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#### School-Based Smoking Prevention Interventions in Low and Middle-Income Countries: a Systematic Review

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# School-Based Smoking Prevention Interventions in Low and Middle-**Income Countries: a Systematic Review**

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# Abstract

**Objective:** To assess the effectiveness of SBSPIs in keeping adolescents as 'never-smokers' in low and middle income countries (LMICs) and identify the used intervention functions, theoretical constructs, and cultural adaptations within the implemented interventions.

**Design:** Systematic review. Data: MEDLINE (1966+), EMBASE (1974+), Global Health, CINAHL, PsycINFO (1967+), ERIC (1982+), Cochrane CENTRAL, Web of Science, Popline, CENTRAL, SCOPUS, Dissertation Abstracts, and grey literature. Data synthesis: Narrative synthesis. Risk of bias is assessed with Cochrane Risk of Bias tool.

Setting: 11 randomised controlled trials (RCTs) of school-based smoking curricula.

**Participants:** Never-smokers aged 11 to 15 (n=7,712); follow-up ≥6 months; low and middle-income countries; no date limitations; published in English or Arabic languages.

**Interventions:** Interventions were coded according to the Theoretical Domains Framework (TDF), intervention functions of the Behaviour Change Wheel (BCW) and cultural appropriateness features. Then we categorised studies into levels of effectiveness and identified qualitatively which of the cultural adaptation features, theoretical constructs, and intervention functions were associated with effectiveness. The findings were mapped against the capability-motivation and opportunity (COM-B) model to conclude the result.

#### Outcome measure: Remaining a never-smoker at follow-up

**Results:** 11 RCTs were included; of which five arms were effective and five studies had a low risk of bias in all criteria. Methodological heterogeneity prohibited quantitative data synthesis. The review identified nine components that characterized the interventions that were effective in preventing pupils from smoking uptake. Examples of these components 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.

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## Conclusion:

We concluded that deep cultural adaptation influences interventions' effectiveness and effective interventions succeeded to prevent pupils from smoking uptake by improving their psychological capability to remain never-smokers and reducing their social and physical opportunities and reflective and automatic motivations to smoke.

**Keywords:** smoking, prevention, school-based intervention, RCTs, LMICs, Systematic review, TDF, BCW, COM-B

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# 1. Introduction

Tobacco use is a global epidemic as 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 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 consequence is a global concern, and over half a trillion US Dollars are spent annually on tobacco control measures [5].

Smokers in 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 RCTs and reviewed in some systematic reviews to identify factors influencing the effectiveness [10-22]. However, only three reviews were focused on LMICs, they are either limited to African countries [23] or smoking cessation [24], or not systematic review [25]. 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) [26] to specify intervention functions. 2) The Theoretical Domain Framework (TDF) [27] was adapted using the classification of smoking prevention curriculum [28] 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, Lukwago [29] and Castro, Barrera Jr [30] 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 as 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 review aims to identify the association between the effectiveness of school-based interventions in preventing adolescents from smoking initiation in LMICs and the used approaches and strategies for ensuring cultural appropriateness, intervention functions, and theoretical constructs.

## 2. 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,

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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 Specialized Register, Trials Register of Promoting Health Interventions (TRoPHI). The search was conducted from inception to April 2021 using terms relating to school-based smoking prevention interventions with no date restrictions. Articles were filtered later for 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 [31] was used.

We searched all RCTs evaluating school-based smoking prevention interventions in LMICs. Trials were included, if interventions targetted 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. There was no restriction on targeting smoking alone or among other risky behaviour, what the control group received, providing they aimed at preventing smoking initiation. Using biochemical validation of self-reported smoking status was recorded but not required for inclusion.

Three interventions were excluded because the full text was only available in Portuguese, Chinese or Spanish languages. Google translation to Arabic or English languages, although accessible, did not allow in-depth analysis of the key issues explored in this review. Another excluded trial [32] met all the inclusion criteria except one, as pupils were only followed for four months after intervention completion.

One researcher (MB) independently screened all titles, abstracts, and full-text articles for inclusion and exclusion criteria. Two other researchers (AA and HA) independently screened a random sample (25%) of all titles and abstracts of the included and excluded studies, 90% agreement rate was achieved. Any disagreement was resolved through collective discussion, consensus, or referral to other researchers (HE, JN, BB).

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## Data extraction and management

Data were independently extracted by two researchers (MB and AA). Any disagreement was resolved through collective discussion, consensus, or referral to other researchers (HE, BB, 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 [27]: 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 sub-grouped using Griffin and Botvin [28] 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, constituentinvolving, sociocultural, and cultural tailoring), using the Kreuter, Lukwago [29], and Castro, Barrera Jr [30] classifications.

A designed checklist was used to identify the presence or absence of each of the 17 theoretical domains, the nine intervention functions, and the smoking prevention curriculum as well as the two dimensions, the three approaches, the six strategies, and the three 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 summarize 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 [33] was used 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 [34] 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 meta-analysis. It is recommended to calculate effect size in systematic reviews to facilitate comparing the effectiveness of intervention when different statistical test and parameters were used across studies [35-38]. Therefore, Revman software (version 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.

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 [26]. The review was concluded with 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 was in response to a request of school children in Egypt

 who enquired how their schools could play an effective role in preventing smoking at an early age. Thanks to those children who drew our attention to the importance of researching this topic in LMICs. There was no primary data collection that could be involved with the public in this study. It reviewed the available research. Emails, virtual conferences, and webinars will be used to disseminate the findings to LMIC stakeholders and decision-makers.

# 3. 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 included in this review (**Error! Reference source not found.**); representing 39,455 never-smoked pupils aged 11 to 15 years, Table 1 summarizes participants' characteristics. Females represented at least 45% of the sample in all trials, except in one [39]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 one intervention arm except three trials as two compromised two-intervention arms and one included three-intervention arms, so 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[40] 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[40-43]. These trials indicated absence of smoking prevention contents or activities in school curriculum, of these two trials[40, 43] also reported absence of anti-smoking school policy. All trials focused primarily on preventing smoking initiation but one [40] and four trials [39, 41, 44, 45] also involved smoking cessation and other substances-use respectively. All interventions focused on face-to-face activities inside schools. Four arms [40, 41, 43, 46] 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 six-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 interventions arms were effective, compared with cotrols, 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 [47]. However, those who smoked a puff or two were considered never-smokers in one study[45]. Changes in never-smoking rates in the past one[44] or two[39]months before the survey were used in assessing the outcome of two trials. Two trials[39, 41] 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[39, 40, 48]. Whereas others [41-43, 45, 49, 50]calculated odd-ratio 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.

#### **Table 1Baseline characteristics of participants**

Table 1Baseline characteristic	cs of participants		E	3MJ Oper	n	njopen-2022-06661 J by copyright, incl		Pa
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the int smoking prevent	tervention in ion	Number	Age	Sex (females %)	Ethnicity fo	School type (public %)	Family income
1. Perry, 2009, India	Effective		12484	11.9	48.4	Not stated	Not stated	Not stated
2. Motamedi, 2016, South-Africa	Effective		5610	11-12	51	Black 9.5%, White & Source Mixed race (combination race of Asian, Euro and African descent	Not stated	Not stated but schools selected in a low income, densely populated urban area
3. Lotrean, 2013, Romania	Effective.		1071	13-15	51	Not stated of to	Not stated	Not stated
	School intervention	Effective	5752			vnlo vt a		
4. Reddy, 2002, India	School intervention plus family intervention	Effective	5752	11.9	49.5	Not stated nd eur	40%	Not stated
	Islamic based intervention	Ineffective	0			a m ABE		
5. Tahlil. 2015. Indonesia	Health-based intervention	Ineffective	477	11-14	58.5	Not stated	Not stated	Not stated
,,	Combined health and Islamic based intervention	Ineffective		6		ig, Al		
6 Rospicow 2010 South Africa	Harm management	Ineffective	EDEE	14	40 E	Black 59.7%, Colo	100	Not stated but findings
6. Restlicow, 2010 South-Africa,	life skills intervention	Ineffective	5200	14	49.5	26.4%, White 9. 🛃 🦉	100	were adjusted forincome
7. Chou, 2006, China	Ineffective		2661	12.5	47.7	Not stated	Not stated	Not stated
8. Seal, 2006, Thailand	Ineffective		170	15.5	11	Not stated d	Not stated	Not stated
9. Wen, 2010, China	Ineffective		2343	13.4	45.9	Not stated 🙀 💐	50%	Not stated
10. Marsiglia, 2015, Mexico	Ineffective		431	13	55	Mexican a on	100%	Not stated
11. Chen, 2014, China	Ineffective		1807	14.5 ± 1.1	49.6	Linzhi Tibetan añd Guangzhou Hag	Not stated	Not stated
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The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the intervent prevention	tion in smoking	itervention duration	Number of sessions	Frequency of contact	Booster-sessions	Follow-up period	n: first published as	esponse rate at final- evaluation	The attrition rate in the intervention arm compared with control	Smoking prevention	Smoking cessation	Preventing substance use	pupils	teachers	Parents / relatives / community	Inside schools	Outside schools	Teachers	peers	Outsider specialists	Training deliverers	Fidelity checked	icess-evaluation done
Perry, 2009, India	Effective		Not stated	7 in year 1 6 in year 2	One / year	6	2 years	10.1136/t	94.7% year 1 84.0% year 2	Not stated	x	х		x	x	х	х	х	х	х		Y	Y	Y
Motamedi, 2016, South- Africa	Effective		Not stated	12	One / year	6	3 years	omjopen	90%	10% in both arms	x	х	Х	х			х		х			NC	Y	Y
Lotrean, 2013, Romania	Effective.		2 months	5 weekly	Weekly	NC	9 months	1-2022-0	90.2	11% compared with 9.8% in control	х	х		х		х	х	х	х	х		Y	NC	Y
Reddy 2002 India	School intervention	Not stated	Not stated	20	Not stated	NC	1 year	6661;	88.3%	Not stated	Х		Х	х			х		v	v		v	v	
Reduy, 2002, India	School plus family intervention	Effective	Not stated	20	Not stated	NC	_ year	3 on	00.370	Notstated	Х		Х	х		Х	Х	Х	^	^		T		
	Islamic based intervention	8 weeks				20					Х			х			Х							1
Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	8 weeks	8	One/ Week	NC	6 months	brua Ensi	89.5%	Not stated	Х			х			х		х		x	Y	NC	NC
	Combined health & Islamic intervention	Ineffective						ry 2023. eigneme			х			х			х							
Respicow, 2010 South-Africa.	Harm management	Not stated	Not stated	8 per vear	One / vear	NC	2 years	Downlo	93%	41.2% compared with 14.2% in control	х			х			х		x			Y	Y	
,	life skills intervention	Ineffective						aded fro <u>rieur (A</u>	- 7	34.2% compared to cohort 15.3%	х			х			х							
Chou, 2006, China	Ineffective	•	13 weeks	13	Once /Week	NC	1 year پر	m http:/ BES) .	97% at baseline	12.5% compared with 7% in control	х			х			х		х		х	Y	NC	NC
Seal, 2006, Thailand	Ineffective		Not stated	10	Not stated	0	6 months		100%	Not stated	Х		Х	х	Ī		Х		NC	NC	NC	NC	NC	NC
Wen, 2010, China	Ineffective		Not stated	Not stated	Not stated	2	6 months	pen.bn	90%	7.95% compared with 32.55% in control	х			х	х	х	х	х	х	х	х	Y	NC	Y
Marsiglia, 2015, Mexico	Ineffective		10 weeks	20	Two /week	NC	8 months		86%	Not stated	Х		Х				Х		Х			Y	NC	NC
Chen, 2014, China	Ineffective		Not stated	Not stated	Two / year	2	1 year	nilar te	99.5%	Rate was not specified but it is stated it is high	х			х	х		х		х	х		Y	Y	NC
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# **Risk of bias**

Attrition and selection were identified as the most relevant 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 [33] and no trial has low risk of bias in all these criteria. Ineffective trials has higher risk of bias ratio than effective trials (Table 3). Only one effective trial[45] has high risk of bias caused by selecting intervention schools purposively based on being cooperative before starting the intervention. The assessment cannot 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.

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 <sup>1</sup>
Perry, 2009, India	L	U	U	L	L	0/5
Motamedi, 2016, South-Africa	н	н	U	L	U	2/5
Lotrean,2013, Romania	L	U	U	L	L	0/5
Reddy, 2002, India	L	U	U	U	L	0/5
Tahlil, 2015, Indonesia	U	L	U	U	L	0/5
Resnicow, 2010, South-Africa,	U	U	U	н	L	1/5
Chou, 2006, China	L	U	U	н	L	1/5
Seal 2006, Thailand	L	L	U	U	L	0/5
Wen 2010, China	L	н	н	н	L	3/5
Marsiglia, 2015, Mexico	Н	U	U	U	L	1/5
Chen, 2014, China	L	U	U	Н	L	1/5
H = high risk of bias,	U = unclea	r risk of bias,	L = low risk o	of bias		

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

<sup>&</sup>lt;sup>1</sup>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.

# **Cultural appropriateness**

Most (10/15) intervention arms were based on effective interventions originally developed in highincome countries. In three[40, 44, 49] 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 in adolescents smoking preventions and community members who have an understanding of what is 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 third (10/15) of interventions considered using cultural 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 during designing nine arms (socio-cultural 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, demonstrated cultural tailoring which is defined as using all the above cultural appropriateness strategies.

Deep cultural appropriateness, through incorporating cultural, environmental, psychological, and social factors that influence smoking in the targeted population into the proposed intervention [30, 51], was most recognised in the effective interventions. Whereas all the ineffective interventions, except one[48], involved either unclear or surface cultural adaptation of the imported interventions. This was 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) weak consideration of local socio-cultural 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[45, 52], both were effective.

# **Theoretical constructs**

The design of all effective interventions, except one [41], was informed by at least one theory but insufficient details were available on how. **Error! Reference source not found.** maps the presence and absence of the 17 TDF theoretical domains.

All interventions provided information on smoking harms **the knowledge domain**). The information delivered in the ineffective arms was only about smoking-related illnesses, except in two arms[42, 48] as social consequences were added. Only effective interventions explained consequences of secondary smoking. Interventions that combined explaining the health, environmental, social and emotional consequences of smoking were effective[40, 45]. None of the interventions that explained national smoking rates to correct pupils' overestimation of smoking rates (normative education) was effective.

All interventions aimed at 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 [45] **(Skills domain).** 

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Table 4 Summary of Cultur	a appropriateness of the l	ncluded inte	rventions						<b>C</b> la			-01 -02									
									Cuit	urai a	approp		eness	5						How	
			Inte of o				A	Approach								Stage					
The study ID (1 <sup>st</sup> author, year, country)	The study ID t author, year, country) The effectiveness of the intervention in smoking prevention		rvention country rigin	Surface	Deep	Unclear	Bottom-Up	Top-Down	Both	Linguistic	r uses related to te Peripheral	Evenseighement S	Constituent-involving	Sociocultural	Cultural tailoring	Design	Implementation	Evaluation	Informally	qualitative data	Surveys
Perry, 2009, India	Effective		USA		Х				Х	Х	XÃ		Х	Х	Х	Х	Х			х	
Motamedi, 2016, South- Africa	Effective	USA		х				x	х	nd dat ×	aded fi rieŭr (/	х	х	х	х	х	х		х	x	
Lotrean, 2013, Romania	Effective.	Netherland		X				Х	Х	ХЯ	Ê E E E E M	Х	Х		Х			Х	Х		
	School intervention	Partly from			X			X	Х	X	S) tt	Х			Х	Х			Х	Х	
Reddy, 2002, India	School& family intervention	Effective	USA			x			x	х	g, Al tr ×	o://bmj	х			х	х			х	x
	Islamic based intervention	Ineffective		Х					Х	Х	aini	ope	Х	Х		Х				х	
Tahlil 2015 Indonesia	Health-based intervention	Ineffective	Indonesia	Х		16			Х	Х	ng,	n.br	Х	Х		Х				Х	
runni, 2013, muonesia	Combined health and Islamic based intervention	Ineffective	muonesiu	х			V		x	х	and sir	nj.com	х	х		х				х	
Resnicow, 2010 South-	Harm management	Ineffective	Australia		Х				X	Х	X	on	Х	Х		Х				Х	
Africa,	life skills intervention	Ineffective	USA		Х				Χ <	Х	Xte	Ju	Х	Х		Х				Х	
Chou, 2006, China	Ineffective	USA	Х				Х		X <	×	e 1	Х			Х			Х			
Seal, 2006, Thailand	Ineffective	USA	Х				Х		Х	Xog	8, 2	Х			Х			Х			
Wen, 2010, China	Ineffective	China			Х			Х	Х	les.	125	Х	Х		Х				Х		
Marsiglia, 2015, Mexico	Ineffective	USA	Х					Х	Х	Х	at A	Х			Х				Х		
Chen, 2014, China	Ineffective	China			Х		Х		Х		gen	Х			Х				Х		
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NB: Presence of a Cultural appropriateness dimension, approach, strategy, method and time in an intervention arm is indicated with on X. Bibliographique de l

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39 Table 5 Summary of the theoretical	l domains of the included st	udies	BMJ Ope	n					d by copyright, including for us	njopen-2022-066613 on 14 Feb									
			Know	ledge		Skills		Me	eB ଶ		Soc	Co	Bel	Q	Int	Ide	Per	Rei	Ē
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the int smoking preventi	ervention in on	Knowledge on consequences	Normative education	Social competence	Social influence	Combined	mory, attention & cision process	kalensedråpregataansed data	vironmental context & pao23. Downloaded fromement Sumerican (A	cial influences	liefs about nsequences	liefs on capabilities	timism	entions	ntity / Social role	rsonal-goals	inforcement s	otion management
1. Perry, 2009, India	Effective		Х			Х		Х	mir	ΪΞX	X	Х	X		Х	Х		Х	
2. Motamedi, 2016 South-Africa	Effective		Х				Х	Х	iyog	ttp		Х		Х	Х	Х	Х		Х
3. Lotrean, 2013, Romania	Effective.		Х			Х		Х	, AI	//bi	X	X	Х		Х	Х		Х	
4. Reddy, 2002, India	School intervention School intervention plus family intervention	Effective Effective	x x			x x			training,	njopen.br	X X	x x			X X				
5. Tahlil, 2015, Indonesia	Islamic based intervention Health-based intervention Combined health & Islamic based intervention	Ineffective Ineffective Ineffective	X X X	x x x	X		x x	ろ	and similar te	nj.com/ on Ju	X	X X X			X X X				X X
6. Resnicow, 2010 South-Africa,	Harm management life skills intervention	Ineffective Ineffective	X X		х		x	X /	chnolo	ne 13,		X X			X X				x
7. Chou, 2006, China	Ineffective		Х	Х		Х		Х	gie:	02	Х	Х			Х	Х			
8. Seal, 2006, Thailand	Ineffective		Х				Х	Х		аX		Х			Х				Х
9. Wen, 2010, China	Ineffective		Х				Х	Х		AgX	X	Х			Х	Х		Х	Х
10. Marsiglia, 2015, Mexico	Ineffective		Х			Х		Х		nce		Х	Х		Х				
11. Chen, 2014, China	Ineffective		Х			Х				<u>m</u> X	X	Х			Х	Х	[]		
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Nine intervention arms used role-plays, group discussion, and activities or videos in raising awareness of smoking consequences to make the contents attractable and memorable after the intervention **(Memory and attention domain)**. Only effective interventions [45, 46]combined these methods with encouraging pupils to discuss their views on the advantages and disadvantages of smoking before deciding to smoke or not **(Decision process domain)**.

Six arms aimed to increase barriers and minimize 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[50] or not evaluated [39, 43] in the ineffective arms. Additionally five arms included policy 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 [41] or the wider community[40]. This included motivating the community to advocate for national anti-smoking policy [40] or banning tobacco promotion[41].

