control arms before the intervention and after a minimum of 6 months following intervention completion. Self-administered questionnaires filled confidentially at schools was the only method used for assessing outcomes of all trials. Due to financial constraints, none of the trials used biological measures to check the validity of self-reported smoking status. Only five of the included intervention arms were effective, compared with controls, in preventing adolescents at schools from smoking initiation (table 1).

Most trials defined never-smokers as those who never tried smoking in their life, even a puff or two based on the Global Youth Tobacco Survey definition.[46] However, those who smoked a puff or two were considered never-smokers in one study.[44] Changes in never-smoking rates in the past one[43] or two[38] months before the survey were used in assessing the outcome of two trials. Two trials[38 40] did not separate the findings on cigarette smoking from other tobacco use. Some trials presented findings as changes in ever-smoking prevalence among those who never smoked before and after the intervention.[38 39 47] Whereas others[40–42 44 48 49] calculated OR of ever-smoking rates or measured difference in number of never-smokers between intervention and controls.

Accordingly, pooling findings in a meta-analysis was not appropriate due to the inconsistency in defining, measuring, assessing and reporting outcome measures across the included trials. Consequently, narrative data synthesis was used in this review.

Risk of bias

Attrition and selection were identified as the most common sources of bias. Risk of bias was appraised as considerable across the included studies as half of the included trials included high risk of bias in at least one of the five Cochrane risk of bias criteria[32] and no trial has low risk of bias in all these criteria. Ineffective trials have a higher risk of bias ratio than effective trials (table 3). Only one effective trial[44] had high risk of bias caused

Table 1 Baseline characteristics of participants

The study ID (first author, year, country)	The effectiveness of the intervention in smoking prevention	Number	Age	Sex (females %)	Ethnicity	School type (public %)	Family income
Perry *et al*[39] 2009, India	Effective	12 484	11.9	48.4	Not stated	Not stated	Not stated
Motamedi *et al*[44] 2016, South Africa	Effective	5610	11–12	51	Black 9.5%, white 4.0%, mixed race (combination race of Asian, European and African descent) 85.8%	Not stated	Not stated but schools selected in a low income, densely populated urban area
Lotrean *et al*[45] 2013, Romania	Effective	1071	13–15	51	Not stated	Not stated	Not stated
Reddy *et al*[40] 2002, India	School intervention	Effective	5752	11.9	49.5	Not stated	40	Not stated
	School intervention plus family intervention	Effective					
Tahlil *et al*[41] 2015, Indonesia	Islamic-based intervention	Ineffective	477	11–14	58.5	Not stated	Not stated	Not stated
	Health-based intervention	Ineffective					
	Combined health and Islamic-based intervention	Ineffective					
Resnicow *et al*[47] 2010, South Africa	Harm management	Ineffective	5266	14	49.5	Black 59.7%, coloured 26.4%, white 9.9%	100	Not stated but findings were adjusted for income
	Life skills intervention	Ineffective					
Chou *et al*[48] 2006, China	Ineffective		2661	12.5	47.7	Not stated	Not stated	Not stated
Seal[38] 2006, Thailand	Ineffective		170	15.5	11	Not stated	Not stated	Not stated
Wen *et al*[42] 2010, China	Ineffective		2343	13.4	45.9	Not stated	50	Not stated
Marsiglia *et al*[43] 2015, Mexico	Ineffective		431	13	55	Mexican	100	Not stated
Chen *et al*[49] 2014, China	Ineffective		1807	14.5±1.1	49.6	Linzhi Tibetan and Guangzhou Han	Not stated	Not stated

Table 2 Characteristics of included studies

The study ID (first author, year, country)	The effectiveness of the intervention in smoking prevention		Intervention duration	Number of sessions	Frequency of contact	Booster-sessions	Follow-up period	Response rate at final-evaluation	The attrition rate in the intervention arm compared with control	Components			Targets				Settings			The deliverer							
										Smoking prevention	Smoking cessation	Preventing substance use	Pupils		Teachers	Parents/ relatives/ community	Inside schools	Outside schools	Teachers	Peers	Outsider specialists	Training deliverers	Fidelity checked	Process-evaluation done	
Perry *et al*[39] 2009, India	Effective		Not stated	7 in year 1 6 in year 2	One/year	6	2 years	94.7% year 1 84.0% year 2	Not stated	X	X		X	X	X		X	X	X	X		Y	Y	Y	
Motamedi *et al*[44] 2016, South Africa	Effective		Not stated	12	One/year	6	3 years	90%	10% in both arms	X	X	X	X				X		X			NC	Y	Y	
Lotrean *et al*[45] 2013, Romania	Effective		2 months	5 weekly	Weekly	NC	9 months	90.2	11% compared with 9.8% in control	X	X		X		X		X	X	X	X		Y	NC	Y	
Reddy *et al*[40] 2002, India	School intervention	Effective	Not stated	20	Not stated	NC	1 year	88.3%	Not stated	X		X	X				X		X	X		Y	Y	Y	
	School plus family intervention	Effective								X		X	X		X		X	X							
Tahlil *et al*[41] 2015, Indonesia	Islamic-based intervention	Ineffective	8 weeks	8	One/week	NC	6 months	89.5%	Not stated	X			X				X		X		X	Y	NC	NC	
	Health-based intervention	Ineffective								X			X				X								
	Combined health and Islamic intervention	Ineffective								X			X				X								
Resnicow *et al*[47] 2010, South Africa	Harm management	Effective	Not stated	8/year	One/year	NC	2 years	93%	41.2% compared with 14.2% in control	X			X				X		X			Y	Y	Y	
	Life skills intervention	Ineffective							34.2% compared with cohort 15.3%	X			X				X								
Chou *et al*[48] 2006, China	Ineffective		13 weeks	13	Once /week	NC	1 year	97% at baseline	12.5% compared with 7% in control	X			X				X		X		X	Y	NC	NC	
Seal[38] 2006, Thailand	Ineffective		Not stated	10	Not stated	0	6 months	100%	Not stated	X		X	X				X		NC	NC	NC	NC	NC	NC	
Wen *et al*[42] 2010, China	Ineffective		Not stated	Not stated	Not stated	2	6 months	90%	7.95% compared with 32.55% in control	X			X	X	X		X	X	X	X	X	Y	NC	Y	
Marsiglia *et al*[43] 2015, Mexico	Ineffective		10 weeks	20	Two/week	NC	8 months	86%	Not stated	X		X					X		X			Y	NC	NC	
Chen *et al*[49] 2014, China	Ineffective		Not stated	Not stated	Two/year	2	1 year	99.5%	Rate was not specified but it is stated it is high	X			X	X			X		X	X		Y	Y	NC	

Table 3 Summary of the risk of bias in the included studies

Study ID	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome reporting (attrition bias)	Selective outcome reporting (reporting bias)	Ratio of high risk of bias*
Perry *et al*[39] 2009, India	L	U	U	L	L	0/5
Motamedi *et al*[44] 2016, South Africa	H	H	U	L	U	2/5
Lotrean *et al*[45] 2013, Romania	L	U	U	L	L	0/5
Reddy *et al*[40] 2002, India	L	U	U	U	L	0/5
Tahlil *et al*[41] 2015, Indonesia	U	L	U	U	L	0/5
Resnicow *et al*[47] 2010, South Africa,	U	U	U	H	L	1/5
Chou *et al*[48] 2006, China	L	U	U	H	L	1/5
Seal[38] 2006, Thailand	L	L	U	U	L	0/5
Wen *et al*[42] 2010, China	L	H	H	H	L	3/5
Marsiglia *et al*[43] 2015, Mexico	H	U	U	U	L	1/5
Chen *et al*[49] 2014, China	L	U	U	H	L	1/5

H=high risk of bias, U=unclear risk of bias, L=low risk of bias.
*The ratio of the high risk of bias equals the number of criteria coded as high risk of bias in each study out of the five criteria used for assessing the risk of bias.

by selecting intervention schools purposively based on being cooperative before starting the intervention. The assessment could not identify low risk of selection and detection bias in most trials due to insufficient evidence of blinding participants, deliverers or outcome-assessors. Although blinding is difficult in behaviour change intervention, findings might have been influenced by these biases, as self-reporting of smoking inside schools was the only method used for assessing interventions' outcomes.

Cultural appropriateness

Most (10/15) intervention arms were based on effective interventions originally developed in high-income countries (see table 4). The effectiveness in originating countries was stated by intervention designers in the published articles as justifications for using these interventions, which we also checked in this review. In three[39 43 48] of these imported interventions, developers of original interventions trained local public-health-specialists and researchers to adapt the intervention to the targeted context, to ensure balancing fidelity and cultural appropriateness. Local people were involved in designing interventions in all arms. Most (11/15) arms used both top-down and bottom-up approaches by involving both experts and community members with an understanding of what was feasible and acceptable. However, only three arms collected quantitative data on feasibility and acceptability of the contents before implementation.