Activities to reduce social influencers of adolescents' smoking (**social influence domain**) were considered in all the effective interventions, except one[45]. Only effective interventions used peer-pressure to create 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's newsletter. These role-models contributed in supporting other pupils to avoid smoking; informally discussed their beliefs about smoking harms and shared their experience of maintaining none-smoking behaviour and refusing smoking offers by friends. The intervention[43]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 have improved after interventions in seven arms, only five arms [40, 41, 46, 53] showed translating these beliefs into action by avoiding smoking. All arms [40, 45] 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 [46, 53]enhanced participants' self-confidence in their ability to avoid smoking and supporting their relatives and peers to avoid or quit smoking, trained them on that, and allowed them to practice the acquired skills in role-plays and in the existence of professionals. One effective arm [40]established school-based support groups for the trained participants even after the intervention completion. The ineffective arm [44]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 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 five effective arms[40, 41, 46, 53]. One effective[45] and three ineffective [39, 44, 48] interventions didn't 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 [43, 49, 50], 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 or voluntary. The effective arms[40, 41, 45, 46] 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[45] was effective. Only this effective arm allowed participants to practice the acquired skills and burnout 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 encouraged pupils to set proximal and distal goals for themselves, then educated them on how smoking hinders achieving their goals and how better 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 practise 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).

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The **reinforcement domain** was used in three arms, through social rewards for never-smokers. The effective interventions [40, 46] rewarded pupils (as well as teachers and parents in one arm)[40] 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 [43]rewarded winners of schools' competition for the best anti-smoking presentations and essays, without puplishing 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

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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[43], showing pictures of smoking-related illnesses[50], or discussing reasons for refusing smoking offers only from pupils' perspective [44].

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 study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the intervention in smoking prevention			Persuasion	Incentives	Coercion	Training	Restriction	Environmental restructuring	Modelling	Enablement
1.	Perry, 2009, India	Effective		X	Х	х		х	х	Х	Х	Х
2.	Motamedi, 2016 South-Africa	Effective	x	х			х					
3.	Lotrean, 2013, Romania	Effective		x	х	Х		х			x	
4.	Reddy, 2002, India	School intervention	Effective	Х	Х			х	х			
		School intervention plus family intervention	Effective	x	х			Х	Х			
		Islamic based intervention	Ineffective	х				х				
5.	Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	X				х				
	muonesia	Combined health & Islamic based intervention	Ineffective	x				х				
6.	Resnicow, 2010,	Harm management	Ineffective	x				Х				Х
	South-Africa	life skills intervention	Ineffective	Х				х				
7.	Chou,2006, China	Ineffective		х				х		Х		
8.	Seal, 2006, Thailand	Ineffective		x				х				
9.	Wen, 2010, China	Ineffective		Х	х	Х		х	Х	Х		
10.	Marsiglia, 2015, Mexico	Ineffective			х			х				
11.	Chen, 2014, China	Ineffective		Х	Х			Х	Х	Х		

#### Table 6 Summary of the Presence of BCW Intervention Functions in included studies

Presence of a BCW Intervention Function in an intervention arm is indicated with an X

The included interventions showed limited use of the *restrictive function* but 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 antismoking policy went beyond school boundaries to the wider environment through disseminating the national anti-smoking policy and enhance its implementation by community members[40], or advocate banning tobacco advertisements through pupils-signed petition directed to the government[41]. The two ineffective arms [50, 54]established smoking control committee aiming to support antismoking 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 [40]declared teachers and parents plus pupils who never smoked as role-models. The effective interventions used peer-educators, who never smoked, to: chair, stimulate, summarize 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[50] or deliver [43]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[40, 53]. The effective arm [40, 53]encouraged social norm against smoking through establishing smoke-free initiatives run by 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[43] or producing school-posters discouraging smoking[49, 50]. Two ineffective arms[43, 50]established school smoking-related committee but the role of this committee was unexplained. One ineffective intervention [49]reported doing additional efforts to prevent pupils' exposure to smoking at home without explaining how.

Only two arms, one[40] was effective, considered the *enablement intervention function*, through improving pupils' capability (beyond training and education) and opportunity to remain never-smokers. The effective arm [40] offered smoking prevention, quitting, and counselling services at schools for smoker and non-smoker parents, teachers, and pupils. Whereas in the ineffective arm [55] this function was limited to the provision of school-based quitting services for smoker pupils only.

## 4. 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.

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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 [45]or combined with either restriction [41]or modelling function only [46]or with all other functions except the coercion function[40].

# Enhancing capability, motivation, and opportunities to avoid initiating smoking

The effective interventions enhanced Pupils' **psychological capability** to maintain non-smoking behaviour through the followings: 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 recognize, analyse and react to direct and indirect pressures to smoke from peers, family, advertisements and adults. 6) Building pupils' confidence 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 minimized in the effective interventions through 1) Establishing and enforcing anti-smoking policies that prohibit smoking inside schools by teachers, parents, and visitors before pupils. 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

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non-smoking. 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. 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 recognized 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 7,712 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.

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## 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 limited publications resulting from limited experience and inaccessibility to international databases or language barriers. Other systematic reviews [14, 23, 56-60]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 recognized barriers [42, 57, 61].

Although self-reporting is a valid and stable indicator for identifying smoking status in many contexts [62, 63], its sensitivity and specificity vary per age, gender, and culture [64]. Adolescents, especially girls, might under-report their smoking where smoking is culturally unacceptable [65-67]; or over-report that where smokers are considered mature and

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impressive [32, 64, 68-70]. 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 [69] but is challenged by the constrained resources available in LMICs, as other studies have identified [14, 17, 41, 43, 71, 72].

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 [73]. 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 evaluation could have minimized bias in interpreting the effectiveness of these complex-interventions and explaining why the effectiveness varies across contexts [73, 74].

Other limitations of the review are that three trials were excluded because the findings is 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 trails, in reporting the changes in smoking status restricted quantitative synthesis of the findings in this review.

#### 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' utilization of these modern methods [75, 76]. Researchers should explore the feasibility, acceptability, and effectiveness of using these modern methods in school-based interventions in LMICs.

Using standardized 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. Standardizing 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.

#### 5. Conclusion

We concluded that effective interventions succeeded to prevent pupils from smoking uptake by improving their psychological capability to remain never-smokers and reducing their social and physical opportunities and reflective and automatic motivations to smoke. This is achieved through raising awareness of various consequences of smoking using engaging methods and accessible information sources. Improving refusal skills of smoking offers, through demonstration, practise, and feedback on performance. Advising pupils on how to recognize, analyse and react to direct and indirect pressure to smoke. 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. Restricting smoking inside schools. Repeatedly presenting smokers in negative images. Social rewarding of never-smokers and using them as role-models. Peers' education and pressure against smoking. Encouraging pupils to consider parents' disapproval of smoking. Facilitating useful free time usage and negative emotions control. It was also concluded that interventions' effectiveness is influenced by deep cultural adaptation, using top-down and bottom-up approaches.

#### **Contributorship statement**

MB, HE, and BB conceived the review. MB, AA, and HA completed screening and extraction of data. MB, HE, BB, and RH devised the analysis plan and AA and HA provided support for analyses. MB 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 is the guarantor of the paper.

#### Competing interests:None.

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#### Data sharing statement

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) upon reasonable request.

## **Ethics Approval Statement**

There was no ethical approval required for this study as it did not include primary data collection.

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PRISMA-P (Preferr protocol*	ed Reporting Scho	Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended thems to address in a systematic r	eview
Section and topic	Item No	Checklist item	
ADMINISTRATIV	E INFORMA		
Title: Identification Update	1a 1b	A protocol of a systematic review This is a new systematic review and it is not an update of any previous systematic review and previous systematic	
Registration	2	It was registered, with (PROSPERO) in 2016 and the registration number is 82267.	
Authors: Contact	3a	1. Dr. Maryam Ba-Break	
		Teaching Fellow in Global and International Health, Nuffield Centre for International Health and Development, Univers Leeds, Leeds LS2 9JT. UK. Email: M.M.Ba-Break@leeds.ac.uk Phone +44(0)113 343 0824 / Fax +44(0)113 343 6997	ity of
		2. Bridgette Bewick, Associate Professor in Psychological health, wellbeing, and exection, Leeds institute of health science University of Leeds, UK	ces,
		3. Reinhard Huss, Chair and organizer UBI Lab Leeds, Leeds, UK	
		4. Tim Ensor, Professor of International Health Systems Research, Nuffield Centre a ternational Health and Developme University of Leeds, Leeds LS2 9JT. UK.	ent,
		5. Asma Abahussin, Assistant Professor, Department of Biomedical Technology, College of Applied Medical Sciences, Ki University, Riyadh, Saudi Arabia	ng Sau
		<ol> <li>Hamdi Alhakimi, Community Medicine specialist - Medical statistics - Applications of the specialist - Medical statistics - Applications - Applicatist - Medical statistics - Medical statistics - Med</li></ol>	aarsser
		7. Helen Elsey, Senior Lecturer in Global Health, Department of Health Sciences, University of York, UK	
Contributions	3b	MB, HE, and BB conceived the review. MB, AA, and HA completed screening and extraction of data. MB, HE, BB, and RH dev analysis plan and AA and HA provided support for analyses. MB wrote the text. HE, BB, RH, and TE supervised the whole revie process. All authors critically revised the manuscript for intellectual content and advised on the publication process. All authors re-	ised the w ead and

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Amendments	4	There is no amendment to a previously completed protocol. However, the review included Arabic and LMICs while the paper is or focusing on LMICs
Support:		19 - 1 19 - 1 1 - 1
Sources	5a	No financial or other support for the review. It is part of the Ph.D. study of the 1 <sup>st</sup> author. $\begin{bmatrix} 2 \\ 2 \end{bmatrix}$
Sponsor	5b	Not applicable as this is not funded
Role of sponsor or funder	5c	Not applicable as this is not funded
INTRODUCTION		ed to
Rationale	6	See page 3 School-based interventions have been used, over the past three decades in many countries of the sevent adolescents from smoking ini (Thomas et al., 2013). Designing SBSPI is an important step toward controlling the smoking adjedmic in Egypt as there is no evid that one is available. In order to provide an opportunity to learn from other interventions adjedmic in Egypt as there is no evid to be considered to enhance the effectiveness of School-Based Smoking Prevention Interventions adjective adjective adjective adjective was conducted. This systematic review aims to develop an understanding of school-based smoking prevention stat were implemented LMICs countries and what influenced the effectiveness of these interventions in terms of metotical constructs, intervention function methods of implementation and cultural-appropriateness. The review concludes with whathere is to be considered in implementing in low-middle income settings in terms of contents, interventions' functions, cultural-appropriate state review scale delivery methods. The or of this systematic review will be used to make recommendations about SBSPI in Egypt and LMICs. Many RCTs have been implemented worldwide to evaluate the effectiveness of SBSPIs and some systematic reviews explored fact influencing the effectiveness of SBSPIs (Shackleton et al., 2016). Forus et al., 2017, de Kleijn et al., 2017 Thomas et al., 2013, Thomas and Perera, 2006, Thomas, 2002, Georgie et al., 2016, Isense and Hanewinkel, 2012, Wiehe et al., 2015 Bauld et al., 2009, Buhler, 2016, Shackleton et al., 2016a). However, none of the identified systematic reviews focused on RCTs of SBSPI that are implemented in LMICs and explored the cultural-appropriateness of these interventions. b) There is no systematic review used the Behaviour change wheel (BCW), Capability Opportunity Motation -Behaviour (COM-B) model and Theoretical Domain Framework (TDF) to explore the literature on school-based smoking grevention interventions. (SBSPIs). The following theoretical constr
Objectives	7	See page 3
		aphic
		For peer review only - http://bmiopen.bmi.com/site/about/guidelines.xhtml

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This review aims to identify the association between the effectiveness of school-based interventions and theoretical constructs.       This review aims to identify the association LMICS and the used approaches and strating adolescents from smoking initiation in LMICS and the used approaches and strate implemented in LMICS;         1) To determine the effectiveness of school-based intervention in preventing adolescents is moking through schools;       Smoking in LMICS;         2) to explore the cultural-appropriateness of school-based smoking prevention integrations that are implemented in LMICS;       This revention functions and smoking prevention integrations that are implemented in LMICS;         4) to identify the association between the effectiveness of SBSPIs in LMICs and the used in LMICS;       This revention functions, smoking prevention curriculum that has been used in LMICS;         4) to identify the association between the effectiveness of SBSPIs in LMICS and the used intervention functions, smoking prevention curriculum appropriateness, intervention functions, smoking prevention curriculum appropriateness.         See the supplementary documents for the PICO         School-aged children (participants)         Tobacco utilization/ utilisation Smoking       Adolescents / or restriction or ban Program         Vouth Child (children Voung person* youth Child (children Voung person* abstan* or stop or quit antitic person* abstan* or stop or quit antitheduction or teach or training Behaviour Change or moki			BN	ЛJ Open	by copyright,		
Smoking (outcome)School-aged children (participants)School-based interventions (intervention)# Study typeTobacco uptake tobacco utilization/ utilisation Smoking Cigarette/cigar Nicotine Smokeless tobacco / Chewing tobacco, oral tobacco, oral tobacc	<b>Th</b> ad int	<ul> <li>is review aims to identification for the second s</li></ul>	tify the association g initiation in LMI and theoretical con <i>ffectiveness</i> of schoo <i>tral-appropriateness</i> theoretical constructs ents' smoking throug ciation between the teness; intervention	n between the effectiveness of school Cs and the used approaches and stra- structs. bl-based interventions in preventing adol s of school-based smoking prevention in s, <i>intervention functions and smoking pre</i> gh schools; effectiveness of SBSPIs in LMICs and t functions, smoking prevention curriculu	as ie en	d intervention for ensuring smoking in 1 ons that are in curriculum to ved: approaction heoretical-cor	ons in preventing cultural appropriateness LMICs; nplemented in LMICs; hat has been used in LMICs h and strategies for ensuring hstructs.
School or class based>Tobacco uptake tobacco use Tobacco utilization/ utilisation Smoking Cigarette/cigarAdolescents / adolscen*Primary Prevention or Control or restriction or ban Program* policy /policies healthFinandomised gontrolledNicotine Smokeless tobacco / Chewing tobacco, oral Shisha/ Argeela Adolescents behaviour or risky behaviourAdolescents / person*Primary Prevention or Control or restriction or ban Program* promotion or strategy* promotion or health education massisMeta- massisTobacco / Chewing tobacco, oral tobacco, oral tobacco, water pipe /Shisha/ Argeela Adolescents behaviourStudent* (ClassmatesPreedom from smoking Class* (Classmates (Pupil*)Tobacto or training Behavior/ Behaviour change or modificationTobacto person*Nicotine Smokeless tobacco, water pipe (Shisha/ Argeela Adolescents behaviourStudent* (Pupil*)Freedom from smoking Class* (Pupil*)Tobacto or training Behavior/ Behaviour change or modificationTobacto or person*Minor* or behaviour/education or teach or training modificationMeta- massisTobacto or person* person*Tobacto or person*Tobacto or person* person*Tobacto or person* person*Tobacto or person*Tobacto or person* person*Tobacto or person* person* person*Tobacto or person* person*Tobacto or person* person*Tobacto or person* person*Tobacto or person* person*Tobacto or person* person*Tobacto or person* person*Tobacto or person* <br< th=""><th>S</th><th>Smoking (outcome)</th><th>School-aged children (participants)</th><th>School-based interventions (intervention)</th><th>a <b>g</b>om nup r <b>(A</b>BES) ata mining</th><th>ady type</th><th></th></br<>	S	Smoking (outcome)	School-aged children (participants)	School-based interventions (intervention)	a <b>g</b> om nup r <b>(A</b> BES) ata mining	ady type	
	T to T u C N to to to to b b	Tobacco uptake obacco use Tobacco utilization/ utilisation Smoking Cigarette/cigar Nicotine Smokeless obacco/ Chewing obacco Snuff obacco, oral obacco, Water pipe Shisha/ Argeela Adolescents oehaviour or risky oehaviour	Adolescents / adolscen* youth Child /children Young people Young person* Pupil* Student* Classmates Minor* or juvenile*	School or class based Primary Prevention or Control or restriction or ban Program* Intervention or strategy* Policy /policies health promotion or health education cessation or reduc* or abstain* or stop or quit anti- smoking Smoking free or freedom from smoking Class* Education or promotion /education or teach or training Behavior/ Behaviour change or modification	Al tratning, and similar technologies.	lomised rolled Meta- vsis matic w	

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Eligibility criteria	8	See page 4
		Eligibility Criteria The following criteria were used for considering studies for this review:
		Types of Studies
		<ul> <li>Inclusion criteria</li> <li>RCTs as they are strong sources of evidence on effectiveness (Bowling, 2014);</li> <li>Baseline smoking was measured before starting the intervention;</li> <li>The Intervention was implemented in in a country classified as a low or middle (lower-middle, or upper-middle) income country at the time of implementing the intervention; according to the World Bank (WB) classification of countries by ir (WB, 2017). LMICs were considered because the income and the development level of a country determine the available resources at school and capacity of schools to design and implement school-based interventions within the available resources at school and capacity of schools to design and implement school-based interventions methy perific resources to be implemented which might not be available in LMICs, the review focused on LMICs in order to identify the evidence rela LMICS. Some systematic reviews of school-based behaviour change interventions are important barr that focus on developing countries or LMICs as many effective strategies might not be feasible, accessible and affordabl LMICs (Shackleton et al., 2016), Nishio et al., 2018, Thomas et al., 2013) where resources limitations are important barr there (Bauld et al., 2009). For example: using interventions based on the internet, computer or mobile phone might not b applicable for poor countries, like Egypt, where electricity and internet are not accessible at most schools, totally or parti (CAPMS, 2017).</li> <li>NB: The World Bank classification of countries by income is selected because it is not only an indication of the relative wealth of country as it is also used as an indirect indication of the country development, as the significant change in the global economic lat challenge using the old classification of developing countries (Fantom and Serajuddin, 2016).</li> </ul>
		<ul> <li>Exclusion criteria</li> <li>Full-text articles are not available in English or Arabic language (after contacting the author).</li> </ul>
		Types of participants
		<ul> <li>Inclusion criteria</li> <li>Pupils at adolescence age (10-17 years), according to WHO (2014) definition of adolescence age, were targeted at any statistic intervention. Adolescence age was considered because many articles only include the mean or median of age without specifying the range of age-targeted by the intervention; smoking initiation age varies across countries therefore different groups were targeted by SBSPIs that aim to prevent smoking initiation; school enrolment age varies across countries. Alt most SBSPIs in high-income countries target pupils at the age of 13-15 years (Thomas et al., 2013), this review was not I to interventions that target pupils aged 13-15 years and SBSPIs that targeted pupils at all adolescence years were considered or school enrolment age varies across were considered to interventions that target pupils aged 13-15 years and SBSPIs that targeted pupils at all adolescence years were considered years across countries target pupils at all adolescence years were considered years were considered pupils at all adolescence years were considered years and years and years across years and yea</li></ul>

avoid bias and missing important information related to preventing smoking initiation through schools. Exclusion criteria
- School-based Intervention that only targeted the smoking behaviour of teachers or parents.
Types of interventions
<ul> <li>Inclusion criteria</li> <li>School-based interventions or programs that aim to prevent smoking among pupils, regardless of: The complexity of the intervention and if the intervention targets smoking alone or in addition to other tobacco-use or rist behaviour</li> <li>Who delivered the intervention (teachers, peers, parents, researchers, health professionals, undergraduate or graduate students or others)</li> <li>What the control groups received (no intervention, the standard or regular school education activities, different type of intervention, others). Studies with no control groups were not included.</li> </ul>
<ul> <li>Exclusion criteria</li> <li>Pregnancy-related intervention</li> <li>Clinical-based interventions</li> <li>Interventions that focus only on smoking cessation, passive smoking, alcohol or illicit drug</li> <li>If the intervention activities are based on colleges, university or nursery setting</li> <li>Intervention that only involves family-based or community-based activities even if pupils were recruited through schools.</li> </ul>
Types of outcome measures
<ul> <li>Inclusion criteria</li> <li>The primary outcome was the impact of the intervention on the smoking status of pupils who were never-smokers at baseline</li> <li>The smoking status was assessed using either self-reported smoking or any bio-medical validation test such as Saliva thiocyanate or cotinine or expired air carbon monoxide levels (Prokhorov et al., 1993, Patrick et al., 1994).</li> <li>The outcome was measured after a minimum follow-up of six months after completion of the intervention. The six month follow-up period was considered because 1) this is the minimum period recommended for assessing changes caused by comp health interventions (Higgins and Green, 2008); 2) it has been used in all Cochrane reviews of SBSPI (Thomas et al., 2013, Thomas and Perera, 2006, Thomas, 2002). 3) This period was used in nine of the 15 systematic reviews that were used to inft the search strategy of this review. Whereas different periods were used in six reviews as follow: three reviews considered six months follow-up period after starting the intervention (Peirson et al., 2016, Hale et al., 2014, Hefler et al., 2017) but none of them was a Cochrane review or provided justification for this selection; one review required at least one-year follow-up after intervention ended (Wiehe et al., 2005) and two reviews considered studies with short follow-up period, at least six weeks aft intervention completion (Georgie et al., 2016, Sussman et al., 2014).</li> </ul>
<ul> <li>Exclusion criteria</li> <li>No smoking outcome data were reported for example: only reporting changes in awareness or intention to smoke;</li> </ul>