Table 4 summarises approaches, dimensions and strategies used for cultural appropriateness of each intervention arms. Contents of all interventions were delivered by people (mainly teachers) who share culture with the targeted-population (constituent-involving cultural appropriateness strategy), using dominant local languages (linguistic cultural appropriateness). Two-thirds (10/15) of interventions considered using a culturally appropriate package of contents and materials such as images, colours, clothes and pictures of community members (peripheral cultural appropriateness). Cultural values and beliefs of targeted communities were considered when designing nine arms (sociocultural adaptation strategy). However, only three arms demonstrated relevance of interventions to the targeted population (evidential cultural appropriateness). Only in two intervention arms, both were effective, were cultural tailoring which is defined as using all the above cultural appropriateness strategies included.

Deep cultural adaptation is defined as going beyond changing intervention contents and delivery methods to match the targeted population's characteristics (such as using local people, clothes, music and language to develop and deliver interventions) to involve through incorporating cultural, environmental, psychological and social factors that influence smoking in the targeted population into the proposed intervention.[29 50] Measures for deep cultural adaptation were mostly recognised in the effective interventions. Whereas all the ineffective interventions, except one,[47] involved either unclear or surface cultural adaptation of the imported interventions. These adaptations were limited to altering the language and appearance of contents to suit the targeted populations (peripheral and linguistic cultural appropriateness) with some (in three arms only) including weak consideration of local sociocultural predictors of smoking. Involving adolescents in designing interventions, by exploring their perspectives on why and why-not their peers smoke and how schools could prevent them from smoking, was considered only in two interventions,[44 51] both were effective.

Theoretical constructs

The design of all effective interventions, except one,[40] was informed by at least one theory but insufficient details were available on how theory was incorporated. Table 5

Table 4 Summary of cultural appropriateness of the included interventions

The study ID (first author, year, country)	The effectiveness of the intervention in smoking prevention		Cultural appropriateness																			
			Intervention country of origin	Dimension			Approach			Strategy							Stage			How		
				Surface	Deep	Unclear	Bottom-up	Top-down	Both	Linguistic	Peripheral	Evidential	Constituent-involving	Sociocultural	Cultural tailoring	Design	Implementation	Evaluation	Informally	Qualitative data	Surveys
Perry *et al*[39] 2009, India	Effective		USA		X				X	X	X	X	X	X	X	X	X			X	
Motamedi *et al*[44] 2016, South Africa	Effective		USA		X				X	X	X	X	X	X	X	X	X	X		X	X
Lotrean *et al*[45] 2013, Romania	Effective		Netherland		X				X	X	X	X	X	X	X			X	X	X	
Reddy *et al*[40] 2002, India	School intervention	Effective	Partly from USA			X			X	X	X		X			X	X			X	X
	School and family intervention	Effective				X			X	X	X		X			X	X			X	X
Tahlil *et al*[41] 2015, Indonesia	Islamic based intervention	Ineffective	Indonesia	X					X	X			X	X		X				X	
	Health-based intervention	Ineffective		X					X	X			X	X		X				X	
	Combined health and Islamic-based intervention	Ineffective		X					X	X			X	X		X				X	
Resnicow *et al*[47] 2010, South Africa	Harm management	Ineffective	Australia		X				X	X	X		X	X		X				X	
	Life skills intervention	Ineffective	USA		X				X	X	X		X	X		X				X	
Chou *et al*[48] 2006, China	Ineffective		USA	X				X		X	X		X			X			X		
Seal[38] 2006, Thailand	Ineffective		USA	X				X		X	X		X			X			X		
Wen *et al*[42] 2010, China	Ineffective		China			X			X	X			X	X		X				X	
Marsiglia *et al*[43] 2015, Mexico	Ineffective		USA	X					X	X	X		X			X				X	
Chen *et al*[49] 2014, China	Ineffective		China			X		X		X			X			X				X	

NB: Presence of a cultural appropriateness dimension, approach, strategy, method and time in an intervention arm is indicated with an X.