Information sources	9	See page 4
		The following databases were searched, using several search filters1:
		- Medline (Ovid)
		- Embase (Ovid)
		- PubMed (Ovid)
		- Global Health (Ovid)
		- PsycINFO (Ovid)
		- CINAHL(Ebsco)
		- Web of Science (Thomson),
		- Popline (K4 Health)
		- Cochrane Central Register of Controlled Trials –CENTRAL (Wiley)
		- ERIC (Education Resources Information Centre)
		- WHO Regional Databases
		- PubMed central (PMC)
		- Cochrane Database of Systematic Reviews
		<ul> <li>ProQuest Middle East &amp; Africa Database</li> </ul>
		- SCOPUS
		- CENTRAL (Cochrane Central Register of Controlled Trials)
		- ICTRP International Clinical Trials Registry Platform (WHO) (International)
		- Tobacco control 1992-
		- Journals of Smoking-Related Disorders
		- ICTRP International Clinical Trials Registry Platform (WHO) (International)
		- DARE (Database of Abstracts of Reviews of Effects)
		- Centre of review and dissemination
		- IRIP utilities Social
		- ASSIA (Applied Social Sciences index And Abstracts) ProQuest dispertations and theses
		- Flectronic thesis online services (ethos)
		- DART_Furone_F_ theses portal
		- South African thesis and dissertation (SATD)
		Databases searches were supplemented by searching the following websites:
		- ASSISI (A Stop Smoking in School Irial) intervention model in UK
		- Action on Smoking and Health (ASH) The Netional Institute for Health and Core Encellance (NHCE) methods
		- The National Institute for Health and Care Excellence (NICE) website

<sup>1</sup> Indicated between brackets

		<ul> <li>Centre for Tobacco Control Research</li> <li>Cochrane Tobacco Addiction review Group</li> <li>Trials Register of Promoting Health Interventions (TRoPHI)</li> <li>UK Public Health Association</li> <li>The European Smoking prevention Framework Approach (EFSA)</li> </ul>
Search strategy	10	See page 3 and 4
		The search was conducted in January 2017 and then updated in November 2019 and April 2021. All databases were searched as far bac as they allowed. The <b>Error! Reference source not found.</b> summarises the key-terms and literature mapping concepts using PICO framework. Terms related to countries were not included in the used key terms because countries' names are not always stated in the published articles. Therefore, eligible articles were filtered later to identify if the intervention was implemented in a country with low or middle income. The <b>Error! Reference source not found.</b> shows the full electronic search strategy employed in Medline database, as an example.
		Checking reference lists was used to identify more articles, as recommended by Gough et al (2017). Moreover, authors are contacted to obtain full-text, when unavailable in Arabic or English languages through the University of Leeds Library, or details of interventions, when unclearly explained in the published articles. Furthermore, individual Medline and Web of Science searches were run to track 60 authors who published articles on adolescents' smoking in LMICs, with no date restriction. Grev literature search was limited to
		understanding contexts where the interventions were implemented.
Study records:		See page 3 and 4
Data management	11a	All the record will be kept in Endnote and spread sheets throughout the review
Selection process	11b	A stepwise approach was used to identify relevant articles; titles screening was used first to exclude duplicates and clearly irrelevant articles followed by abstracts screening. The eligibility checklist used to screen abstracts is attached in the Appendix <b>B</b> , if the answer to the included questions was yes or unclear, then the full-text was reviewed. The process of screening the identified studies and reasons f exclusion are illustrated in the PRISMA diagram, based on Moher et al (2009). The researcher independently screened all titles, abstract and full-text for inclusion and exclusion criteria. Thereafter a random sample (10%) of all titles and abstracts of the included and excluded studies were independently screened by another postgraduate researcher. An agreement rate of 90% was achieved and any disagreement was resolved through discussion. Any study that the researcher was unsure about inclusion was collectively discussed with supervisors. Blinding procedures, of authors' name, institutions and journals, was not used in sampling studies for double screening. Studies that were identified through alternative ways, such as checking references list of included studies, were subject to the same inclusion and exclusion criteria and screening process as studies that emerged from database searches. No study was excluded based on the year of publication. Only three studies were excluded, one from Brazil, China and Mexico each, because the full-text was only available in Portuguese, Chinese and Spanish languages respectively. Another SBSPI trial (Al-sheyab et al., 2016) was excluded although it was implemented in a low-income country (during the intervention period) because pupils were followed for four-months only after completion of the intervention
Data collection process	11c	Data extraction was informed by the Cochrane strategy for data extraction (Higgins and Green, 2008). A data extraction form was adapted from the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement (Moher et al., 2010) and
		For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml
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3			TIDieR (Template for Intervention Description and Replication) checklist (Hoffmann et al., 2014). This form was used to extract data
4			from each intervention on the following: 1) study design, aim and objectives, number of arms in the trial, interventions contents, smoking
5			prevention curriculum, intervention functions, theoretical-underpinning and constructs, and what the control group received (what). 2)
6			Participants' number, age, sex and ethnicity, attrition and response rate (Who). 3) delivery methods, intervention deliverer and any
7			training provided for them (how). 4) The year (when) and country of implementation, intervention setting (inside school only or also
8			included activities outside school) and school types (where). 5) the intervention duration, number of sessions, frequency of contact,
9 10			duration of follow-up after intervention completion and booster sessions (how much). 6) Risk of bias, country of interventions' origin and cultural- appropriateness of intervention, guality of implementation, fidelity and any reported facilitators, challenges or barriers (how
11			well). 7) Justification for using SBSPI (why). 8) Smoking behaviour outcome data, definitions of the identified outcome and main
12			conclusions.
13			Several theoretical perspectives were used to review the included interventions in order to get a comprehensive understanding of SBSPI
14 15			in LMICs: 1) The middle layer of BCW (Michie et al., 2014a) was used to specify intervention functions of the included SBSPIs. 2) The
16			Theory coding scheme (Michie and Prestwich, 2010) was used to identify the theoretical-underpinning of the included studies. 3) Griffin
17			and Botvin (2010) classification of smoking prevention curriculum was used to adapt the Theoretical Domain Framework (TDF) (Atkins
18			et al., 2017) which was then used to explain the theoretical constructs of the included interventions. 4) The findings from the above steps
19			were discussed using the inner layer of BCW, the capability, opportunity, motivation and behaviour (COM-B) model. 5) The cultural-
20			appropriateness of the included interventions was assessed using Kreuter et al. (2003) and Castro et al. (2010) classifications of
21			approaches, dimensions and strategies of cultural- appropriateness. Using these theoretical perspectives allowed identifying the
22			approaches and dimensions of cultural- appropriateness, intervention functions, implementation methods, theoretical-constructs and
23			shoking prevention curriculum that were commonly used in effective SDSPIs in LivitCs to enhance pupils capability, opportunity and motivation to avoid smoking initiation. This provided a full range of potential options for SPSDIs that were used in low middle income
24			settings and facilitated providing rationales for selecting among those options for SBSPI in the Egyptian context
25	Data items	12	See noge 4 and 5
26	Data tients	12	See page 4 and 5
27			The data extraction form included function checklists that were used in this review to identify the presence or absence of each of the nine
28			intervention functions, the 17 theoretical-domains and the smoking prevention curriculum in each arm of the included SBSPI in LMICs.
29			More than one function, theoretical-domain and curriculum were allowed to be selected for one intervention or activity. For example
30			classroom discussion of the advantages and disadvantages of smoking was coded under the 'education' and 'persuasion' function. To
31			explore cultural- appropriateness of the included SBSPIs, the checklist identified interventions country of origin plus approaches,
32			dimensions and strategies used in adapting each intervention's arm to the culture of the targeted population. To explore the theoretical-
33			underpinning of the included interventions, the checklist included the following five questions: 1) was a theory mentioned at any stage of
34			the intervention; 2) were the relevant theoretical constructs targeted by the interventions; 3) was the theory used to select recipients or
35			tailor interventions; 4) were the relevant theoretical constructs measured; 5) was the theory tested or refined in the interventions. Answers
30 27			to these questions were coded as yes, no or unclear based on the available information in the included articles. Thereafter, all the named
38			Authors were contacted to get more information on their interventions and data was coded only based on the existing evidence on each of
30			the identified criteria/elements. Key findings were summarised in tables to facilitate validity checking and comparison across studies. All
40			the identified enterial elements. Key minings were summarised in tubles to raemate variately enceking and comparison across studies. An
יד 10			

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		<ul> <li>another postgraduate researcher. Any disagreements were resolved by consensus of recourse to the supervisors. This and resources limitation of this study as well as the university restriction of shared work in PhD thesis restricted fully double screening of the included articles.</li> <li>Based on the recommendations by Michie et al. (2014a) and Francis et al. (2012), the reviewers referred to the definitions and examples of each intervention function and theoretical-domain to ensure effective utilization of these frameworks in coding the intervention functions and theoretical-domains that were used in SBSPIs. Additionally, a discussion of these definitions and examples was organized before starting data extraction in order to clarify boundaries between intervention functions and thus achieve better intercoder agreement on the extracted data.</li> </ul>
Outcomes and prioritization	13	See page 6 The effectiveness of each intervention arm was assessed by comparing the smoking behaviour of adolescents in the intervention and control arms, before and after the interventions. All the three trials that included more than one intervention arm also compared the smoking behaviour of adolescents across interventions arms. The outcome of all the included trials was assessed after at least six-months of follow-up.
Risk of bias in individual studies	14	See page 9
		The Cochrane Collaboration's tool for assessing risk of bias in intervention studies (Higgins and Green, 2008) was used to assess whether the included studies have high, low or unclear risk of selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias such as an extreme baseline imbalance between the arms of each study. As recommended by Higgins and Thomas (2018), data were extracted on randomisation, blinding, allocation concealment, selective and incomplete outcome reporting and other bias concerns. Authors were contacted to verify any risk of bias information if not identified in the published articles. If the available data is insufficient to judge the risk of bias, then unclear risk of bias is selected. High risk of bias is selected when the available evidence indicates plausible bias that seriously weakens confidence in the findings. A guideline was used for coding the identified risk of bias; adapted from Glasziou et al. (2001), Higgins and Green (2008), Ryan R (2013) and Higgins and Thomas (2018). Scaling risk of bias was not used in this review, although it offers attractive simplicity, because it involves giving weight to different criteria in the scale and it is difficult to justify the weight assigned to each criterion (Higgins and Green, 2008). Furthermore, scaling risk of bias showed unreliable assessments of validity and it is not supported by empirical evidence, therefore, it is discouraged in systematic reviews (Higgins and Thomas, 2018). The researcher independently assessed the risk of bias then another postgraduate researcher independently checked the risk of bias in a random sample (25%) of the included articles. Any disagreements (one case) were resolved by consensus or recourse to the supervisors.
Data synthesis	15a 15b 15c 15d	See page 5 In systematic reviews, data synthesis means the process of organizing, combining and summarising the findings of the included studies (Tacconelli, 2010). In this review, data synthesis was informed by the Cochrane handbook for systematic reviews of interventions (Higgins and Green, 2008) and the Centre for Reviews and Dissemination guidance for undertaking review in health care (Tacconelli, 2010) and ESRC guidance on conducting narrative synthesis in systematic reviews (Popay et al., 2006). The data extraction form, discussed aboveError! Reference source not found., was used to assess the possibility of conducting a quantitative synthesis of the findings. According to Cochrane guidance for systematic reviews of interventions (Higgins and Green, 2008), meta-analysis and rearression are used to pool the findings of homogeneous studies in order to increase sample size and obtain a better estimation of the

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Confidence in cumulative evidence	17	See page 4, 5 and 9 Described above
Meta-bias(es)	16	See page 5 The funnel plot of the included interventions will be used to assess publication bias and demonstrates the effect estimate of each intervention against the sample size of this review as per the Cochrane handbook for systematic reviews of interventions (Higgins and Green, 2008, Shuster, 2011) and (Sterne et al., 2011). Error! Reference source not found.
		impact of interventions. In this review, there is heterogeneity across the included studies in defining, measuring, assessing and presentir outcomes of the included interventions. Separating the included studies into subgroups that used similar definitions, measurements and ways of reporting outcomes would have resulted in a very small sample size in each group that might not make significant changes in th findings on effectiveness. Therefore, quantitative synthesis, including meta-analysis and meta-regression, was considered inappropriate in this review and a narrative synthesis of the findings was used. However, the effect size of the interventions was calculated, using the guidance by Borenstein et al. (2009) and Chinn (2000), in order to outline the effect of SBSPIs in preventing smoking initiation as this is recommended to facilitate comparing the effectiveness of intervention when different statistical test and parameters were used across studies included in systematic reviews (Nakagawa and Cuthill, 2007, Fritz et al., 2012). The effect estimate of the include interventions was presented in a funnel plot, see, <b>Error! Reference source not found.</b> , which demonstrates the effect size and draw the funnel plot, in consultation with a professional statistician. The following steps were followed to synthesis the data: <b>1)</b> after extracting the data from each study, all findings were summarised in tables. <b>2)</b> To achieve the first four objectives of this review, the extracted data was used to produce a narrative descriptive summary of the intervention functions, theoretical-underpinning and effectiveness of these interventions in preventing smoking initiation among pupils. These issues will be discussed in the results section. <b>3)</b> Thereafter, patterns among the included interventions were identified and discussed in terms of the intervention functions, theoretical constructs and smoking prevention curriculum involved and the effect of these interventions on preventing pupils from smoking initiation. <b>4)</b> To ach

\* It is strongly recommended that this checklist be read in conjunction with the PRISMA-P Explanation and Elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015 Jan 2;349(jan02 1):g7647.

# <u>The appendices:</u> Appendix A the search strategy in the Medline, SBSPIs in LMICs

#	Key words	No of hits	Notes updated on 18/12/2017
#1	exp "tobacco use"/ or exp smoking/ or Nicotine/		
#2	(Tobacco OR smok* OR cigar* OR Shisha OR water pipe OR		
	Argeela OR nicotine).tw.		
#3	#1 OR #2		Tobacco use/ smoking
#4	(Health* adj2 (promot* OR educat* OR improvement)).tw		
#5	(prevent* OR Control OR program* OR interven* OR		
	strateg* OR polic* OR technique* OR framework* OR		
	Campaign* OR communicat* OR marketing OR advertis* OR		
	media ).tw		
#6	(educat* OR promot* OR teach* OR advise* OR counsel* OR		
	encourage* OR train* OR behavio#ur change* OR		
	campaign).tw		
#7	(anti smok* OR smok* free ) OR (freedom adj3 smoking)		
#8	((Cessation OR reduc* OR abst?in* OR stop* OR quit* OR		
	anti OR free* OR discourag* OR prevent*) adj3 (cigar* OR		
	smok*)).tw		
#9	Psychotherapy, Group/ OR Counseling/		
#10	#4 OR #5 OR #6 OR #7 OR #8 OR #9		Behaviour
			change/prevention/promotion
#11	Child/ OR Adolescent/ OR Student/ OR pupil/ School OR		
	Adolescent Behavior		
#12	(Adolescen* OR youth* OR child* OR young* OR Student*		
	OR pupil* OR class* OR Minor* OR juvenile* OR teen* OR		
	youth* OR girls OR boys OR school*).tw.		
#13	#11 OR #12		Adolescents
#14	#3 and #10 and #13	2,4214	prevention OR control &
			Tobacco &
			adolescents/Adolescents
#15	school*.tw OR class*.tw.		
#16	(school* adj3 based).tw. OR (class* adj3 based).tw.		
#17	#15 OR #16		School-based
#18	#15 and 17	7,433	School-based prevention OR
			control & Tobacco &
			adolescents/Adolescents
#19	randomized controlled trial.pt. OR controlled clinical trial.pt.		6
	OR randomized.ab. OR placebo.ab. OR drug therapy.fs. OR		
	randomly.ab. OR trial.ab. OR groups.ab.		
#20	#19 Not exp animals/ not humans.sh.		RCT
#21	Meta-analysis OR Systematic review		
#22	#20 OR #21		RCT OR meta-analysis OR
			systematic review
#23	#18 and #22	1,840	RCT studies on School-based
			prevention / control & Tobacco
			& adolescents/Adolescents
#24	limit to humans	1,241	

Page	39	of 39	
raye	22	01 39	

#	Key words	No of hits	Notes updated on 18/12/2017
#1	exp "tobacco use"/ or exp smoking/ or Nicotine/		
#2	(Tobacco OR smok* OR cigar* OR Shisha OR water pipe OR Argeela OR nicotine).tw.		
#3	#1 OR #2		Tobacco use/ smoking
#4	(Health* adj2 (promot* OR educat* OR improvement)).tw		
#5	(prevent* OR Control OR program* OR interven* OR strateg* OR polic* OR technique* OR framework* OR Campaign* OR communicat* OR marketing OR advertis* OR media ).tw		
#6	(educat* OR promot* OR teach* OR advise* OR counsel* OR encourage* OR train* OR behavio#ur change* OR campaign).tw		
#7	(anti smok* OR smok* free ) OR (freedom adj3 smoking)		
#8	((Cessation OR reduc* OR abst?in* OR stop* OR quit* OR anti OR free* OR discourag* OR prevent*) adj3 (cigar* OR smok*)).tw		
#9	Psychotherapy, Group/ OR Counseling/		
#10	#4 OR #5 OR #6 OR #7 OR #8 OR #9		Behaviour change/prevention/promotion
#11	Child/ OR Adolescent/ OR Student/ OR pupil/ School OR Adolescent Behavior		
#12	(Adolescen* OR youth* OR child* OR young* OR Student* OR pupil* OR class* OR Minor* OR juvenile* OR teen* OR youth* OR girls OR boys OR school*).tw.		
#13	#11 OR #12		Adolescents
#14	#3 and #10 and #13	2,4214	prevention OR control & Tobacco & adolescents/Adolescents
#15	school*.tw OR class*.tw.		
#16	(school* adi3 based).tw. OR (class* adi3 based).tw.		
#17	#15 OR #16		School-based
#18	#15 and 17	7,433	School-based prevention OR control & Tobacco & adolescents/Adolescents
#19	randomized controlled trial.pt. OR controlled clinical trial.pt. OR randomized.ab. OR placebo.ab. OR drug therapy.fs. OR randomly.ab. OR trial.ab. OR groups.ab.	9	5.
#20	#19 Not exp animals/ not humans.sh.		RCT
#21	Meta-analysis OR Systematic review		
#22	#20 OR #21		RCT OR meta-analysis OR systematic review
#23	#18 and #22	1,840	RCT studies on School-based prevention / control & Tobacco & adolescents/Adolescents
#24	limit to humans	1,241	

#### Appendix B Eligibility checklist of SBSPI studies in LMICs

Study title: First au Assessment	thor: Answers	Year: Comments
Assessment	Answers	Comments
Intervention		
Is the intervention/programs aim to prevent	□Yes □Unclear	Go to the next question
smoking among pupils?	□No	exclude
Is the intervention/programs School-based, With	□Yes □Unclear	Go to the next question
or without other activities outside school setting?	□No	exclude
Is the intervention focused on smoking prevention	□Yes □Unclear	Go to the next question
not only on cessation or alcohol or illicit drug?	□No	exclude
Is the intervention not pregnancy-related or clinical	□Yes □Unclear	Go to the next question
based?	□No	exclude
Population		
Are the participants pupils aged 10-17 years (at	□Yes □Unclear	Go to the next question
adolescent age), at any phase of the intervention:	□No	exclude
Was baseline smoking status measured before	□Yes □Unclear	Go to the next question
starting the intervention?	□No	exclude
Is the intervention/programs implemented in a	□Yes □Unclear	Go to the next question
Low or Middle income country (at the intervention	□No	exclude
time) or implemented in an Arabic country,		
Study design		
Is it RCT?	□Yes □Unclear	Go to the next question
•		exclude
Was the outcome measured at follow-up period of	□Yes □Unclear	Go to the next question
least six-months of after completion of the intervention?	□No	exclude
Outcome measured		
Did the study report the outcome on smoking	□Yes □Unclear	Go to the next question
status of pupils (never, ever, current smoking)		
(WHAT has been changed)	⊠No	exclude
Did the study report the outcome on smoking	□Yes □Unclear	Include
status of pupils (never, ever, current smoking)		Explore more (other
(WHAT has been changed)		articles, contacting authors)
FINAL DECISION:		

**NB:** this Eligibility checklist was applied to all abstract emerged from data-bases search in order to identify studies that are included in the systematic review of SBSPI in Arabic and LICs; If the answer is yes or unclear, then the full-texts was reviewed.

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### A Systematic Review of intervention functions, theoretical constructs, and cultural adaptations of School-Based Smoking Prevention Interventions in Low and Middle-Income Countries

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Manuscript ID	bmjopen-2022-066613.R1
Article Type:	Original research
Date Submitted by the Author:	25-Oct-2022
Complete List of Authors:	Ba-Break, Maryam; University of Leeds Bewick, Bridgette; University of Leeds Huss, Reinhard; UBI Lab Ensor, Tim; University of Leeds Abahussin, Asma; King Saud University, Department of Biomedical Technology Alhakimi, Hamdi; Utrecht University, Department of Public Health Sciences Elsey, Helen ; University of York, Health Sciences
<b>Primary Subject Heading</b> :	Smoking and tobacco
Secondary Subject Heading:	Global health, Public health, Smoking and tobacco
Keywords:	International health services < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Organisation of health services < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Community child health < PAEDIATRICS, Child protection < PAEDIATRICS
	1

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# A Systematic Review of intervention functions, theoretical constructs, and cultural adaptations of School-Based Smoking Prevention Interventions in Low and Middle-Income Countries

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# Abstract

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

**Data sources:** MEDLINE, EMBASE, Global Health, CINAHL, PsycINFO, ERIC, Cochrane CENTRAL, Web of Science, Popline, CENTRAL, SCOPUS, dissertations, and grey literature were searched through August 2022 with no date limitations.

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

**Data extraction and synthesis :** Interventions data were coded according to the Theoretical Domains Framework , intervention functions of the Behaviour Change Wheel and cultural appropriateness features. Using narrative synthesis we identified which of cultural adaptation features, theoretical constructs, and intervention functions were associated with effectiveness. The findings were mapped against the capability-motivation and opportunity model to conclude the result. Risk of bias is assessed with Cochrane Risk of Bias tool.

**Results:** We identified 11 RCTs (n=7,712 never-smokers aged 11-15); of which five arms were effective and five studies 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 characterized 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:** We concluded that deep cultural adaptation were considered more in the effective interventions . Effective interventions considered improving pupil's psychological capability to remain never-smokers and reducing their social and physical opportunities and reflective and automatic motivations to smoke. Future trials should use standardized measurements of smoking to allow meta-analysis in future reviews.

Funding: Self-funded

**Keywords:** smoking, prevention, school-based intervention, RCTs, LMICs, Systematic review, TDF, BCW, COM-B

# Strengths and limitations of this study

- This systematic review was based on a comprehensive search of randomized control trials 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 provide the best protection against bias.
- The review used smoking outcomes from 7,712 baseline never-smokers and provide 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 LMICs, or limited publications on that 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 as 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 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 consequence is a global concern, and over half a trillion US Dollars are spent annually on tobacco control measures [5].

Smokers in 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 RCTs and reviewed in some systematic reviews to identify factors influencing the effectiveness [10-22]. However, only three reviews were focused on LMICs, one is limited to African countries and included non RCTs [23], one explored smoking cessation only [24], and one was not a systematic review [25]. 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) [26] to specify intervention functions. 2) The Theoretical Domain Framework (TDF) [27] was adapted using the classification of smoking prevention curriculum [28] 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, Lukwago [29] and Castro, Barrera Jr [30] 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 as 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 the used approaches and strategies for ensuring cultural appropriateness, intervention functions, and theoretical constructs of the effective and ineffective school-based smoking prevention interventions that were implemented in low and middle income countries.

#### 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 Specialized Register, Trials Register of Promoting Health Interventions (TROPHI). The search was conducted from inception to Augsut 2022 using terms relating to school-based smoking prevention interventions, See supplement 1, with no date restrictions. Articles were filtered later for 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 [31] was used.

We searched all RCTs evaluating school-based smoking prevention interventions in LMICs. Trials were included, if interventions targetted 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. There was no restriction on targeting smoking alone or among other risky behaviour and, what the control group received, providing if they aimed at preventing smoking initiation. The main outcome is remaining never-smoker pupils. 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 [32] met all the inclusion criteria except one, as pupils were only followed for four months after intervention completion.

One researcher (MB) independently screened all titles, abstracts, and full-text articles for inclusion and exclusion criteria. Two other researchers (AA and HA) independently screened a random sample (25%) of all titles and abstracts of the included and excluded studies, 90% agreement rate was achieved. Any disagreement was resolved through collective discussion, consensus, or referral to other researchers (HE, JN, BB).

#### Data extraction and management

Data were independently extracted by two researchers (MB and AA). Any disagreement was resolved through collective discussion, consensus, or referral to other researchers (HE, BB, 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 [27]: 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 sub-grouped using Griffin and Botvin [28] 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, Lukwago [29], and Castro, Barrera Jr [30] classifications.

A designed checklist was used to identify the presence or absence of each of the 17 theoretical domains, the nine intervention functions, and the smoking prevention curriculum as well as the two dimensions, the three approaches, the six strategies, and the three 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 summarize 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 [33] was used 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 [34] 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 meta-analysis. It is recommended to calculate effect size in systematic reviews to facilitate comparing the effectiveness of intervention when different statistical test and parameters were used across studies [35-38]. Therefore, Revman software (version 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 Supplement 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 [26]. The review was concluded with 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 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 included in this review (Error! Reference source not found.); representing 39,455 never-smoked pupils aged 11 to 15 years, Table 1 summarizes participants' characteristics. Females represented at least 45% of the sample in all trials, except in one [39]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 one intervention arm except three trials as two compromised two-intervention arms and one included three-intervention arms, so 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[40] 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 [40-43]. These trials indicated absence of smoking prevention contents or activities in school curriculum, of these two trials[40, 43] also reported absence of anti-smoking school policy. All trials focused primarily on preventing smoking initiation but one [40] and four trials [39, 41, 44, 45] also involved smoking cessation and other substances-use respectively. All interventions focused on face-to-face activities inside schools. Four arms [40, 41, 43, 46] 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 six-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 interventions arms were effective, compared with cotrols, 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 [47]. However, those who smoked a puff or two were considered never-smokers in one study[45]. Changes in never-smoking rates in the past one[44] or two[39]months before the survey were used in assessing the outcome of two trials. Two trials[39, 41] 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[39, 40, 48]. Whereas others [41-43, 45, 49, 50]calculated odd-ratio 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.

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### Table 1Baseline characteristics of participants

The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the int smoking preventi	tervention in	Number	Age	Sex (females <u>%</u> )	Ethnicity	School type (public %)	Family income				
1. Perry, 2009, India	Effective	Effective		11.9	48.4	Not stated	Not stated	Not stated				
2. Motamedi, 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				
3. Lotrean, 2013, Romania	Effective.		1071	13-15	51	Not stated	Not stated	Not stated				
4. Reddy, 2002, India	School intervention School intervention plus family intervention	intervention Effective intervention plus Effective				Not stated	40%	Not stated				
5. Tahlil, 2015, Indonesia	Islamic based interventionIneffectiveHealth-based interventionIneffectiveCombined health andIneffective		477	11-14	58.5	Not stated	Not stated	Not stated				
6. Resnicow, 2010 South-Africa,	Harm management life skills intervention	management Ineffective 5; stills intervention Ineffective		14	49.5	Black 59.7%, Coloured 26.4%, White 9.9%	100	Not stated but findings were adjusted forincome				
7. Chou, 2006, China	Ineffective	•	2661	12.5	47.7	Not stated	Not stated	Not stated				
8. Seal, 2006, Thailand	Ineffective		170	15.5	11	Not stated	Not stated	Not stated				
9. Wen, 2010, China	Ineffective		2343	13.4	45.9	Not stated	50%	Not stated				
10. Marsiglia, 2015, Mexico	Ineffective		431	13	55	Mexican	100%	Not stated				
11. Chen, 2014, China	Ineffective	1807	14.5 ± 1.1	49.6	Linzhi Tibetan and Guangzhou Han	Not stated	Not stated					

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#### Table 2 characteristics of included studies

Table 2 character	istics of included studies																						
			5					R		c	ompone	ents		Targ	ets	se	ttings	Th	e delive	erer			Pro
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the intervent prevention	ion in smoking	itervention duration	Number of sessions	Frequency of contact	Booster-sessions	Follow-up period	sponse rate at final- evaluation	The attrition rate in the intervention arm compared with control	Smoking prevention	Smoking cessation	Preventing substance use	pupils	teachers	Parents / relatives / community	Inside schools	Outside schools	Teachers	peers	Outsider specialists	Training deliverers	Fidelity checked	cess-evaluation done
Perry, 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	х		х	х	х	x	x	х	х		Y	Y	Y
Motamedi, 2016, South- Africa	Effective		Not stated	12	One / year	6	3 years	90%	10% in both arms	х	х	Х	х			х		х			NC	Y	Y
Lotrean, 2013, Romania	Effective.		2 months	5 weekly	Weekly	NC	9 months	90.2	11% compared with 9.8% in control	х	х		х		х	х	х	х	х		Y	NC	Y
Reddy, 2002, India	School intervention	Not stated	Not stated	20	Not stated	NC	1 vear	88.3%	Not stated	Х		Х	Х			Х		x	x		Y	Y	γ
,	School plus family intervention	Effective				_	,		Not stated	Х		Х	Х	x	Х	Х							
	Islamic based intervention	8 weeks				20				Х			Х			х							Ī
Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	8 weeks	8	One/ Week	NC	6 months	89.5%	Not stated	Х			х	İ		Х		х		x	Y	NC	NC
	Combined health & Islamic intervention	Ineffective						21		х			х			х							
Resnicow, 2010 South-Africa,	Harm management	Not stated	Not stated	8 per year	One / year	NC	2 years	93%	41.2% compared with 14.2% in control	x			х			x		x			Y	Y	Y
	life skills intervention	Ineffective						4	34.2% compared to cohort 15.3%	x			х			х							
Chou, 2006, China	Ineffective		13 weeks	13	Once /Week	NC	1 year	97% at baseline	12.5% compared with 7% in control	x			х			х		х		х	Y	NC	NC
Seal, 2006, Thailand	Ineffective		Not stated	10	Not stated	0	6 months	100%	Not stated	Х		Х	х			х		NC	NC	NC	NC	NC	NC
Wen, 2010, China	Ineffective		Not stated	Not stated	Not stated	2	6 months	90%	7.95% compared with 32.55% in control	x			х	х	х	х	х	х	х	х	Y	NC	Y
Marsiglia, 2015, Mexico	Ineffective		10 weeks	20	Two /week	NC	8 months	86%	Not stated	Х		Х				Х		Х			Y	NC	NC
Chen, 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			х	х		x		х	х		Y	Y	NC

- 50 51 52 53 54 55 56 57 58 59 60

#### **Risk of bias**

Attrition and selection were identified as the most relevant 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 [33] and no trial has low risk of bias in all these criteria. Ineffective trials has higher risk of bias ratio than effective trials (Table 3). Only one effective trial [45] has high risk of bias caused by selecting intervention schools purposively based on being cooperative before starting the intervention. The assessment cannot 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.

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 <sup>1</sup>
Perry, 2009, India	L	U	U	L	L	0/5
Motamedi, 2016, South-Africa	н	н	U	L	U	2/5
Lotrean,2013, Romania	L	U	U	L	L	0/5
Reddy, 2002, India	L	U	U	U	L	0/5
Tahlil, 2015, Indonesia	U	L	U	U	L	0/5
Resnicow, 2010, South-Africa,	U	U	U	н	L	1/5
Chou, 2006, China	L	U	U	Н	L	1/5
Seal 2006, Thailand	L	L	U	U	L	0/5
Wen 2010, China	L	н	н	Н	L	3/5
Marsiglia, 2015, Mexico	Н	U	U	U	L	1/5
Chen, 2014, China	L	U	U	Н	L	1/5
H = high risk of bias,	U = unclea	r risk of bias,	L = low risk o	of bias		

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

<sup>&</sup>lt;sup>1</sup>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.

#### **Cultural appropriateness**

 Most (10/15) intervention arms were based on effective interventions originally developed in high-income countries. In three [40, 44, 49] 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 who understand what is 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 third (10/15) of interventions considered using cultural 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 during designing nine arms (socio-cultural 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, demonstrated cultural tailoring which is defined as using all the above cultural appropriateness strategies.

Deep cultural appropriateness, through incorporating cultural, environmental, psychological, and social factors that influence smoking in the targeted population into the proposed intervention [30, 51], was most recognised in the effective interventions. Whereas all the ineffective interventions, except one [48], involved either unclear or surface cultural adaptation of the imported interventions. This was 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) weak consideration of local socio-cultural 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 [45, 52], both were effective.

# **Theoretical constructs**

The design of all effective interventions, except one [41], was informed by at least one theory but insufficient details were available on how. **Error! Reference source not found.** 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 [42, 48] as social consequences were added. Only effective interventions explained consequences of secondary smoking. Interventions that combined explaining the health, environmental, social and emotional consequences of smoking were effective[40, 45]. 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 [45] **(Skills domain).** 

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# Table 4 Summary of cultural appropriateness of the included interventions

								Cult	tural a	appro	priat	eness	5								
						on	A	pproac	:h			stra	tegy			9	Stage			How	
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the int smoking preventi	tervention country origin	Surface	Deep	Unclear	Bottom-Up	Top-Down	Both	Linguistic	Peripheral	Evidential	Constituent-involving	Sociocultural	Cultural tailoring	Design	Implementation	Evaluation	Informally	qualitative data	Surveys	
Perry, 2009, India	Effective		USA		Х				Х	Х	Х	Х	Х	Х	Х	Х	Х			Х	
Motamedi, 2016, South- Africa	Effective	USA		x				х	х	х	х	х	х	x	х	х	x		х	x	
Lotrean, 2013, Romania	Effective.	Netherland		Х				Х	Х	Х	Х	Х	Х		Х			Х	Х		
	School intervention	Effective	Partly from			Х			Х	Х	Х		Х			Х	Х			Х	Х
Reddy, 2002, India	School& family intervention	Effective	USA			х			х	х	x		х			х	х			х	x
	Islamic based intervention	Ineffective		Х					Х	Х			Х	Х		Х				Х	
Tahlil. 2015. Indonesia	Health-based intervention	Ineffective	Indonesia	Х		K			Х	Х			Х	Х		Х				Х	
,	Combined health and Islamic based intervention	Ineffective		х					x	х			х	х		х				Х	
Resnicow, 2010 South-	Harm management	Ineffective	Australia		Х				X	X	Х		Х	Х		Х				Х	
Africa,	life skills intervention	Ineffective	USA		Х				Х	X	X		Х	Х		Х				Х	
Chou, 2006, China	Ineffective		USA	Х				Х		X	Х		Х			Х			Х		
Seal, 2006, Thailand	Ineffective		USA	Х				Х		Х	Х		Х			Х			Х		
Wen, 2010, China	Ineffective		China			Х			Х	Х			Х	Х		Х				Х	
Marsiglia, 2015, Mexico	Ineffective		USA	Х					Х	Х	Х		Х			Х				Х	
Chen, 2014, China	Ineffective	China			Х		Х		Х			Х			Х				Х		

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

				Knowl	edge		Skills		Me dec	Beł	Env	Soc	Beli Cor	Beli	Opt	Inte	Ide	Per	Rei	Em
	The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the inte smoking preventio	rvention in n	Knowledge on consequences	Normative education	Social competence	Social influence	Combined	mory, attention & ision process	navioural regulation	vironmental context & ources	ial influences	iefs about ısequences	iefs on capabilities	timism	entions	ntity / Social role	sonal-goals	nforcement s	otion management
1.	Perry, 2009, India	Effective		Х			Х		Х		Х	Х	Х	Х		Х	Х		Х	
2.	Motamedi, 2016 South-Africa	Effective		Х				Х	Х	Х			Х		Х	Х	Х	Х		Х
3.	Lotrean, 2013, Romania	Effective.		Х			Х		Х			Х	Х	Х		Х	Х		Х	
		School intervention	Effective	Х			Х				Х	Х	Х			Х				
4.	Reddy, 2002, India	School intervention plus family intervention	Effective	х			х				х	х	х			х				
		Islamic based intervention	Ineffective	Х	Х	X							Х			Х				
5	Tablil 2015 Indonesia	Health-based intervention	Ineffective	Х	Х			Х				Х	Х			Х				Х
5.	runn, 2013, maonesia	Combined health & Islamic based intervention	Ineffective	х	х			x	う				х			х				х
e	Posnicow 2010 South Africa	Harm management	Ineffective	Х		Х			x 🗸				Х			Х				
0.	Resilicow, 2010 South-Allica,	life skills intervention	Ineffective	Х				Х	Х 🗕				Х			Х				Х
7.	Chou, 2006, China	Ineffective		Х	Х		Х		Х			Х	Х			Х	Х			
8.	Seal, 2006, Thailand	Ineffective		Х				Х	Х		Х		Х			Х				Х
9.	Wen, 2010, China	Ineffective		Х				Х	Х		Х	Х	Х			Х	Х		Х	Х
10.	Marsiglia, 2015, Mexico	Ineffective		Х			Х		Х				Х	Х		Х				
11.	Chen, 2014, China	Ineffective		Х			Х				Х	Х	Х			Х	Х			

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1	
2	Nine intervention arms used role-plays, group discussion, and activities or videos in raising
3	awareness of smoking consequences to make the contents attractable and memorable after
4	the intervention (Momery and attention domain). Only offective interventions [45, 46]
5	the intervention (weinory and attention domain). Only enective interventions [43, 40]
7	combined these methods with encouraging pupils to discuss their views on advantages and
8	disadvantages of smoking before deciding to smoke or not (Decision process domain).
9	Civerence aimed to increase berriers and minimize facilitators of exclusion in public environment
10	Six arms aimed to increase barriers and minimize racinitators of smoking in pupils environment
11	(Environmental-context and resources domain). All these arms involved enhancing
12	accessibility to information on smoking consequences inside schools. While pupils' exposure to
13	this information was high only in the effective interventions, this exposure was either low [50]
14	or not evaluated [39, 43] in the ineffective arms. Additionally five arms included policy that
15	prevent numils, teachers, parents and visitors from smoking inside schools. In the effective
16	prevent pupils, teachers, parents and visitors from smoking inside schools. In the effective
17	arms, improving information accessibility and anti-smoking policy went beyond schools to
18	include home [41] or the wider community [40]. This included motivating the community to
19	advocate for national anti-smoking policy [40] or banning tobacco promotion [41].
20	
21	Activities to reduce social influencers of adolescents' smoking (social influence domain) were
22	considered in all the effective interventions, except one [45]. Only effective interventions used
23	peer-pressure to create positive attitude toward non-smoking, or introduced pupils (alone or
24	with teachers or parents) who never smoked as role-models by announcing their names in
25	school's newsletter. These role-models contributed in supporting other pupils to avoid
20 27	smoking: informally discussed their beliefs about smoking barms and shared their experience
27	of maintaining none-smoking behaviour and refusing smoking offers by friends. The
20	of maintaining none-smoking behaviour and refusing smoking oners by menus. The
30	Intervention [43] that almed to change influencers of smoking at nome through parents
31	education on smoking harms without using pupils as role-models or peer-pressure were
32	ineffective even when parents signed contracts not-to-smoke at home. Some ineffective arms
33	aimed to change social norms only through explaining the social refusal of smoking by
34	adolescents or obtaining written commitments from teachers or parents or verbal public
35	commitments from pupils in front of their classmates not-to-smoke.
36	
37	All arms considered correcting pupils' <b>beliefs about smoking consequences</b> , at least on health.
38	Although pupils' beliefs that smoking is harmful have improved after interventions in seven
39	arms, only five arms [40, 41, 46, 53] showed translating these beliefs into action by avoiding
40	smoking All arms [40, 45] that involved correcting beliefs about the emotional addictive
41	smoking. An arms [40, 45] that involved correcting benefs about the emotional, addictive,
42	
44	errective.
45	Besides increasing awareness and beliefs that smoking is harmful, three arms aimed to
46	onhance numils' <b>holiefs about their canability</b> to avoid smalking. The effective arms [46, 52]
47	enhance pupils beliefs about their capability to avoid smoking. The effective arms [46, 53]
48	enhanced participants' self-confidence in their ability to avoid smoking and supporting their
49	relatives and peers to avoid or quit smoking, trained them on that, and allowed them to
50	practice the acquired skills in role-plays and in the existence of professionals. One effective
51	arm [40] established school-based support groups for the trained participants even after the
52	intervention completion. The ineffective arm [44] trained pupils, using filmed real-life
53	scenarios to refuse smoking offers after explaining smoking harms and encouraged them to
54	low motors when they amole Hereiger authors advanted and that condensing the
55	leave smokers when they smoke. However, authors acknowledged that condensing these
56	activities over short period due to time and resources constraints may have contributed to its
5/	ineffectiveness.
20 50	
59 60	
00	

14

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 five effective arms[40, 41, 46, 53]. One effective [45] and three ineffective [39, 44, 48] interventions didn't 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 [43, 49, 50], 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 or voluntary. The effective arms [40, 41, 45, 46] 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 [45] was effective. Only this effective arm allowed participants to practice the acquired skills and burnout 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 encouraged pupils to set proximal and distal goals for themselves, then educated them on how smoking hinders achieving their goals and how better 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 practise 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 [40, 46] rewarded pupils (as well as teachers and parents in one arm)[40] 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 [43] rewarded winners of schools' competition for the best anti-smoking presentations and essays, without puplishing 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 [43], showing pictures of smoking-related illnesses [50], or discussing reasons for refusing smoking offers only from pupils' perspective [44].