Table 5 Summary of the theoretical domains of the included studies

The study ID (first author, year, country)	The effectiveness of the intervention in smoking prevention	Knowledge		Skills			Memory, attention and decision process	Behavioural regulation	Environmental context and resources	Social influences	Beliefs about consequences	Beliefs on capabilities	Optimism	Intentions	Identity /social role	Personal-goals	Reinforcement S	Emotion management
		Knowledge on consequences	Normative education	Social competence	Social influence	Combined												
Parry *et al*[39] 2009, India	Effective	X			X		X		X	X	X	X		X	X		X	
Motamedi *et al*[44] 2016 South Africa	Effective	X				X	X	X			X		X	X	X	X		X
Lotrean *et al*[45] 2013, Romania	Effective	X			X		X			X	X	X		X	X		X	
Reddy *et al*[40] 2002, India	School intervention	Effective	X		X				X	X	X			X				
	School intervention plus family intervention	Effective	X		X				X	X	X			X				
Tahill *et al*[11] 2015, Indonesia	Islamic-based intervention	Ineffective	X	X	X						X			X				
	Health-based intervention	Ineffective	X	X		X				X	X			X				X
	Combined health and Islamic-based intervention	Ineffective	X	X		X					X			X				X
Resnicow *et al*[47] 2010, South Africa	Harm management	Ineffective	X		X			X			X			X				
	Life skills intervention	Ineffective	X			X	X				X			X				X
Chou *et al*[48] 2006, China	Ineffective		X	X	X		X			X	X			X	X			
Seal[38] 2006, Thailand	Ineffective		X			X	X		X		X			X				X
Wen *et al*[42] 2010, China	Ineffective		X			X	X		X	X	X			X	X		X	X
Marsiglia *et al*[14] 2015, Mexico	Ineffective		X		X		X				X	X		X				
Chen *et al*[49] 2014, China	Ineffective		X		X				X	X	X			X	X			

maps the presence and absence of the 17 TDF theoretical domains.

All interventions provided information on smoking harms (knowledge domain). The information delivered in the ineffective arms was only about smoking-related illnesses, except in two arms[41 47] as social consequences were added. Only effective interventions explained the consequences of secondary smoking. Interventions that combined explaining the health, environmental, social and emotional consequences of smoking were effective.[39 44] None of the interventions that explained national smoking rates to correct pupils' overestimation of smoking rates (normative education) was effective.

All interventions aimed at either enhancing pupils' social influence skills (by making them aware of social pressure to smoke and training them to refuse smoking offers by friends, relatives or tobacco companies), or social competence skills (by providing training on at least one of the followings: self-awareness, self-esteem, self-control, stress-coping techniques, problem solving and decision-making), or both. Training on social influence skills was emphasised in all effective interventions while combining both skills was effective only in one arm[44] (skills domain).

Nine intervention arms used role-plays, group discussion and activities or videos in raising awareness of smoking consequences to make the contents attractive and memorable after the intervention (memory and attention domain). Only effective interventions[44 45] combined these methods with encouraging pupils to discuss their views on advantages and disadvantages of smoking before deciding to smoke or not (decision process domain).

Six arms aimed to increase barriers and minimise facilitators of smoking in pupils' environment (environmental-context and resources domain). All these arms involved enhancing accessibility to information on smoking consequences inside schools. While pupils' exposure to this information was high only in the effective interventions, this exposure was either low[49] or not evaluated[38 42] in the ineffective arms. Additionally five arms included policies that prevent pupils, teachers, parents and visitors from smoking inside schools. In the effective arms, improving information accessibility and anti-smoking policy went beyond schools to include home[40] or the wider community.[39] This included motivating the community to advocate for national anti-smoking policy[39] or banning tobacco promotion.[40]

Activities to reduce social influencers of adolescents' smoking (social influence domain) were considered in all the effective interventions, except one.[44] Only effective interventions used peer-pressure to create a positive attitude toward non-smoking, or introduced pupils (alone or with teachers or parents) who never smoked as role-models by announcing their names in school newsletters. These role-models contributed in supporting other pupils to avoid smoking; informally discussed their beliefs about smoking harms and shared their experience of maintaining non-smoking behaviour and refusing smoking offers by friends. The intervention[42] that aimed to change influencers of smoking at home through parents' education on smoking harms without using pupils as role-models or peer-pressure were ineffective even when parents signed contracts not-to-smoke at home. Some ineffective arms aimed to change social norms only through explaining the social refusal of smoking by adolescents or obtaining written commitments from teachers or parents or verbal public commitments from pupils in front of their classmates not-to-smoke.

All arms considered correcting pupils' beliefs about smoking consequences, at least on health. Although pupils' beliefs that smoking is harmful had improved after interventions in seven arms, only five arms[39 40 45 52] showed translating these beliefs into action by avoiding smoking. All arms[39 44] that involved correcting beliefs about the emotional, addictive, environmental and social consequences of smoking in addition to harms on health were effective.