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 study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the ir smoking preven	ntervention in tion	Education	Persuasion	Incentives	Coercion	Training	Restriction	Environmental restructuring	Modelling	Enablement
1.	Perry, 2009, India	Effective		Х	Х	х		х	Х	Х	Х	Х
2.	Motamedi, 2016 South-Africa	Effective		x	x			х				
3.	Lotrean, 2013, Romania	Effective		x	x	Х		Х			х	
4.	Reddy, 2002, India	School intervention	Effective	Х	Х			х	Х			
		School intervention plus family intervention	Effective	х	х			х	х			
		Islamic based intervention	Ineffective	Х				Х				
5.	Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	X				Х				
	indonesia	Combined health & Islamic based intervention	Ineffective	x				х				
6.	Resnicow, 2010,	Harm management	Ineffective	X				Х				Х
	South-Africa	life skills intervention	Ineffective	Х				Х				
7.	Chou,2006, China	Ineffective		Х				х		Х		
8.	Seal, 2006, Thailand	Ineffective		x				Х				
9.	Wen, 2010, China	Ineffective		Х	х	Х		Х	Х	Х		
10.	Marsiglia, 2015, Mexico	Ineffective		x	x			х				
11.	Chen, 2014, China	Ineffective		Х	х			Х	Х	Х		

Table 6 Summary of the Presence of BCW Intervention Functions in included studies

Presence of a BCW Intervention Function in an intervention arm is indicated with an X

The included interventions showed limited use of the *restrictive function* but 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 antismoking policy went beyond school boundaries to the wider environment through disseminating the national anti-smoking policy and enhance its implementation by community members [40], or advocate banning tobacco advertisements through pupils-signed petition directed to the government [41]. The two ineffective arms [50, 54] established smoking control committee aiming to support antismoking 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 [40] declared teachers and parents plus pupils who never smoked as role-models. The effective interventions used peer-educators, who never smoked, to: chair, stimulate, summarize 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[50] or deliver [43] 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 [40, 53]. The effective arm [40, 53] encouraged social norm against smoking through establishing smoke-free initiatives run by 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 [43] or producing school-posters discouraging smoking [49, 50]. Two ineffective arms [43, 50] established school smoking-related committee but the role of this committee was unexplained. One ineffective intervention [49] reported doing additional efforts to prevent pupils' exposure to smoking at home without explaining how.

Only two arms, one [40] was effective, considered the *enablement intervention function*, through improving pupils' capability (beyond training and education) and opportunity to remain never-smokers. The effective arm [40] offered smoking prevention, quitting, and counselling services at schools for smoker and non-smoker parents, teachers, and pupils. Whereas in the ineffective arm [55] 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 [45] or combined with either restriction [41] or modelling function only [46] or with all other functions except the coercion function [40].

# Enhancing capability, motivation, and opportunities to avoid initiating smoking

The effective interventions enhanced Pupils' **psychological capability** to maintain non-smoking behaviour through the followings: 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 recognize, analyse and react to direct and indirect pressures to smoke from peers, family, advertisements and adults. 6) Building pupils' confidence 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 minimized in the effective interventions through 1) Establishing and enforcing anti-smoking policies that prohibit smoking inside schools by teachers, parents, and visitors before pupils. 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. 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. 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 recognized 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 7,712 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 limited publications resulting from limited experience and inaccessibility to international databases or language barriers. Other systematic reviews [14, 23, 56-60]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 recognized barriers [42, 57, 61].

Although self-reporting is a valid and stable indicator for identifying smoking status in many contexts [62, 63], its sensitivity and specificity vary per age, gender, and culture [64]. Adolescents, especially girls, might under-report their smoking where smoking is culturally unacceptable [65-67]; or over-report that where smokers are considered mature and

 impressive [32, 64, 68-70]. 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 [69] but is challenged by the constrained resources available in LMICs, as other studies have identified [14, 17, 41, 43, 71, 72].

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 [73]. 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 evaluation could have minimized bias in interpreting the effectiveness of these complex-interventions and explaining why the effectiveness varies across contexts [73, 74].

Other limitations of the review are that three trials were excluded because the findings is 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 trails, 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' utilization of these modern methods [75, 76]. Researchers should explore the feasibility, acceptability, and effectiveness of using these modern methods in school-based interventions in LMICs.

Using standardized 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. Standardizing 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 improving their psychological capability to remain never-smokers and reducing their social and physical opportunities and reflective and automatic motivations to smoke were considered in the effective interventions more than the ineffective trials. In the effective interventions, this is achieved through raising awareness of various consequences of smoking using engaging methods and accessible information sources. Improving refusal skills of smoking offers, through demonstration, practise, and feedback on performance. Advising pupils on how to recognize, analyse and react to direct and indirect pressure to smoke.

Enhancing pupils' self-confidence and ability to make a conscious decision to remain neversmokers, make that a personal goal, and obtain social support for that. Restricting smoking inside schools. Repeatedly presenting smokers in negative images. Social rewarding of neversmokers and using them as role-models. Peers' education and pressure against smoking. Encouraging pupils to consider parents' disapproval of smoking. Facilitating useful free time usage and negative emotions control. It was also concluded that interventions' effectiveness is influenced by deep cultural adaptation, using top-down and bottom-up approaches.

#### **Contributorship statement**

MB, HE, and BB conceived the review. MB, AA, and HA completed screening and extraction of data. MB, HE, BB, and RH devised the analysis plan and AA and HA provided support for analyses. MB 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 is the guarantor of the paper.

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#### Data sharing statement

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) upon reasonable request.

#### **Ethics Approval Statement**

There was no ethical approval required for this study as it did not include primary data collection.

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#	Key words	No of hits	The PICO
#1	exp "tobacco use"/ or exp smoking/ or Nicotine/		
#2	(Tobacco OR smok* OR cigar* OR Shisha OR water pipe OR		
#2	HI OP #2		Tobacco uso/ smoking
#5	#1 OK #2 (Health* adi2 (promot* OP adjugat* OP improvement)) tw		
#4	(Realth adj2 (promot OK educat OK improvement)).tw		
#5	stratog* OP polic* OP tochnique* OP framework* OP		
	Campaign* OR communicat* OR marketing OR advertis* OR		
	media ) tw		
#6	(educat* OR promot* OR teach* OR advise* OR counsel* OR		
π0	encourage* OR train* OR behavio#ur change* OR		
	campaign) tw		
#7	(anti smok* OB smok* free ) OB (freedom adi3 smoking)		
#8	((Cessation OB reduc* OB abst?in* OB ston* OB quit* OB		
	anti OR free* OR discourag* OR prevent*) adi3 (cigar* OR		
	smok*)).tw		
#9	Psychotherapy, Group/ OR Counseling/		
#10	#4 OR #5 OR #6 OR #7 OR #8 OR #9		Behaviour
#10	#4 OK #5 OK #0 OK #7 OK #8 OK #5		change/prevention/promotion
#11	Child/OR Adolescent/OR Student/OR nunil/ School OR		change/prevention/promotion
#11	Adolescent Behavior		
#12	(Adolescent OR youth* OR child* OR young* OR Student*		
11 12	OR pupil* OR class* OR Minor* OR juvenile* OR teen* OR		
	youth* OR girls OR boys OR school*).tw.		
#13	#11 OR #12		Adolescents
#14	#3 and #10 and #13	2,4214	prevention OR control &
			Tobacco &
			adolescents/Adolescents
#15	school*.tw OR class*.tw.		
#16	(school* adj3 based).tw. OR (class* adj3 based).tw.		
#17	#15 OR #16		School-based
#18	#15 and 17	7,433	School-based prevention OR
			control & Tobacco &
			adolescents/Adolescents
#19	randomized controlled trial.pt. OR controlled clinical trial.pt.		
	OR randomized.ab. OR placebo.ab. OR drug therapy.fs. OR		5
	randomly.ab. OR trial.ab. OR groups.ab.		
#20	#19 Not exp animals/ not humans.sh.		RCT
#21	Meta-analysis OR Systematic review		-
#22	#20 OR #21		RCT OR meta-analysis OR systematic review
#23	#18 and #22	1,840	RCT studies on School-based
			prevention / Tobacco
			/Adolescents
#24	limit to humans	1,241	

#### Supplement 1: The full electronic search strategy employed in Medline database, as an example.






#### PRISMA 2020 Checklist

LE e 1 STRACT stract 2 FRODUCTION tionale 3	Identify the report as a systematic review. The title and the aim clearly state that this is a systematic review See the PRISMA 2020 for the Abstracts checklist. Yes the PRISMA 2020 for Abstracts checklist was followed to structure the abstract Describe the rationale for the review in the context of existing knowledge. Tobacco use is a global epidemic as its rate, estimated to be 22% among adults, continues to increase annually (WHO, 2014a,
e 1 STRACT stract 2 FRODUCTION cionale 3	Identify the report as a systematic review. The title and the aim clearly state that this is a systematic review See the PRISMA 2020 for the Abstracts checklist. Yes the PRISMA 2020 for Abstracts checklist was followed to structure the abstract Describe the rationale for the review in the context of existing knowledge. Tobacco use is a global epidemic as its rate, estimated to be 22% among adults, continues to increase annually (WHO, 2014a,
STRACT stract 2 FRODUCTION tionale 3	The title and the aim clearly state that this is a systematic review See the PRISMA 2020 for the Abstracts checklist. Yes the PRISMA 2020 for Abstracts checklist was followed to structure the abstract Describe the rationale for the review in the context of existing knowledge. Tobacco use is a global epidemic as its rate, estimated to be 22% among adults, continues to increase annually (WHO, 2014a,
STRACT       stract     2       TRODUCTION       cionale     3	See the PRISMA 2020 for the Abstracts checklist. Yes the PRISMA 2020 for Abstracts checklist was followed to structure the abstract Describe the rationale for the review in the context of existing knowledge. Tobacco use is a global epidemic as its rate, estimated to be 22% among adults, continues to increase annually (WHO, 2014a,
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TRODUCTION : ionale 3	Describe the rationale for the review in the context of existing knowledge. Tobacco use is a global epidemic as its rate, estimated to be 22% among adults, continues to increase annually (WHO, 2014a,
tionale 3	<b>Describe the rationale for the review in the context of existing knowledge.</b> Tobacco use is a global epidemic as its rate, estimated to be 22% among adults, continues to increase annually (WHO, 2014a,
	Tobacco use is a global epidemic as its rate, estimated to be 22% among adults, continues to increase annually (WHO, 2014a,
ectives 4	<ul> <li>WHO, 2019). Smoking is one of the major risk factors for Non-Communicable Diseases (NCD) that cause 70% of global deaths (WHO, 2018). 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 (WHO, 2015). These harms are preventa therefore, preventing smoking and its consequence is a global concern, and over half a trillion US Dollars are spent annually of tobacco control measures (WHO, 2008).</li> <li>Smokers in LMICs represent 80% of the smokers worldwide (WHO, 2015). Three-quarters of the global NCD deaths happen in LMICs, mainly (82%) before the age of 70 years (WHO, 2014b, WHO, 2019). The global data indicates poor implementation of effective preventive measures in LMICs compared with high-income countries (WHO, 2019). Tobacco products are affordable and accessible in many LMICs where tobacco taxation and restriction of tobacco promotion and advertisement are poorly implemented (WHO, 2015, WHO, 2013a, WHO, 2013b).</li> <li>Over the past four decades, school-based interventions have been used to prevent adolescents from smoking initiation in mar countries(Thomas et al., 2015). The effectiveness of school-based smoking prevention interventions (SBSPI) was evaluated in many RCTs and reviewed in some systematic reviews to identify factors influencing the effectiveness (Shackleton et al., 2016).</li> <li>Onrust et al., 2016, Schreuders et al., 2017, de Kleijn et al., 2015, Thomas et al., 2009b, Buhler, 2016, Shackleton et al., 2018) smoking cessation (Kumar et al., 2021), or not systematic review (Huriah and Lestari, 2020). 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 or what influenced the effectiveness.</li> <li>This review is important beca</li></ul>

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page 2

Page 4, The

last

Location where item is reported

Page 1 and 4



# PRISMA 2020 Checklist

Section and Topic	ltem #	Checklist item	Location where item is reported
		This systematic review aims to identify the used approaches and strategies for ensuring cultural appropriateness, intervention functions, and theoretical constructs of the effective and ineffective school-based smoking prevention interventions that were implemented in low and middle income countries.	paragraph of the introduction section.
NETHODA		<ul> <li>The objectives are: <ol> <li>To determine the <i>effectiveness</i> of school-based interventions in preventing adolescents' smoking in LMICs;</li> <li>to explore the <i>cultural appropriateness</i> of school-based smoking prevention interventions that are implemented in LMICs;</li> <li>to determine the <i>theoretical constructs, intervention functions, and smoking prevention curriculum</i> that has been used in LMICs to prevent adolescents' smoking through schools;</li> <li>to identify the association between the effectiveness of SBSPIs in LMICs and the involved: approach and strategies for ensuring cultural- appropriateness; intervention functions, smoking prevention curriculum, and theoretical constructs.</li> </ol> </li> </ul>	
METHODS			The data of the large
Eligibility criteria	5	<ul> <li>Specify the inclusion and exclusion onteria for the review and now studies were grouped for the syntheses.</li> <li>Eligibility Criteria The following criteria were used for considering studies for this review: Types of Studies <ul> <li>Inclusion criteria</li> <li>RCTs as they are strong sources of evidence on effectiveness (Bowling, 2014);</li> <li>Baseline smoking was measured before starting the intervention;</li> <li>The Intervention was implemented in in a country classified as a low or middle (lower-middle, or upper-middle) income country at the time of implementing the intervention; according to the World Bank (WB) classification of countries by income (WB, 2017). LMICs were considered because the income and the development level of a country determine the available resources at school and capacity of schools to design and implement school-based interventions within the available resources at school and capacity of schools to design and implement school-based interventions need specific resources to be implemented which might not be available in LMICs, the review focused on LMICs in order to identify the evidence related to LMICS. Some systematic reviews of school-based behaviour change intervention recommended conducting systematic reviews that focus on developing countries or LMICs as many effective strategies might not be feasible, accessible and affordable in LMICs (Shackleton et al., 2016b, Nishio et al., 2013, Thomas et al., 2013) where resources limitations are important barriers there (Bauld et al., 2009a). For example: using interventions based on the internet, computer or mobile phone might not be applicable for poor countries, like Egypt, where electricity and internet are not accessible at most schools, totally or partially (CAPMS, 2017).</li> </ul> </li> </ul>	The 1 <sup>st</sup> and 2 <sup>nd</sup> paragraphs on page 5

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# PRISMA 2020 Checklist

3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9			<b>NB:</b> The World Bank classification of countries by income is selected because it is not only an indication of the relative wealth of a country as it is also used as an indirect indication of the country development, as the significant change in the global economic landscape challenge using the old classification of developing countries (Fantom and Serajuddin, 2016).	
10 11			<ul> <li>Exclusion criteria</li> <li>Full-text articles are not available in English or Arabic language (after contacting the author).</li> </ul>	
12			Types of participants	
14				
15			<ul> <li>Inclusion criteria</li> <li>Rupils at adolescence age (10.17 years), according to W/HO (2014c) definition of adolescence age, were targeted at any</li> </ul>	
16			stage of the intervention. Adolescence age was considered because many articles only include the mean or median of	
17 18			age without specifying the range of age-targeted by the intervention: smoking initiation age varies across countries	
19			therefore different age groups were targeted by SBSPIs that aim to prevent smoking initiation; school enrolment age	
20			varies across countries. Although most SBSPIs in high-income countries target pupils at the age of 13-15 years (Thomas	
21			et al., 2013), this review was not limited to interventions that target pupils aged 13-15 years and SBSPIs that targeted	
22			pupils at all adolescence years were considered to avoid bias and missing important information related to preventing	
23 24			smoking initiation through schools.	
24			<ul> <li>Exclusion criteria</li> </ul>	
26			<ul> <li>School-based Intervention that only targeted the smoking behaviour of teachers or parents.</li> </ul>	
27			Types of interventions	
28			◆ Inclusion criteria	
29			- School-based interventions or programs that aim to prevent smoking among pupils, regardless of:	
30 31			✓ The complexity of the intervention and if the intervention targets smoking alone or in addition to other tobacco-use	
32			or risky behaviour	
33			✓ Who delivered the intervention (teachers, peers, parents, researchers, health professionals, undergraduate or	
34			graduate students or others)	
35			✓ What the control groups received (no intervention, the standard or regular school education activities, different	
36			type of intervention, others). Studies with no control groups were not included.	
37			✤ Exclusion criteria	
38 30			- Pregnancy-related intervention	
39 40			- Clinical-based interventions	
41			- Interventions that focus only on smoking cessation, passive smoking, alcohol or illicit drug	
42			<ul> <li>If the intervention activities are based on colleges, university or nursery setting</li> </ul>	
43			- Intervention that only involves family-based or community-based activities even if pupils were recruited through	
44			schools.	
45 46		1	i or peer review only - http://bnijopen.bnij.com/site/about/guideimes.xhtmi	I
40 47				

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# PRISMA 2020 Checklist

3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 22			<ul> <li>Types of outcome measures</li> <li>Inclusion criteria</li> <li>The primary outcome was the impact of the intervention on the smoking status of pupils who were never-smokers at baseline</li> <li>The smoking status was assessed using either self-reported smoking or any bio-medical validation test such as Saliva thiocyanate or cotinine or expired air carbon monoxide levels (Prokhorov et al., 1993, Patrick et al., 1994).</li> <li>The outcome was measured after a minimum follow-up of six months after completion of the intervention. The six month follow-up period was considered because 1) this is the minimum period recommended for assessing changes caused by complex health interventions (Higgins and Green, 2008); 2) it has been used in all Cochrane reviews of SBSPI (Thomas et al., 2013, Thomas and Perera, 2006, Thomas, 2002). 3) This period was used in nine of the 15 systematic reviews that were used to inform the search strategy of this review. Whereas different periods were used in six reviews as follow: three reviews considered six months follow-up period after starting the intervention (Peirson et al., 2016, Hale et al., 2014, Hefler et al., 2017) but none of them was a Cochrane review or provided justification for this selection; one review required at least one-year follow-up after the intervention ended (Wiehe et al., 2005) and two reviews considered studies with short follow-up period, at least six weeks after intervention completion (Georgie et al., 2016, Sussman et al., 2014).</li> <li>Exclusion criteria</li> <li>No smoking outcome data were reported for example: only reporting changes in awareness or intention to smoke;</li> <li>Data on pupils' smoking status before implementing the intervention was unavailable, after contacting the authors.</li> <li>No study was excluded based on the year of publication. Only three studies were excluded, one from Brazil, China and Mexico each, because the full-text was not available in English or Arabic. Another SBSPI trial (Al-sheyab et al., 2016) was excluded a</li></ul>	
<ul> <li>33</li> <li>34</li> <li>35</li> <li>36</li> <li>37</li> <li>38</li> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> </ul>	Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. The following databases were searched, using several search filters1: - Medline (Ovid) - Embase (Ovid) - PubMed (Ovid) - Global Health (Ovid) - PsycINFO (Ovid) - CINAHL(Ebsco)	The 1st paragraph in the search strategy and trial selection section pages 4 and 5