Besides increasing awareness and beliefs that smoking is harmful, three arms aimed to enhance pupils' beliefs about their capability to avoid smoking. The effective arms[45 52] enhanced participants' self-confidence in their ability to avoid smoking and supporting their relatives and peers to avoid or quit smoking, trained them in this and allowed them to practice the acquired skills in role-plays and in the presence of professionals such as teachers or health professionals . One effective arm[39] established school-based support groups for the trained participants even after the intervention completion. The ineffective arm[43] trained pupils, using filmed real-life scenarios, to refuse smoking offers after explaining smoking harms and encouraged them to leave smokers when they smoke. However, authors acknowledged that condensing these activities over a short period due to time and resources constraints may have contributed to its ineffectiveness.

All arms involved enabling adolescents to make an informed and conscious decision to remain non-smokers (intention theoretical domain). Although the intention to smoke markedly reduced in 10 arms, adolescents' ability to translate this good intention to action by staying never-smokers at the end of the follow-up was demonstrated only in 5 effective arms.[39 40 45 52] One effective[44] and three ineffective[38 43 47] interventions did not report changes in adolescents' intention to smoke.

The identity and social role domain was coded in seven arms, four were effective. In the ineffective arms,[42 48 49] all participants were required to make public commitments inside school to avoid smoking and discuss smoking harms with peers, but it was unclear if this commitment was obligatory by school or voluntary. The effective arms[39 40 44 45] allowed pupils who never smoked to make a self-conscious voluntary intention to be identified as non-smokers, be role-models and take active roles in persuading their relatives or peers to avoid smoking.

Training on coping strategies with anxiety and depression and stress-management (emotion management domain) was provided in six arms, only one[44] was effective. Only this effective arm allowed participants to practice

the acquired skills and burn out techniques like physical activities and hobbies through enhancing adolescents' accessibility to some relevant facilities in the community.

The domains of personal-goals, behavioural regulation or optimism were only used in one intervention, which was effective. This intervention encourage pupils to set proximal and distal goals for themselves, then educated them on how smoking hinders achieving their goals and how a better quality of life could be obtained without smoking (personal-goals setting domain). It also enhanced them to monitor their usage of free time and emotional reaction, trained them on anxiety and anger management, encouraged them to use their free time to practice hobbies and exercises to beat boredom; enabled them to overcome accessibility constraints to leisure facilities (behavioural regulation domain). The same intervention also stimulated pupils' self-confidence that they will win sports competitions and have a healthy and bright future by avoiding smoking (optimism domain).

The reinforcement domain was used in three arms, through social rewards for never-smokers. The effective interventions[39 45] rewarded pupils (as well as teachers and parents in one arm)[39] who maintained non-smoking behaviour until the end of follow-up by announcing their names in school newsletters and posters, to encourage others to imitate them. The ineffective arm[42] rewarded winners of schools' competition for the best anti-smoking presentations and essays, without publishing their smoking status, by giving them schools' smoking-control-committee membership.

Intervention functions

Table 6 illustrates the interventions effectiveness in relation to the involved intervention functions. All trials used *education and training functions* to deliver the above-explained theoretical domains of knowledge and skills. Besides explaining smoking-related illness, effective interventions discussed other (addictive, emotional and environmental) consequences of primary and secondary smoking, using memorable educational methods such as group discussion, role-plays and videos.

All effective arms involved the *persuasion function, through illuminating* disadvantages and advantages of smoking using real-life scenarios in role-plays or videos followed by debate or group discussion on that; then training pupils to balance the disadvantages and advantages of smoking before deciding to smoke or not. The persuasion function in ineffective arms was limited to explaining biological hazards of smoking using animal experiments,[42] showing pictures of smoking-related illnesses[49] or discussing reasons for refusing smoking offers only from pupils' perspective.[43]

The *incentivisation function* was under-represented in the included interventions but used more in the effective arms. Only social incentives were used, as no financial incentives were offered in any included intervention. The discussion above about the reinforcement domain explains the difference between the used incentives in the effective and ineffective arms.

No intervention used the *coercion function*. No trial reported using or creating an expectation of punishments of smokers, even when smoking inside schools.

The included interventions showed limited use of the *restrictive function* but this was used more in effective arms; through preventing pupils, teachers, visitors and parents from smoking inside or around school premises. In the effective arms, the anti-smoking policy went beyond school boundaries to the wider environment through disseminating the national anti-smoking policy and enhancing its implementation by community members,[39] or advocating banning tobacco advertisements through pupil-signed petitions directed to the government.[40] The two ineffective arms[49 53] established smoking control committees aiming to support anti-smoking activities and banning smoking inside schools, but it was unclear if the anti-smoking policy was enforced or not.

The included arms showed limited use of the *modelling function,* which was only included in effective interventions, through declaring pupils who never smoked as role-models, then training them to discuss smoking harms with their peers. One effective arm[39] declared teachers and parents plus pupils who never smoked as role-models. The effective interventions used peer-educators who never smoked to: chair, stimulate, summarise and present outcomes of group activities and run formal peer educational sessions inside classes. Their role in the effective arms also included: (1) sharing personal experience on making friendships without smoking; (2) illustrating (through role-plays and videos) positive attitude toward non-smoking and ways to resist peers and social pressure to smoke; (3) leading informal discussion outside classes with smoker and non-smoker pupils about various smoking consequences. Whereas peer-educators, with unreported smoking status, were used only in two ineffective arms, mainly to assist[49] or deliver[42] formal educational sessions on smoking harms inside classes or to speak to smoker pupils outside classes.

The *environmental reconstructing* function was identified in four arms, only one was effective.[39 52] The effective arm[39 52] encouraged social norms against smoking through establishing smoke-free initiatives run by a smoking-prevention-committee, which consists of pupils who never smoked and formally promised to support their peers to avoid smoking. Their activities went beyond schools to include pupils' home and neighbourhood environments. Whereas this function in ineffective arms, when existed, was limited to school celebration of the World No-Smoking-day[42] or producing school-posters discouraging smoking.[48 49] Two ineffective arms[42 49] established a school smoking-related committee but the role of this committee was unexplained. One ineffective intervention[48] reported taking additional efforts to prevent pupils' exposure to smoking at home without explaining how.

Table 6 Summary of the presence of BCW intervention functions in included studies

The study ID (first author, year, country)	The effectiveness of the intervention in smoking prevention		Education	Persuasion	Incentives	Coercion	Training	Restriction	Environmental restructuring	Modelling	Enablement
Perry *et al*[39] 2009, India	Effective		X	X	X		X	X	X	X	X
Motamedi *et al*[44] 2016, South Africa	Effective		X	X			X				
Lotrean *et al*[45] 2013, Romania	Effective		X	X	X		X			X	
Reddy *et al*[40] 2002, India	School intervention	Effective	X	X			X	X			
	School intervention plus family intervention	Effective	X	X			X	X			
Tahlil *et al*[41] 2015, Indonesia	Islamic based intervention	Ineffective	X				X				
	Health-based intervention	Ineffective	X				X				
	Combined health & Islamic based intervention	Ineffective	X				X				
Resnicow *et al*[47] 2010, South Africa	Harm management	Ineffective	X				X				X
	Life skills intervention	Ineffective	X				X				
Chou *et al*[48] 2006, China	Ineffective		X				X		X		
Seal[38] 2006, Thailand	Ineffective		X				X				
Wen *et al*[42] 2010, China	Ineffective		X	X	X		X	X	X		
Marsiglia *et al* [43] 2015, Mexico	Ineffective		X	X			X				
Chen *et al*[49] 2014, China	Ineffective		X	X			X	X	X		

Presence of a BCW Intervention Function in an intervention arm is indicated with an X.
BCW, Behaviour Change Wheel.

Only two arms, one of which[39] was effective, considered the *enablement intervention function*, through improving pupils' capability (beyond training and education) and opportunity to remain never-smokers. The effective arm[39] offered smoking prevention, quitting and counselling services at schools for smoker and non-smoker parents, teachers and pupils. Whereas in the ineffective arm[54] this function was limited to the provision of school-based quitting services for smoker pupils only.

DISCUSSION

We found that importing effective interventions does not guarantee effectiveness if the cultural appropriateness of interventions was not incorporated properly. Paying less attention to cultural tailoring made some interventions effective in one context and ineffective in another context even when the two-targeted population share the same ethnicity but live in different countries.

No intervention used all the 17 theoretical domains. Although arms that involved the least number of domains were ineffective, the review concluded that using more domains does not guarantee effectiveness. The knowledge, intention, skills and belief on consequences theoretical domains were involved in all interventions. The commonly used domains in the effective intervention are social influence; attention and decision process; memory; identity and social role; followed by the beliefs about capability; emotion management; and environmental context and resources domains. The optimism, behavioural regulation and personal-goals domains were only used in the effective interventions.