46 Indicated between brackets

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# PRISMA 2020 Checklist

-       Web of Science (Thomson), -       Popline (K4 Health) -         -       Cochrane Central Register of Controlled TrialsCENTRAL (Wiley) -       ERIC (Education Resources Information Centre) -         -       WHO Regional Databases -       PubMed central (PMC) -       Cochrane Databases -       PubMed central (PMC) -         -       Cochrane Databases -       PubMed central (PMC) -       Cochrane Central Register of Controlled Trials) -       CCENTRAL (Cochrane Central Register of Controlled Trials) -       CENTRAL (Cochrane Central Register of Platform (WHO) (International) -       Databases -       ScoPUS -       CENTRAL (Cochrane Central Register of Platform (WHO) (International) -       DARE (Database of Abstracts of Reviews of Effects) -       Centre of review and dissemination -       TRIP database -       ASSIA (Applied Social Sciences Index And Abstracts) -       ProQuest dissertation (SATD)       Databases searches were supplemented by searching the following websites: -       ASSIST (A Stop Smoking In School Trial) intervention model In UK -       Action on Smoking and Health (ASH) -       The National Institute for Health and Care Excellence (NICE) website -       Centre for Tobacco Control Research -       Cochrane Tobacco Addiction review Group -       Trials Register of Promoting Health Interventions (TRoPHI) -       UK Public Health As	Section and Topic	ltem #	Checklist item	Location where item is reported
Search strategy       7       Present the full search strategies for all databases, registers and websites, including any filters and limits used.       The section on search strategy and then updated in November 2019, April 2021 and August 2022. All databases were searched as far back as they allowed. Supplement 1 summarises the key-terms and literature mapping concepts using       The section on search strategy and trial selection			<ul> <li>Web of Science (Thomson),</li> <li>Popline (K4 Health)</li> <li>Cochrane Central Register of Controlled Trials –CENTRAL (Wiley)</li> <li>ERIC (Education Resources Information Centre)</li> <li>WHO Regional Databases</li> <li>PubMed central (PMC)</li> <li>Cochrane Databases of Systematic Reviews</li> <li>ProQuest Middle East &amp; Africa Databases</li> <li>SCOPUS</li> <li>CENTRAL (Cochrane Central Register of Controlled Trials)</li> <li>ICTRP International Clinical Trials Registry Platform (WHO) (International)</li> <li>Tobacco control 1992.</li> <li>Journals of Smoking-Related Disorders</li> <li>ICTRP International Clinical Trials Registry Platform (WHO) (International)</li> <li>Tobacco control 1992.</li> <li>Journals of Smoking-Related Disorders</li> <li>ICTRP International Clinical Trials Registry Platform (WHO) (International)</li> <li>DARE (Database of Abstracts of Reviews of Effects)</li> <li>Centre of review and dissemination</li> <li>TRIP database</li> <li>ASSIA (Applied Social Sciences Index And Abstracts)</li> <li>PoroQuest dissertations and theses</li> <li>Electronic thesis online services (ethos)</li> <li>DART –Europe- E – theses portal</li> <li>South African thesis and dissertation (SATD)</li> </ul> Databases searches were supplemented by searching the following websites: <ul> <li>ASSIST (A Stop Smoking in School Trial) intervention model in UK</li> <li>Action on Smoking and Health (ASH)</li> <li>The National Institute for Health and Care Excellence (NICE) website</li> <li>Centre for Tobacco Control Research</li> <li>Cochrane Tobacco Addiction review Group</li> <li>Trials Register of Promoting Health Interventions (TROPHI)</li> <li>UK Public Metabath Accontrice</li> </ul>	is reported
Search strategy7Present the full search strategies for all databases, registers and websites, including any filters and limits used.The section on search strategy and trial selection7Present the full search strategies for all databases, registers and websites, including any filters and limits used.The section on search strategy and trial selection			- The European Smoking prevention Framework Approach (EFSA)	
PICO framework. Terms related and countries were were were were were were were and and pages 4 and	Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used. The search was conducted in January 2017 and then updated in November 2019, April 2021 and August 2022. All databases were searched as far back as they allowed. Supplement 1 summarises the key-terms and literature mapping concepts using PICO framework. Terms related to commonly weite: Hormious and Margine Allowed Lewis Second Second Second Second	The section on search strategy and trial selection pages 4 and

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# PRISMA 2020 Checklist

3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 9 10 11 12 13 14			stated in the published articles. Therefore, eligible articles were filtered later to identify if the intervention was implemented in a country with low or middle income. Supplement 1shows the full electronic search strategy employed in Medline database, as an example. Checking reference lists was used to identify more articles, as recommended by Gough et al (2017). Moreover, authors are contacted to obtain full-text, when unavailable in Arabic or English languages through the University of Leeds Library, or details of interventions, when unclearly explained in the published articles. Furthermore, individual Medline and Web of Science searches were run to track 60 authors who published articles on adolescents' smoking in LMICs, with no date restriction. Grey literature search was limited to understanding contexts where the interventions were implemented.	5.
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. A stepwise approach was used to identify relevant articles; titles screening was used first to exclude duplicates and clearly irrelevant articles followed by abstracts screening. The eligibility checklist used to screen abstracts is attached in Supplement 1, if the answer to the included questions was yes or unclear, then the full-text was reviewed. The process of screening the identified studies and reasons for exclusion are illustrated in the PRISMA diagram, based on Moher et al (2009). The researcher independently screened all titles, abstracts and full-text for inclusion and exclusion criteria. Thereafter a random sample (10%) of all titles and abstracts of the included and excluded studies were independently screened by another postgraduate researcher. An agreement rate of 90% was achieved and any disagreement was resolved through discussion. Any study that the researcher was unsure about inclusion was collectively discussed with supervisors. Blinding procedures, of authors' name, institutions and journals, was not used in sampling studies for double screening. Studies that were identified through alternative ways, such as checking references list of included studies, were subject to the same inclusion and exclusion criteria and screening process as studies that emerged from database searches. All the record were kept in Endnote and spread sheets throughout the review.	Page 5 the last paragraph in the section of the section on the search strategy and trial selection
<ul> <li>31</li> <li>32</li> <li>33</li> <li>34</li> <li>35</li> <li>36</li> <li>37</li> <li>38</li> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> <li>45</li> </ul>	Data collection process	9	Data extraction was informed by the Cochrane strategy for data extraction (Higgins and Green, 2008). A data extraction form was adapted from the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement (Moher et al., 2010) and TIDieR (Template for Intervention Description and Replication) checklist (Hoffmann et al., 2014). This form was used to extract data from each intervention on the following: 1) study design, aim and objectives, number of arms in the trial, interventions contents, smoking prevention curriculum, intervention functions, theoretical-underpinning and constructs, and what the control group received (what). 2) Participants' number, age, sex and ethnicity, attrition and response rate (Who). 3) delivery methods, intervention deliverer and any training provided for them (how). 4) The year (when) and country of implementation, intervention setting (inside school only or also included activities outside school) and school types (where). 5) the intervention duration, number of sessions, frequency of contact, duration of follow-up after intervention completion and booster sessions (how much). 6) Risk of bias, country of interventions' origin and cultural- appropriateness of intervention, quality of implementation, fidelity and any reported facilitators, challenges or barriers (how well). 7) Justification for using SBSPI (why). 8) Smoking behaviour outcome data, definitions of the identified outcome and main conclusions.	Page 5 the 1st and 2nd paragraphs in the section on Data extraction and management.

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Section and Topic	ltem #	Checklist item	Location where item is reported
		of SBSPI that could be effective in LMIC. The following theoretical perspectives were used in this study to review SBSPIs that were implemented in LMICs: 1) The middle layer of BCW (Michie et al., 2014) was used to specify intervention functions of the included SBSPIs. 2) The Theory coding scheme (Michie and Prestwich, 2010) was used to identify the theoretical-underpinning of the included studies. 3) Griffin and Botvin (2010) classification of smoking prevention curriculum was used to adapt the Theoretical Domain Framework (TDF) (Atkins et al., 2017) which was then used to explain the theoretical constructs of the included interventions. 4) The findings from the above steps were discussed using the inner layer of BCW, the capability, opportunity, motivation and behaviour (COM-B) model. 5) The cultural- appropriateness of the included interventions was assessed using Kreuter et al. (2003) and Castro et al. (2010) classifications of approaches, dimensions and strategies of cultural-appropriateness. Using these theoretical perspectives allowed identifying the approaches and dimensions of cultural-appropriateness, intervention functions, implementation methods, theoretical-constructs and smoking prevention curriculum that were commonly used in effective SBSPIs in LMICs to enhance pupils' capability, opportunity and motivation to avoid smoking initiation. This provided a full-range of potential options for SBSPIs that were used in low-middle-income settings and facilitated providing rationales for selecting among those options for SBSPI in the Egyptian context.	
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. The effectiveness of each intervention arm was assessed by comparing the smoking behaviour of adolescents in the intervention and control arms, before and after the interventions. All the three trials that included more than one intervention arm also compared the smoking behaviour of adolescents across interventions arms. The outcome of all the included trials was assessed after at least six-months of follow-up	The 2 <sup>nd</sup> paragraph in page 5
-	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. No assumption were made, we relied on the paper's content on the effectiveness of the interventions.	Page 5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. The Cochrane Collaboration's tool for assessing risk of bias in intervention studies (Higgins and Green, 2008) was used to assess whether the included studies have high, low or unclear risk of selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias such as an extreme baseline imbalance between the arms of each study. As recommended by Higgins and Thomas (2018), data were extracted on randomisation, blinding, allocation concealment, selective and incomplete outcome reporting and other bias concerns. Authors were contacted to verify any risk of bias information if not identified in the published articles. If the available data is insufficient to judge the risk of bias, then unclear risk of bias is selected. High risk of bias is selected when the available evidence indicates plausible bias that seriously weakens confidence in the findings. A guideline was used for coding the identified risk of bias; adapted from Glasziou et al. (2001), Higgins and Green (2008), Ryan R (2013) and Higgins and Thomas (2018). Scaling risk of bias was not used in this review, although it offers attractive simplicity, because it involves giving weight to different criteria in the scalar padriteisidifficult-totipstifyrithpewdighicassigne@bowetagbicdiberiowh(Higgins and Green, 2008).	Page 6, the last paragraph in the Data extraction and management section.
	Section and Topic	Section and TopicItem #Data items10aData items10aStudy risk of bias assessment11	Social and Topic         Item Topic         Checklist item           Image: Topic and the state of the state state of the state of the state of the state state of the state

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# PRISMA 2020 Checklist

3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9 10 11 12			Furthermore, scaling risk of bias showed unreliable assessments of validity and it is not supported by empirical evidence, therefore, it is discouraged in systematic reviews (Higgins and Thomas, 2018). The researcher independently assessed the risk of bias then another postgraduate researcher independently checked the risk of bias in a random sample (25%) of the included articles. Any disagreements (one case) were resolved by consensus or recourse to the supervisors	
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26	Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. The data extraction form included function checklists that were used in this review to identify the presence or absence of each of the nine intervention functions, the 17 theoretical-domains and the smoking prevention curriculum in each arm of the included SBSPI in LMICs. More than one function, theoretical-domain and curriculum were allowed to be selected for one intervention or activity. For example classroom discussion of the advantages and disadvantages of smoking was coded under the 'education' and 'persuasion' function. To explore cultural- appropriateness of the included SBSPIs, the checklist identified interventions country of origin plus approaches, dimensions and strategies used in adapting each intervention's arm to the culture of the targeted population. To explore the theoretical-underpinning of the included interventions, the checklist included the following five questions: 1) was a theory mentioned at any stage of the intervention; 2) were the relevant theoretical constructs targeted by the interventions; 3) was the theory used to select recipients or tailor interventions; 4) were the relevant theoretical constructs measured; 5) was the theory tested or refined in the interventions. Answers to these questions were coded as yes, no or unclear based on the available information in the included articles. Thereafter, all the named theories in the included interventions were listed.	Page 6, the 2 <sup>nd</sup> paragraph in the Data extraction and management section.
27 28 29 30 31 32 33 34 35 36 37 38	Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). 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.	Page 5 and 6 the Data extraction and management section
<ul> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> <li>45</li> </ul>		13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. Based on the recommendations by Michie et al. (2014) and Francis et al. (2012), the reviewers referred to the definitions and examples of each intervention function and theoretical-domain to ensure effective utilization of these frameworks in coding the intervention functions and theoretical-domains that were used in SBSPIs. Additionally, a discussion of these definitions and examples was organized before starting data-extraction jop and enjtood sife/bound gride between intervention functions and	Page 5 and 6

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#### PRISMA 2020 Checklist

Section an Topic	d Item #	Checklist item
		domains and thus achieve better inter-coder agreement on the extracted dataAuthors were contacted to get more information on their interventions and data was coded only based on the existing evidence on each of the identified criteria/elements.
0 1 2 3 4 5 6 7 8 9	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses. 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 (Michie et al., 2014). The review was concluded with how effective SBSPIs in LMICs enhanced the capability, opportunity and motivation of pupils to avoid smoking initiation. Key findings were summarised in tables to facilitate validity checking and comparison across studies.
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. 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 (Atkins et al., 2017): 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 sub-grouped using Griffin and Botvin (2010) 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. (2003), and Castro et al. (2010) classifications. A designed checklist was used to identify the presence or absence of each of the 17 theoretical domains, the nine intervention functions, and the smoking prevention curriculum as well as the two dimensions, the three approaches, the six strategies, and the three 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 summarize key findings and facilitate c
2 3 4 5	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). A narrative synthesis of the findings (Popay et al., 2006) 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 meta-analysis. It is For peer review only - http://bmiopen.bmi.com/site/about/guidelines.xhtml recommended to calculate effect size in systematic reviews to facilitate comparing the effectiveness of intervention when

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Location where item is reported

Page 5 and 6

Page 6

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3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9			different statistical test and parameters were used across studies (Nakagawa and Cuthill, 2007, Fritz et al., 2012, Borenstein et al., 2009, Chinn, 2000). Therefore, Revman software (version 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.	
10 11 12 13 14 15 16		13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results. 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. As described above no statistical analysis was done but 25% of the synthesised data were double-checked by another researcher and discussed within a team of 5 researcher	
17 18 19 20 21 22 23 24	Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). The Cochrane risk of bias tool (Higgins and Green, 2008) was used 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. A visual inspection of a funnel plot was used to assess publication bias risk.	
25 26 27 28 29 30	Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. All data were extracted by the researcher then a randomly selected sample (25%) of the included articles was checked independently by another postgraduate researcher. Any disagreements were resolved by consensus or recourse to the supervisors. Time and resources limitation of this study as well as the university restriction of shared work in PhD thesis restricted fully double screening of the included articles.	
31	RESULTS			
32 33 34 35 36 37 38	Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. 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 included in this review (Figure 2); representing 39,455 never-smoked pupils aged 11 to 15 years. Females represented at least 45% of the sample in all trials, except in one (Seal, 2006)they were 11%. See figure 2 at the end of this documents for the Prisma diagram	Page 7 and 8
39 40 41 42		16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. Three interventions were excluded because the full text was only available in Portuguese, Chinese or Spanish languages. Another excluded trial (Al-sheyab et al., 2016) met all the inclusion criteria except one, as pupils were only followed for four months after intervention completion	Page 6
43 44 45 46 47	Study characteristics	17	Cite each included study and present its characteristics. 11-clustered RCTs met the ខាន្តាទារកែទ្ធានាំងការដាក់ដោះ ស្រាមចាត់ អានាក់ទោះ ទោះទៅទៅនៅទទេសាខាន់ summarses the characteristics of these trials.	Page 6

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3 4 5	Section and Topic	ltem #	Checklist item								Location where item is reported
6 7 8 9 10 11 12 13 14 15 16 17 18			The included trials w Romania, Thailand, In two-intervention arn included at least one received the same bu prevention were disc trials indicated abser Perry et al., 2009) als initiation but one (Pe 2016) also involved s activities inside schoo implemented activiti	ere conducte ndonesia and ns and one ir control grou ut delayed in cussed only in nce of smokin to reported a erry et al., 20 moking cess ols. Four arm es outside so	ed in the follow d Mexico. Each acluded three- up who receive tervention after four trials(Re apprevention absence of anti 09) and four tr ation and other is (Lotrean et a chools. Booster	ving LMICs: thre a trial comprised intervention arm ed a regular scho er intervention c eddy et al., 2002l contents or activ i-smoking school rials (Marsiglia e er substances-us al., 2013, Reddy r-sessions were	e in China, two one interventions, so the revier of curriculum. completion. Co b, Tahlil et al., vities in school policy. All tria t al., 2015, Sea e respectively. et al., 2002b, M delivered in for	b each in India, a ion arm except t w included 15 in In one trial(Pern intents of schoo 2015, Wen et al curriculum, of t ils focused prima I, 2006, Reddy e All intervention Wen et al., 2010 ur trials only.	and South three trials nterventio ry et al., 20 l curriculu ., 2010, Pe hese two arily on pr et al., 2002 is focused , Perry et a	Africa, and one each in s as two compromised on arms. All trials 209) the control group m in relation to smoking erry et al., 2009). These trials(Wen et al., 2010, eventing smoking 2b, Motamedi et al., on face-to-face al., 2009) also	
20 21 22 23 24 25 26 27 28 29 30 31 32	Risk of bias in studies	18	Present assessments of Attrition and selection the included studies (Higgins and Green, 2 effective trials (Table schools purposively b selection and detection Although blinding is of reporting of smoking <b>Table 1 Summary of</b> Study ID	f risk of bias for on were ident as half of the 2008) and no 2008) and	or each included tified as the m e included trial trial has low e effective trial ng cooperative ost trials due t thaviour chang ols was the onl ias in the inclu Allocation Concealment	a study. ost relevant sou s included high of risk of bias in all (Motamedi et a before starting to insufficient ev ge intervention, f y method used f aded studies Blinding of outcome	rces of bias. Ri risk of bias in a these criteria. I., 2016) has h the interventi idence of blinc findings might for assessing in Incomplete Outcome	sk of bias was a t least one of th Ineffective trial igh risk of bias c on. The assessm ling participants have been influ- nterventions' ou Selective Outcome	ppraised a e five Coc s has high aused by s nent canno , deliverer enced by t tcomes. Ratio of high risk	is considerable across hrane risk of bias criteria er risk of bias ratio than selecting intervention ot identify low risk of rs or outcome-assessors. these biases, as self-	Page 11
33 34 35				Generation (selection bias)	(selection bias)	assessment (detection bias)	Reporting (attrition bias)	Reporting (reporting bias)	of bias <sup>2</sup>		
36 37 38			Perry, 2009, India Motamedi, 2016, South-Africa	Н	H	U	L	U	2/5		
39 40			Lotrean,2013, Romania	L	U	U	L	L	0/5		
41 42 43			Tahlil, 2002, India Tahlil, 2015, Indonesia	U	L	U	U	L	0/5		
44 45			Resnicow, 2010, South-Africa,	F <mark></mark> Br peer	review Unly - h	ttp://bmjopen.bn	nj.com/ <mark>s</mark> ite/abo	ut/guidelines.xht	1/5 ml		