None of the included interventions used all the BCW intervention functions. All interventions included the education and training functions, at least. Coercion was the only unused function in all interventions. All effective interventions used persuasion besides education and training functions. The effective arms used these three functions alone[44] or combined with either restriction[40] or modelling function only[45] or with all other functions except the coercion function.[39]

Enhancing capability, motivation and opportunities to avoid initiating smoking

The effective interventions enhanced pupils' psychological capability to maintain non-smoking behaviour through the following: (1) raising their awareness of the environmental, social, psychological and addictive consequences of smoking in addition to its impact on health; (2) adequately exposing and providing access to information about smoking consequences to pupils in schools through posters, booklets and newsletters; (3) explaining the emotion that makes adolescents smoke and training pupils on monitoring, managing and coping with emotional reactions, anger, stress, depression and anxiety; (4) improving pupils' skills in resisting smoking offers in their societies by illustrating these skills, giving them opportunities to practice these skills, providing feedback on their performances and exploring ways to improve their skills; (5) advising them on how to recognise, analyse and react to direct and indirect pressures to smoke from peers, family, advertisements and adults; and (6) building pupils' confidence so that they can compete in sports and have a healthy future if they refrain from smoking.

The physical opportunities for pupils to initiate smoking were minimised in the effective interventions through: (1) establishing and enforcing anti-smoking policies that prohibit smoking inside schools by teachers, parents and visitors before pupils; and (2) engaging community members to enforce the national anti-smoking policies.

The effective arms considered reducing pupils' social opportunities to initiate smoking through: (1) exposing pupils to non-smoking role-models in schools; (2) pointing out important individuals in the pupils' society who never smoked; (3) involving non-smokers in videos, pictures and role-plays at schools to demonstrate skills that enhance non-smoking; (4) representing smokers in unfavourable images repeatedly through these means at schools to deter pupils from smoking; (5) encouraging pupils who have never smoked to present themselves as role-models who could inspire others to emulate; (6) training and empowering these pupils to persuade others inside and outside schools to avoid smoking; (7) providing consultation on friendship enhancement without having to smoke and encourage sharing experience on that; (8) allowing sufficient time for practicing peer-education skills with feedback from professionals; (9) applying peer-pressure to create positive attitudes toward non-smoking; and (10) encouraging obtaining social support from teachers, parents or friends on smoking avoidance.

To influence pupils' beliefs of what is bad and good about smoking and strengthen their conscious intention (reflective motivation) not-to-smoke, the effective interventions used the followings: (1) balancing the advantages and disadvantages of smoking and non-smoking after explaining those using engaging educational methods; (2) comparing the emotional reasons behind smoking with the psychological consequences of smoking; (3) considering parents' disapproval of smoking; and (4) setting distal personal goals, discuss how smoking might hinder achieving that, then making a conscious decision not-to-smoke, setting that as a personal goal and providing written or verbal commitment to avoid smoking. Effective arms also enhanced pupils' self-confidence in remaining non-smokers and encouraged those who never smoked to make a conscious voluntary intention to be recognised as role-models.

Additionally, the effective interventions involved the following to influence pupils' reflex responses and emotional reactions to their urges, desires, needs and wishes (*automatic motivation*) to smoke. (1) Encouraging pupils to monitor their free time usage and emotional reaction. (2) Discussing useful methods of enjoying free time without smoking. (3) Improving access to affordable community services to facilitate practicing leisure,

hobbies and physical activities to release pupils' negative emotions and beat boredom. (4) Rewarding pupils (also teachers and parents if possible) who never smoked, at least socially through announcing their names on newsletters to encourage others to imitate them.

Strengths

The strengths of this review are the comprehensive search of SBSPI in multiple databases, grey literature and reference lists with no restrictions on dates. Experts were consulted. Double-checking 25% of the included and excluded abstracts and full text for eligibility with a high agreement rate. It is improbable that key interventions were missed. Reviewing RCTs that used smoking outcomes from 7712 baseline never-smokers, provided clear indications of whether interventions are effective. The multiple explorations of these trials to identify the dimensions, approaches and strategies for cultural appropriateness; theoretical constructs; and intervention functions.

Limitations

The review authors could have introduced further bias by making assumptions during data extraction and analysis, but the consistency of the findings and low heterogeneity in comparison suggest that the conclusions are reliable.

Only 11 trials met the eligibility criteria of this review; probably because of constrained resources to implement long-term high-quality school-based interventional RCTs on smoking prevention in LMICs, or the small number of publications due to the limited experience and inaccessibility to international databases or language barriers. Other systematic reviews[14 17 22 55–58] identified a similar gap and limitations of RCTs from LMICs including short follow-up periods, pupils' attrition, performance bias and poor reporting of findings. Limited financial and human resources in LMICs were important recognised barriers.[41 56 59]

Although self-reporting is a valid and stable indicator for identifying smoking status in many contexts,[60 61] its sensitivity and specificity vary by age, gender and culture.[62] Adolescents, especially girls, might under-report their smoking where smoking is culturally unacceptable[63–65]; or over-report where smokers are considered mature and impressive.[31 62 66–68] As all the included interventions relied only on self-reporting of smoking status, the outcomes assessment might not be completely accurate. Using biochemical measures for validating self-reporting improves outcomes assessments[67] but is challenged by the constrained resources available in LMICs, as other studies have identified.[14 17 40 42 69 70]

High risk or poor reporting of attrition bias in some studies is another limitation. Better reporting of attrition rates with attrition analysis and adjustment of findings could have helped in better explanations of interventions' effectiveness.[71] Poor reporting of fidelity and implementation quality without process evaluation in some studies is another limitation. Assessing the extent of delivering interventions as planned through process evaluations could have minimised bias in interpreting the effectiveness of these complex-interventions and explaining why the effectiveness varies across contexts.[71 72]

Other limitations of the review are that three trials were excluded because the findings were unavailable in English or Arabic. Findings were not always disaggregated by gender. This restricted determining if the same or different interventions are needed to prevent both male and female adolescents from smoking initiation. Inconsistency, across the included trials, in reporting the changes in smoking status restricted quantitative synthesis of the findings in this review. The limited available information about cultural adaptation of interventions restricted further exploration of when 'deep cultural appropriateness' is achieved.

Implication for research

This review has highlighted that there are still gaps in the evidence on what influences the effectiveness of SBSPIs in LMICs. More long-term RCTs on smoking prevention at schools should be conducted in LMICs, with good attention to measures to reduce attrition, detection and selection bias. Further research is required to test intervention functions and theoretical constructs that would be effective in each gender. The web, smartphones or social media were not used to deliver any of the included interventions, despite the global increase in adolescents' usage of these modern technologies.[73 74] Researchers should explore the feasibility, acceptability and effectiveness of using these technologies for modern methods in school-based interventions in LMICs.

Using standardised trial designs, definitions of smoking status and methods of measuring and reporting interventions outcomes, would allow quantitative data synthesis in future reviews for meta-analysis. Standardising key study design features would enable researchers in LMICs to use and thus enhance researching and publishing evidence on this topic. Research should gather information on barriers, requirements and cost of developing and implementing SBSPIs in LMICs and their cost-effectiveness. Funding for researching these gaps is crucial to accelerate the global control of the smoking pandemic.

CONCLUSION

We concluded that effective interventions focused more on improving adolescents' psychological capability to remain never-smokers and reducing their (social and physical) opportunities and (reflective and automatic) motivations to smoke, compared with ineffective trials. Effective interventions achieved that through: (1) raising awareness of various consequences of smoking using engaging methods and accessible information sources. (2) Improving refusal skills of smoking offers, through demonstration, practice and feedback on performance. (3) Advising pupils on how to recognise, analyse and react to direct and indirect pressure to smoke. (4) Enhancing pupils' self-confidence and ability to make a conscious

decision to remain never-smokers, make that a personal goal and obtain social support for that. (5) Restrict smoking inside schools. Repeatedly presenting smokers in negative images. (6) Social rewarding of never-smokers and using them as role-models. Peers' education and pressure against smoking. (7) Encouraging pupils to consider parents' disapproval of smoking. (8) Facilitating useful free time usage and negative emotions control.

We also concluded that interventions' effectiveness is influenced by deep cultural adaptation, using top-down and bottom-up approaches. Inconsistency, across included trials, in reporting the changes in smoking status hindered quantifying the weight of the role of each of these items in interventions' effectiveness.

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Contributors MB-B, HE and BB conceived the review. MB-B, AA and HA completed screening and extraction of data. MB-B, HE, BB and RH devised the analysis plan and AA and HA provided support for analyses. MB-B wrote the text. HE, BB, RH and TE supervised the whole review process. All authors critically revised the manuscript for intellectual content and advised on the publication process. All authors read and approved the final version of the review. MB-B is the guarantor of the paper.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. All data relevant to the study are included in the article or uploaded as supplementary information. The data sets analysed in the current study are available from the corresponding author (MB-B) upon reasonable request.

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