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3 4 5	Section an Topic	d Ite #	m Checklis	st item								Location where item is reported
6			Chou, 2	2006, China	L	U	U	Н	L	1/5		
7			Seal 20	06, Thailand	L	L	U	U	L	0/5		
8   9			Wen 20	010, China	L	н	Н	Н	L	3/5		
10 11			Marsig Mexico	lia, 2015, )	н	U	U	U	L	1/5		
12			Chen, 2	2014, China	L	U	U	Н	L	1/5		
13 14			H=hig	gh risk of bia	s, <mark>U</mark> = ur	clear risk of	bias, $L = low$	risk of bi	as			
15 16 17 18	Results of individual studies       19       For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.									cision		
22 23 24 25 26							The primary	outcome				Statistical
22		The	study ID	The result diffe							difference	
29 30 31	(1 <sup>st</sup> author, year, country)		thor, year, untry)	The inc	dicator/ the st	atistical test repo	orted in the article	The inf group	ervention (95% Cl)	The control (95% Cl)	P value of the difference after the intervention	after intervention
32		erry 200	9 India	Coefficient reg	ression of any		Baseline	3.42 (2	1.95-4.89)	1.38 (09 – 2.85)	0.04	Significant
33	ſ	eny, 200	<i>3</i> , mua	coefficient reg	ression of any	tobacco use	Linear rate of change	s - 0.59 (	1.63-0.45)	0.94 (-0.10-1.98)		
34	N S	1otamedi outh-Afri	i, 2016, ca	OR of initiating the intervention	; cigarette smo on	king in intervention	on versus control after		0.0	64*	0.02	Significant
36	L R	otrean, 2 omania	013,	The OR of smo regression mod	king initiation i del)	in control versus i	ntervention ( Logistic		2.23 (1.2	29 - 3.85)	<0.01	Significant
38			School	Ever-use of tob	oacco (mixed-e	ffect regression	Baseline	0.42 (0	.30 - 0.54)	0.39 (0.25-0.061)	0.001	Significant
39	R	eddy,	intervention	model, F-test)			After the interventio	n 0.57 (0	).42-0.77)	0.94 (0.73-0.12)		
40	2	002,	School plus	The rate of our	ar-use of tobac	co (mixed offoct	Baseline	0.34 (0	).22-0.53)	0.39 (0.25-0.06)	0.001	Significant
41	li li	ndia	family	regression mod	del, F-test)		After the interventio	n 0.34 ((	).26-0.50)	0.94 (0.73-0.12)	1	

# <sup>44</sup> <sup>2</sup>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. <sup>45</sup> bias. <sup>46</sup>

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3 4 5	Section Topic	and	ltem #	Checklis	st item				Loc whe is re	ation ere item eported		
6 7 8			Isl ba int	amic- ised tervention	The mean score of life time smoking behaviour rate after the intervention $\pm$ SD (1= never to 9 smoked > 100 cigarettes)	1.2 ± 0.07	$1.17 \pm 1.3$	0.16	Insignificant			
9 10 11		Tahlil, 2015, Indone	He ba es int	ealth- ised tervention	The mean score of life time smoking behaviour rate after the intervention ± SD (1=never to 9 smoked >00 cigarettes)	2.1 ± 2.2	1.17 ± 1.3	0.84	Insignificant			
12 13 14 15		ia	Cc he Isl int	ombined ealth & amic tervention	The mean score of life time smoking behaviour rate after the intervention ± SD (1=never to 9 smoked >100 cigarettes)	$1.4 \pm 1.0$	1.17 ± 1.3	0.10	Insignificant			
16 17 18 19 20 21 22	*Statistic	al detail	s were i	not provided	I in the article							
23 24	Results of synthese	of es	20a	For each	synthesis, briefly summarise the characteristics and risk of bias amo	ng contributing studi	es.					
25       1. Cultural appropriateness       Page 13         27       Most (10/15) intervention arms were based on effective interventions originally developed in high-income countries. In three       Page 13												
Most (10/15) intervention arms were based on effective interventions originally developed in high-income countries. In three (Perry et al., 2009, Chou et al., 2006, Marsiglia et al., 2015) 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 in adolescents smoking preventions and community members who have an understanding of what is feasible and acceptable. However, only three arms collected quantitative data on feasibility and acceptability of the contents before implementation.												
36 37				Table 3	summarises approaches, dimensions and strategies used for c	ultural appropriat	eness of each inte	ervention arms.				
<ul> <li>38</li> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> </ul>	Table 3	3 Sum	mary	of cultu	ral appropriateness of the included interventions							
44 45		The stu	dy ID	T	he effectiveness of the intervention in http://bmjopen.bmj.com	/site/about/gu <b>œlati</b>	mai.appropriatenes	S				
46 47	46											



3 4 5	Section and Topic	ltem #	Checl	klist item																		Loc whe is r	ation ere ite eporte	m ed
6 7	(1 <sup>st</sup> author, ye	ear, cour	ntry)	smoking preventi	on	c In	D	imensi	on	A	Approa	ch			stra	tegy			9	Stage			How	
, 8 9 10 11 12 13 14						tervention untry of origin	Surface	Deep	Unclear	Bottom-Up	Top-Down	Both	Linguistic	Peripheral	Evidential	Constituent-involving	Sociocultural	Cultural tailoring	Design	Implementation	Evaluation	Informally	qualitative data	Surveys
15	Perry, 2009, In	ndia		Effective		USA		X				Х	Х	X	Х	Х	Х	Х	Х	X			Х	
16 17	Motamedi, 201 Africa	16, Sout	h-	Effective		USA		x				x	х	x	x	х	x	х	х	x	x		х	х
18	Lotrean, 2013,	Romar	nia	Effective.		Netherland		X				Х	Х	Х	Х	Х	Х		Х			Х	Х	
19	School interventionEffective USANXXX															Х	Х							
20     Reddy, 2002, India     School& family intervention     Effective     Party from USA     X <th< td=""><td></td><td>Х</td><td>х</td></th<>																Х	х							
23				Islamic based intervention	Ineffective		Х					Х	Х			Х	х		Х				Х	
24	Tahlil 2015 In	donesia	1	Health-based intervention	Ineffective	Indonesia	Х					Х	Х			Х	х		Х				Х	
25 26 27		uonesia		Combined health and Islamic based intervention	Ineffective	muonesiu	х					x	х			х	х		х				Х	
27	Resnicow, 2010	0 South	-	Harm management	Ineffective	Australia		X				X	Х	Х		Х	Х		Х				Х	
29	Africa,			life skills intervention	Ineffective	USA		Х				X	X	X		Х	Х		Х				Х	
30 21	Chou, 2006, Ch	nina		Ineffective		USA	Х				X		X	X		Х			Х			Х		
32	Seal, 2006, Th	ailand		Ineffective		USA	Х				Х		Х	Х		Х			Х			Х		
33	Wen, 2010, Ch	ina		Ineffective		China			Х			Х	Х			Х	Х		Х				Х	
34	Marsiglia, 2015	5, Mexic	0	Ineffective		USA	Х					Х	Х	Х		Х			Х				Х	
35 36	Chen, 2014, Ch	nina		Ineffective		China			Х		Х		Х			Х			Х				Х	
37	NB: Presence o	of a Cult	ural app	propriateness dimension, app	roach, strateg	y, method and	l time	in ar	inte	rvent	ion ar	m is i	ndica	ted w	ith aı	n X.								
38 39 40 41			The d	<b>Theoretical constru</b> lesign of all effective interv ls were available on how. <b>T</b>	<b>cts</b> entions, exce C <b>able 4</b> map	ept one (Redo s the presence	dy et ce an	al., 2 d abs	002b	o), wa e of ti	as info he 17	orme ' TDF	ed by theo	at lea retica	ast o al do	ne th mair	neory ns.	but i	nsuff	icient	t	Pag 14	e 12 a	ind
42 43 44 45 46 47	Table 4 Sun	nmary	of the	e theoretical domains of For pee	the include	ed studies - http://bmjop	pen.b	mj.cc	om/sit	te/ab	out/g	uide	ines.>	html							1			

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# PRISMA 2020 Checklist

Secti Topic	on and	ltem #	Checl	klist item																	Loc whe is re	ation ere iter eporte
				Ko,	5																	
(1	The stu <sup>st</sup> author, ye	udy ID ear, cour	ntry)	The effectiveness of the inte smoking preventio	ervention in on	Knowledge on Consequences	e Normative education	Social competence	Skills Social influence	Combined	Memory, attention & decision process	Behavioural regulation	Environmental context & resources	Social influences	Beliefs about Consequences	Beliefs on capabilities	Optimism	Intentions	Identity / Social role	Personal-goals	Reinforcement s	Emotion management
1.	Perry, 200	09 <i>,</i> Indi	ia	Effective	Effective				Х		Х		X	Х	Х	Х		Х	Х		Х	
2.	Motamed South-Afr	li, 2016 <sup>.</sup> ica		Effective		х				x	х	x			x		x	x	x	х		x
3.	Lotrean, 2 Romania	2013,		Effective.		х			x		х			x	x	х		x	x		x	
				School intervention	Effective	Х			Х				Х	Х	Х			Х				
4.	4. Reddy, 2002, India		ia	School intervention plus family intervention	Effective	х			х				x	x	x			x				
				Islamic based intervention	Ineffective	Х	Х	Х							Х			Х				
5.	5. Tahlil, 2015,		Health-based intervention	Ineffective	Х	X			X				X	X			X				Х	
	Indonesia			Combined health & Islamic based intervention	Ineffective	х	х			х					х			х				х
6.	Resnicow	, 2010		Harm management Ineffective		Х		Х			Х				Х			X				
	South-Afr	ica,		life skills intervention	Ineffective	Х				Х	Х				Х			Х				Х
7.	Chou, 200	06, Chin	a	Ineffective			Х		Х		Х			Х	Х			Х	Х			
8.	Seal, 2006	5, Thail	land Ineffective					la pasi	-om (	X	X	inden in	X	-	Х			Х				Х

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9. Wen, 202	10, Chin	a		Ineffective	Х					Х	Х		X	Х	X		Х	Х	Х	Х	
10. Marsiglia Mexico	a, 2015,			Ineffective	х				x		Х				x	x	x				
11. Chen, 20	14, Chin	na		Ineffective	Х				Х				X	Х	Х		Х	Х			
	Tabl	Table	5 illustrat	Intervention functions es the interventions effect	tiveness in V Interver	relation	on to	the	invo ns ir	lved	inter	ventio	n fun	ctions					Pag 17	e 16 a	ind
		<u>c 5 5 </u>	ininary (																		
	(1	The stu 1 <sup>st</sup> autho coun	dy ID or, year, try)	The effectiveness of the smo	e intervention king preventi	in on	Persuasion	Incentives	Coercion	Training	Restriction	nvironmental estructuring	Modelling	Enablement							
	1.	Perry, 20	009, India	Effective		x	x	x		x	x	х	х	x							
	2.	Motame South-A	edi, 2016 frica	Effective		x	x			x											
	3.	Lotrean, Romania	2013, a	Effective		x	x	X		x			x								
	4.	Reddy, 2	2002, India	School intervention	Effective	X	X			Х	X										
				School intervention plus family intervention	Effective	x	x			х	x										
				Islamic based intervention	Ineffective	x				х											
	5.	Tahlil, 20 Indones	015, ia	Health-based intervention	Ineffective	x				х											
				Combined health & Islamic based intervention	Ineffective	x				x											
	6.	Resnicov	w, 2010,	Harm management	Ineffective	x				x				x							
		South-A	Irica	life skills intervention	Ineffective	X				Х											
	7.	Chou,20	06, China	Ineffective		x				x		х									
	8.	Seal, 200 Thailanc	06, I	Ineffective For peer review of	only - http://	x pojop	en br	nj.co	um/si	X te/ab	hout/g	yuidelir	nes xh	tml					 		

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Section and Topic	ltem #	Checklist item											Location where item is reported
	9.	Wen, 2010, China	Ineffective	х	х	х		х	х	х			
	10.	Marsiglia, 2015, Mexico	Ineffective	х	x			x					
	11.	Chen, 2014, China	Ineffective	х	x			Х	х	х			
	Pres	ence of a BCW	Intervention Function in an interventi	on a	ırm	is ir	dica	ated	with	an X	II		
	20b	Present results of confidence/credib	all statistical syntheses conducted. If meta-a ale interval) and measures of statistical hetero	inaly: gene	sis w eity. I	as d If cor	one, npar	prese ing g	ent fo roups	r each , descr	the s ibe tl	summary estimate and its precision (e.g. the direction of the effect.	
		Statistical synth	eses was not conducted.										
	20c	Present results of The effectivene intervention and arm also compa- assessed after a studies identifie Figure 1 shows against the sam handbook for sy funnel with the exaggerated int publication bias language of the published in lan included interve If there is no pu then most of th adolescents' sm	all investigations of possible causes of heter ass of each intervention arm was assesse d control arms, before and after the inter- ared the smoking behaviour of adolescer at least six-months of follow-up, which ra- ed the long-term impact of SBSPI, at leas the funnel plot of the included intervent ple size of this study, in which the study ystematic reviews of interventions (Higg presence of bias because of some small ervention effect estimates of these inter- bublication language. As explained in se- ague other than English and Arabic langu ention could be other reasons for the as- blication bias and the included interven- e dots are expected to be located in the noking behaviour positively.	oger d by erver nts a ange t aft cions size ins a er st rven ion, ectio ages ymm tions top	eity con ntior cros d fro er o whi is p nd C udie tion sele n 0, . Va etry s we left	amo npar s. / s int om s ne y ich c lotte Gree es wi s. Ac ective two riati / of t rre e of th	ng st ing t ing t All th erve ix-m ear o lemo ed o lemo ed o lemo ccoro c ccoro c stuc on in stuc on in the f ffect me fu	udy r he s he th ention nonth of co onstr n the 008, ower ding tcom diss n sar cunne cive i unne	esult moki ree t ns ar ns to mple ates hori Shus met to (S ne rej were nple el plo n pre l plot	s. ing bel rials th rms. Th three- eting in the ef izontal ter, 20 hodolo terne of porting exclue sizes a ot (Ster eventing as neg	navio nat ir ne ou year nterv fect axis 011), opgica et al. g, se ded ind h rne e ng ac gativ	our of adolescents in the ncluded more than one intervention utcome of all the included trials was rs. Half (6/12) of the included ventions, see Table 6. c estimate of each intervention s. According to the Cochrane , the funnel plot is asymmetrical al quality which produced l., 2011), suggested the presence of elective analysis reporting or the in this review because the study heterogeneity in the intensity of the et al., 2011). dolescents from smoking initiation, ve effect size is what influence	Page 6 and 20
	20d	Present results of	all sensitivity analyses conducted to assess	the r	obus	tnes	s of t	the sy	/nthe	sized re	esults	ls.	Page 6
	the included interventions. Separating the included studies into subgroups that used similar definitions, measurements and ways of reporting outcomes would have resulted in a very small sample size in each group that might not make significant changes in the findings on effectiveness. Therefore, quantitative synthesis, including meta-analysis and meta-regression, was considered inappropriate in this review and a narrative synthesis of the findings was used. However, the effect size of the interventions was calculated, using the guidance by Borenstein et al. (2009) and Chinn. (2000), in order to outline the effect of												

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3 4 Section and 5 Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9		SBSPIs in preventing smoking initiation as this is recommended to facilitate comparing the effectiveness of intervention when different statistical test and parameters were used across studies included in systematic reviews (Nakagawa and Cuthill, 2007, Fritz et al., 2012). The effect estimates of the include interventions was presented in a funnel plot, see, Figure 1,	
9       Reporting         10       Reporting         11       biases         12       13         13       14         15       16         17       18         19       20         21       22         23       24         25       26         27       28         29       30         31       22	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. Figure 1, demonstrates the effect estimate of each of the included intervention against the sample size of this study. The Revman software version 5.1, which was provided for free by the Cochrane for systematic reviews of interventions (Higgins and Green, 2008, Shuster, 2011), was used to calculate the effect size and draw the funnel plot, in consultation with a professional statistician. Figure 1 The effect size of the included interventions in a funnel plot 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4	Page 6 and supplement 1
32 33 Certainty of	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
34 evidence		Explained above	
35 DISCUSSION			
36       Discussion         37       38         39       40         41       42         43       44         45       46	23a	Provide a general interpretation of the results in the context of other evidence. • Cultural-appropriateness The importance of cultural-appropriateness to ensure the transferability of the effectiveness of interventions and integration into the new system or context and the need for guidance to achieve that has been emphasised in the literature (Evans et al., 2019). Generally, most of the high-quality evidence on SBSPI is based on few high-income countries. For example, the last Cochrane systematic review of School-based programmes for preventing smoking included only eight RCTs implemented in LMICs (Thomas et al., 2013). This review identified only 12 RCTs aimed at preventing adolescents from smoking initiation through their schools in LMICS and evidence the eligibility criteria. Abio Gride 1986 of the tight arths were based on SBSPI originally	

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		developed in high-income countries. Accordingly, intervention developers in LMICs, face challenges in balancing the dynamic tension between keeping the fidelity of effective interventions that were imported from another context and cultural-appropriateness of these interventions to the targeted context. This tension could result in either surface cultural-appropriateness or major changes of the effective ingredients of the imported interventions and both may decrease interventions' effectiveness (Castro et al., 2010, Castro et al., 2004, Colby et al., 2013).	
		The deep cultural-appropriateness was considered in 80% of the included effective arms, see Table 3. In contrast, all ineffective interventions, except one, involved either unclear or surface adaptation of contents and activities to the targeted adolescents' culture, although these interventions were based on either literature review of SBSPIs evidence (Tahlil et al., 2015, Wen et al., 2010, Chen et al., 2014) or SBSPIs that showed effectiveness in developed high-income countries (Resnicow et al., 2008, Chou et al., 2006, Seal, 2006, Marsiglia et al., 2015). Targeting adolescents from the same ethnicity but live in different countries using similar SBSPIs without deep cultural-appropriateness does not lead to the same desired outcome, as in the intervention by Marsiglia et al. (2015).	
		Cultural-tailoring is commonly ignored in cultural-adaptation although it enhances the effectiveness of behaviour change interventions (Kreuter et al., 2003). In this review, cultural-tailoring strategy was only used in effective arms. Cultural-tailoring of behaviour change interventions aims to include contents that address shared cultural issues regarding the targeted behaviour with a consideration of cultural-differences between individuals in these issues in order to succeed in changing the behaviour of large proportions of the targeted population (Gould et al., 2017, Kreuter et al., 2003, Kreuter et al., 1999). While the translation of contents is the most obvious form of intervention adaptation, cultural-tailoring is the most challenging form of adaptation (Castro et al., 2010, Castro et al., 2004, Colby et al., 2013). The effectiveness of SBSPIs in LMICs is enhanced by paying attention to cultural-tailoring of contents to ensure addressing individual variance among target groups in term of their beliefs and interests in the included contents and delivery methods, as demonstrated in SBSPIs by Wegner et al. (2008), Caldwell et al. (2010) and Perry et al. (2009). In contrast, paying less attention to individual variance within the target population minimizes interventions' effectiveness even if extensive activities were done to adapt the intervention to the local context through the other five strategies for ensuring cultural- appropriateness, as was the case of Tahlil et al. (2015), Resnicow et al. (2010). The designers of the last two SBSPIs acknowledged that more consideration of the heterogeneity in predictors of smoking (such as ethnicity, knowledge and beliefs) among the targeted adolescents were needed for achieving better outcomes.	
		The theoretical constructs	
		Underpinning behaviour change interventions with theory followed by evaluating the intervention allow testing the appropriateness of this theory in addressing the targeted behaviour which in turn could enable further utilization and adaptation of the theory and the intervention in future (Rothman, 2004). Despite that, articles on behaviour changes interventions do not often refer to theories in designing, adopting, implementing or evaluating interventions, as many reviews identified (Davies et al., 2010, Painter et al., 2008). In this review, only seven of the included SBSPIs in LMICs indicated theory employment at any stage of the intervention but all the effective interventions, exceptione (Reddy et al., 2002a), referred to at	

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Section and Item Topic #	Checklist item	Location where item is reported
	least one theory that informed designing the intervention.	
	In this review, using TDF to identify the theoretical constructs on the included SBSPIs in LMICs helped in overcoming the dilemma of lack and poor reporting of theories-underpinning in the included studies. The involved theoretical domains were mapped against the COM-B model by Michie et al. (2014) to identify what theoretical domains were used by effective SBSPIs to enhance pupils' capability, opportunity and motivation to avoid smoking initiation in LMICs.	
	Intervention functions	
	This is the first review to use the BCW to map the interventions used to prevent smoking prevention in general. So we are not aware of any review or smoking prevention interventions to compare the findings with it.	
23b	Discuss any limitations of the evidence included in the review.	Page 21
	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 limited publications resulting from limited experience and inaccessibility to international databases or language barriers. Other systematic reviews (Nishio et al., 2018, Thomas et al., 2013, Caan et al., 2015, Brown et al., 2014, Hale et al., 2014, MacArthur et al., 2016, Langford et al., 2015)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 recognized barriers (Brown et al., 2014, Kreuter et al., 2016, Tahili et al., 2015). Although self-reporting is a valid and stable indicator for identifying smoking status in many contexts (Wills and Cleary, 1997, Bauman and Koch, 1983), its sensitivity and specificity vary per age, gender, and culture (Dolcini et al., 1996). Adolescents, especially girls, might under-report their smoking where smoking is culturally unacceptable (Valladolid-Lopez et al., 2015, Dietz et al., 2015, Patrick et al., 1994); or over-report that where smokers are considered mature and impressive (Ng et al., 2006, Mermelstein et al., 2002, Al-sheyab et al., 2016, Arora et al., 2011, Dolcini et al., 1996). 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 (Mermelstein et al., 2016, Peirson et al., 2016, Thomas et al., 2013, Reddy et al., 2002b, Wen et al., 2010). 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 (Hoffmann et al., 2014). Poor reporting of f	

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Section and Topic	ltem #	Checklist item
		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.
	23c	Discuss any limitations of the review processes used.
2		The review was limited to articles that were published in English or Arabic, therefore, three trials were excluded because the findings is unavailable in English or Arabic.
3	23d	Discuss implications of the results for practice, policy, and future research.
5		This review highlighted the following gaps in the available evidence regarding factors that influence the effectiveness of SBSPIs in LMICs, which should be filled by further studies:
7 3 9		More high-quality and long-term RCTs are required for a better understanding of what strategies, intervention functions and theoretical constructs enhance effectiveness on SBSPI in the context of LMICs. More attention should be paid to measures that reduce selection and detection bias.
)   2 3		Researchers and designers of SBSPI should use standardized methods for defining, measuring, assessing and reporting changes in adolescents' smoking status before and after the interventions. This would allow quantitative synthesis of the findings on the effectiveness of SBSPIs in LMICs and facilitate comparisons across these interventions. The definitions and methods of the GYTS are recommended to be used in this regard because they are designed to allow global and regional comparison of adolescents'
+ 5		smoking.
5		For accurate assessment of interventions' effectiveness, it is recommended to measure biochemical markers, at least among a
7		random sample of participants when resources are limited, to cross-validate the result of self-reporting of smoking
3 9 ) 		(Mermelstein et al., 2002). This is to avoid over-reporting or under-reporting of participants' smoking status. Misreporting of adolescents' smoking is influenced by their gender and culture (Valladolid-Lopez et al., 2015, Dietz et al., 2015, Patrick et al., 1994) and their attitude toward smoking (Ng et al., 2006, Mermelstein et al., 2002, Al-sheyab et al., 2016, Arora et al., 2011, Dolcini et al., 1996).
2 3 4		More research is required on how cultural-appropriateness influences the effectiveness of SBSPIs in LMICs. A meta-analysis of more homogenous RCTs could be conducted to explore the effectiveness of each cultural-appropriateness dimension, strategy
5		and approach.
5		The review identified that SBSPIs in LMICs are inadequately theoretically-underpinned; no intervention tested or refined any theory or used theory in tailoring interventions or selecting participants. More evidence is required on the theoretical-
3 9 )		underpinning of SBSPIs in LMICs and how theories may influence the effectiveness of these interventions. This is to allow proper design and replication of effective SBSPIs in similar contexts, as recommended by the MRC guidance on complex- interventions (Craig et al. 2008)
		Financial-incentives for non-smokers or punishments of smokers were not used in any of the included SBSPIs. However, it is
2		worth exploring the feasibility, acceptability and effectiveness of using punishments and financial-incentives in SBSPIs to
i		prevent adolescents from smoking initiation in the context of LMICs. It is also important to analyse the dose-response
5	1	For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

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Location where item is reported

The summary is in page 21.



<ul> <li>relationships or cost-effectiveness of using incentives in SBSPIs in different contexts along with exploring what alternative incentives could be used in SBSPIs in LMICs where resources are limited.</li> <li>The effectiveness of discussing the positive consequences of non-smoking behaviour on the length and quality of peoples' life, social relationships, income and environment alongside the negative consequences of smoking in preventing adolescents from smoking initiation needs more investigation in LMICs.</li> <li>Normative-education was used only in four arms, all were ineffective, to correct pupils' overestimation of smoking rates among peers. More RCTs are needed to identify the need for, as well as evaluating the impact of, using normative-education in SBSPIs to prevent smoking initiation by adolescents in LMICs.</li> <li>More information should be gathered on barriers, required resources and cost of developing and implementing SBSPIs in LMICs and thus accelerating the global control of the smoking epidemic.</li> <li>None of the included intervention used the internet, smartphones and social media although adolescents, utilization of these methods is increasing globally (Park and Calamaro, 2013, Savci and Aysan, 2017). Accordingly, it might be worth exploring the applicability, faesibility, acceptability and effectiveness of SBSPIs (number, frequency and length of sessions). However, this requires a systematic-review and meta-analysis of the global evidence on SBSPIs in SUCs. Some of SBSPIs in LMICs. However, another systematic review that included in this review because of its focus on the effectiveness of SBSPIs in LMICs. However, another systematic review that includes qualitative studies could help in exploring feasibility, acceptability, escurptability escurptability.</li> <li>Gualitative studies were not included in this review because of its focus on the effectiveness of SBSPIs in LMICs. However, another systematic review that includes qualitative studies could help</li></ul>	Section and Topic	ltem #	Checklist item	Location where item is reported
imported from another context, how, why and by whom these changes were made. Detailed information should be also provided about the contents, activities and delivery methods, quality of implementing the included interventions, what worked and did not work, why and how. The provision of these details would facilitate replicating the effective interventions and learning from mistakes in ineffective interventions. Publishing more details on interventions' contents For peer review only http://bmjopen.bmj.com/site/about/guidelines.xhtml			relationships or cost-effectiveness of using incentives in SBSPIs in different contexts along with exploring what alternative incentives could be used in SBSPIs in LMICs where resources are limited. The effectiveness of discussing the positive consequences of non-smoking behaviour on the length and quality of peoples' life, social relationships, income and environment alongside the negative consequences of smoking in preventing adolescents from smoking initiation needs more investigation in LMICs. Normative-education was used only in four arms, all were ineffective, to correct pupils' overestimation of smoking rates among peers. More RCTs are needed to identify the need for, as well as evaluating the impact of, using normative-education in SBSPIs to prevent smoking initiation by adolescents in LMICs. More information should be gathered on barriers, required resources and cost of developing and implementing SBSPIs in LMICs and thus accelerating the global control of the smoking epidemic. None of the included intervention used the internet, smartphones and social media although adolescents, utilization of these methods is increasing globally (Park and Calamaro, 2013, Savci and Aysan, 2017). Accordingly, it might be worth exploring the applicability, feasibility, acceptability and effectiveness of these methods in SBSPIs in LMICs. Some of these issues are explored in study-3 in the Egyptian context. Furthermore, standardization of key aspects of SBSPIs such as key intervention functions and delivery methods could enable reliable research on intensity and duration of SBSPIs (number, frequency and length of sessions). However, this requires a systematic-review and meta-analysis of the global evidence on SBSPIs in order to identify the effective intervention functions and theoretical constructs that could be used to prevent adolescents' smoking through schools. Qualitative studies were not included in this review because of its focus on the effectiveness of SBSPIs in LMICs: Better reporting of attrition rates, runnin	

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Section and Topic	ltem #	Checklist item	Location where item is reported
		and delivery methods or at least storing these details in a publicly accessible database would allow proper data extraction on the behaviour change techniques used in SBSPIs.	
OTHER INFOR	MATIO	N	
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered. The protocol of this review was reviewed internally at the University of Leeds as it was part of the Ph.D. by the first author but the protocol was not published in any journal.	
		The PROSPERO registration of this review was started by the first author in 2016. The review was given PROSPERO registration number was (82267). However, recently we found that this number doesn't exist on the PROSPERO website. When we explored the reason, the PROSPERO team explained that the process of registration was not completed. The first author did not realize that the process needed another step of confirmation to be completed, so the given number is invalid. The PROSPERO team indicated that they can't restore the number as the process was incomplete at the time and they can't register the review after it is completed. Therefore, there is no PROSPERO registration number to be added.	
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	
		The protocol could be accessed through the author.	
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
		The original proposal aimed to focus on both LMICS and Arabic countries. This paper provides explanation of the part that is focused on LMICs only	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
		There was no financial support for this review as it was part of the PhD of the 1st author.	
Competing	26	Declare any competing interests of review authors.	
interests		There is no any competing interests of review authors to be declared.	
Availability of data, code	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	
and other materials		The followings are available upon request from the corresponding author:	
		- template data collection forms;	
		- data extracted from included studies;	
		- data used for all analyses	

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#### Table 6 characteristics of included studies

			5					Re		c	ompone	ents		Tar	gets	s	etting	gs	The	e delive	rer			Pro
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the intervent prevention	ion in smoking	tervention duration	Number of sessions	Frequency of contact	Booster-sessions	Follow-up period	sponse rate at final- evaluation	The attrition rate in the intervention arm compared with control	Smoking prevention	Smoking cessation	Preventing substance use	pupils	teachers	Parents / relatives / community	Inside schools		Dutside schools	Teachers	peers	Outsider specialists	<b>Fraining deliverers</b>	Fidelity checked	cess-evaluation done
Perry, 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	х	х		х	х	х	x	; ,	x	х	х		Y	Y	Y
Motamedi, 2016, South- Africa	Effective		Not stated	12	One / year	6	3 years	90%	10% in both arms	х	х	х	х			x			х			NC	Y	Y
Lotrean, 2013, Romania	Effective.		2 months	5 weekly	Weekly	NC	9 months	90.2	11% compared with 9.8% in control	х	х		х		х	x	; ,	x	х	х		Y	NC	Y
	School intervention	Not stated								Х		Х	Х			X								
Reddy, 2002, India	School plus family intervention	Effective	Not stated	20	Not stated	NC	1 year	88.3%	Not stated	х		Х	х		х	X		х	×	х		Y	Ý	Y
	Islamic based intervention	8 weeks								х			х			X								
Tahlil, 2015, Indonesia	Health-based intervention Ineffective		Ineffective 8 weeks	8	One/ Week	NC	6 months	89.5%	Not stated	х			х			x			x		х	Y	NC	NC
	Combined health & Islamic intervention	Ineffective				5				х			х			х								
Development 2040 Courth Africa	Harm management	Not stated	Netster					0201	41.2% compared with 14.2% in control	х			х			x			v					
Resnicow, 2010 South-Africa,	life skills intervention	Ineffective	Not stated	8 per year	One / year	NC	2 years	93%	34.2% compared to cohort 15.3%	х			x			x			×			Y	Y	Y
Chou, 2006, China	Ineffective	-	13 weeks	13	Once /Week	NC	1 year	97% at baseline	12.5% compared with 7% in control	х			х			x			х		х	Y	NC	NC
Seal, 2006, Thailand	Ineffective		Not stated	10	Not stated	0	6 months	100%	Not stated	Х		Х	Х			X			NC	NC	NC	NC	NC	NC
Wen, 2010, China	Ineffective		Not stated	Not stated	Not stated	2	6 months	90%	7.95% compared with 32.55% in control	х			х	х	х	x	; ; ;	x	х	х	х	Y	NC	Y
Marsiglia, 2015, Mexico	Ineffective	10 weeks	20	Two /week	NC	8 months	86%	Not stated	Х		Х				X		ĺ	Х			Y	NC	NC	
Chen, 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	х			х	х		x			х	х		Y	Y	NC

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WILLS, T. A. & CLEARY, S. D. 1997. The validity of self-reports of smoking: analyses by race/ethnicity in a school sample of urban adolescents. *American journal of public health*, 87, 56-61.

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# **BMJ Open**

#### A Systematic Review of intervention functions, theoretical constructs, and cultural adaptations of School-Based Smoking Prevention Interventions in Low and Middle-Income Countries

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# A Systematic Review of intervention functions, theoretical constructs, and cultural adaptations of School-Based Smoking Prevention Interventions in Low and Middle-Income Countries

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#### Abstract

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

**Data sources:** MEDLINE, EMBASE, Global Health, CINAHL, PsycINFO, ERIC, Cochrane CENTRAL, Web of Science, Popline, CENTRAL, SCOPUS, dissertations, and grey literature were searched through August 2022 with no date limitations.

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

**Data extraction and synthesis:** Interventions data were coded according to the Theoretical Domains Framework , intervention functions of the Behaviour Change Wheel and cultural appropriateness features. Using narrative synthesis we identified which of cultural adaptation features, theoretical constructs, and intervention functions were associated with effectiveness. The findings were mapped against the capability-motivation and opportunity model to conclude the result. Risk of bias is assessed with Cochrane Risk of Bias tool.

**Results:** We identified 11 RCTs (n=7,712 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 characterized 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:** We concluded that deep cultural adaptation, through incorporating cultural, environmental, psychological, and social factors that influence smoking in the targeted population into the proposed intervention, was considered more in effective interventions. Effective interventions considered improving pupil's psychological capability to remain never-smokers and reducing their social and physical opportunities and reflective and automatic motivations to smoke. Future trials should use standardized measurements of smoking to allow meta-analysis in future reviews.

#### Funding: Self-funded

**Keywords:** smoking, prevention, school-based intervention, RCTs, LMICs, Systematic review, TDF, BCW, COM-B

#### Strengths and limitations of this study

- This systematic review was based on a comprehensive search of randomized control trials 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 provide the best protection against bias.
- The review used smoking outcomes from 7,712 baseline never-smokers and provide 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 LMICs, or limited publications on that 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.

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#### Introduction

Tobacco use is a global epidemic as 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 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 consequence is a global concern, and over half a trillion US Dollars are spent annually on tobacco control measures [5].

Smokers in 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 RCTs and reviewed in some systematic reviews to identify factors influencing the effectiveness [10-22]. However, only three reviews were focused on LMICs, one is limited to African countries and included non RCTs [23], one explored smoking cessation only [24], and one was not a systematic review [25]. 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) [26] to specify intervention functions. 2) The Theoretical Domain Framework (TDF) [27] was adapted using the classification of smoking prevention curriculum [28] 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, Lukwago [29] and Castro, Barrera Jr [30] 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 as 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 the used approaches and strategies for ensuring cultural appropriateness, intervention functions, and theoretical constructs of the effective and ineffective school-based smoking prevention interventions that were implemented in low and middle income countries.

#### 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 Specialized Register, Trials Register of Promoting Health Interventions
(TROPHI). The search was conducted from inception to Augsut 2022 using terms relating to school-based
smoking prevention interventions, See supplement 1, with no date restrictions. Articles were filtered
later for 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 [31] was used.

We searched all RCTs evaluating school-based smoking prevention interventions in LMICs. Trials were included, if interventions targetted 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. There was no restriction on targeting smoking alone or among other risky behaviour and, what the control group received, providing if they aimed at preventing smoking initiation. The main outcome is remaining never-smoker pupils. 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 [32] met all the inclusion criteria except one, as pupils were only followed for four months after intervention completion.

One researcher (MB) independently screened all titles, abstracts, and full-text articles for inclusion and exclusion criteria. Two other researchers (AA and HA) independently screened a random sample (25%) of all titles and abstracts of the included and excluded studies, 90% agreement rate was achieved. Any disagreement was resolved through collective discussion, consensus, or referral to other researchers (HE, JN, BB).

#### Data extraction and management

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

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 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 [27]: 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 sub-grouped using Griffin and Botvin [28] 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, Lukwago [29], and Castro, Barrera Jr [30] classifications.

A designed checklist was used to identify the presence or absence of each of the 17 theoretical domains, the nine intervention functions, and the smoking prevention curriculum as well as the two dimensions, the three approaches, the six strategies, and the three 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 summarize 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 [33] was used, independently by 2 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 [34] 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 meta-analysis. It is recommended to calculate effect size in systematic reviews to facilitate comparing the effectiveness of intervention when different statistical test and parameters were used across studies [35-38]. Therefore, Revman software (version 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 Supplement 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 [26]. The review was concluded with 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 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 included in this review (**Error! Reference source not found.**); representing 39,455 never-smoked pupils aged 11 to 15 years, Table 1 summarizes participants' characteristics. Females represented at least 45% of the sample in all trials, except in one [39]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 one intervention arm except three trials as two compromised two-intervention arms and one included three-intervention arms, so 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[40] 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 [40-43]. These trials indicated absence of smoking prevention contents or activities in school curriculum, of these two trials[40, 43] also reported absence of anti-smoking school policy. All trials focused primarily on preventing smoking initiation but one [40] and four trials [39, 41, 44, 45] also involved smoking cessation and other substances-use respectively. All interventions focused on face-to-face activities inside schools. Four arms [40, 41, 43, 46] 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 six-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 interventions arms were effective, compared with cotrols, 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 [47]. However, those who smoked a puff or two were considered never-smokers in one study[45]. Changes in never-smoking rates in the past one[44] or two[39]months before the survey were used in assessing the outcome of two trials. Two trials[39, 41] 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[39, 40, 48]. Whereas others [41-43, 45, 49, 50]calculated odd-ratio 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.

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#### Table 1Baseline characteristics of participants

smoking prevention	on	Number	Age	Sex (females %)	Ethnicity	(public %)	Family income
Effective		12484	11.9	48.4	Not stated	Not stated	Not stated
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
Effective.		1071	13-15	51	Not stated	Not stated	Not stated
chool intervention	Effective						
chool intervention plus amily intervention	Effective	5752	11.9	49.5	Not stated	40%	Not stated
slamic based intervention	Ineffective						
lealth-based intervention	Ineffective	477	11-14	58 5	Not stated	Not stated	Not stated
ombined health and slamic based intervention	Ineffective			50.5	Not stated	Not stated	Notstated
larm management	Ineffective	5266	14		Black 59.7%, Coloured	100	Not stated but findings
fe skills intervention	Ineffective	5200	14	49.5	26.4%, White 9.9%	100	were adjusted forincome
Ineffective		2661	12.5	47.7	Not stated	Not stated	Not stated
Ineffective		170	15.5	11	Not stated	Not stated	Not stated
Ineffective		2343	13.4	45.9	Not stated	50%	Not stated
Ineffective		431	13	55	Mexican	100%	Not stated
Ineffective		1807	14.5 ± 1.1	49.6	Linzhi Tibetan and Guangzhou Han	Not stated	Not stated
	Effective Effective Effective ihool intervention ihool intervention plus mily intervention lamic based intervention ealth-based intervention ombined health and lamic based intervention arm management is skills intervention Ineffective Ineffective Ineffective Ineffective	Effective         Effective         Effective.         :hool intervention       Effective         :hool intervention plus mily intervention       Effective         lamic based intervention       Ineffective         calth-based intervention       Ineffective         ombined health and lamic based intervention       Ineffective         arm management       Ineffective         Ineffective       Ineffective	Effective12484Effective5610Effective.1071:hool interventionEffective:hool intervention plus mily interventionEffectiveamic based interventionIneffectiveamic based interventionIneffectiveamm managementIneffectiveineffective2661Ineffective170Ineffective170Ineffective431Ineffective1807	Effective1248411.9Effective561011-12Effective.107113-15:hool interventionEffective:hool intervention plus mily interventionEffective:hool interventionIneffective:hool interventionIneffective:hoeffective170:hoeffective13.4:hoeffective1807:hoeffective1.1	InterfectiveInterfective (fermines $\gamma_0$ )Effective1248411.948.4Effective561011-1251Effective.107113-1551hool interventionEffective575211.949.5Image and the equation of the e	Effective1248411.948.4Not statedEffective561011-1251Black 9.5%, White 4.0%, Mixed race (combination race of Asian, European, and African descent) 85.8%Effective.107113-1551Not statedthool interventionEffective thool intervention null intervention575211.949.5Not statedamic based interventionIneffective ombined health and lamic based interventionIneffective ineffective47711-1458.5Not statedarm managementIneffective ineffective52661449.5Black 59.7%, Coloured 26.4%, White 9.9%Ineffective17015.511Not statedIneffective234313.445.9Not statedIneffective4311355MexicanIneffective180714.5 ± 1.149.6Linzhi Tibetan and Guangzhou Han	Effective1248411.948.4Not statedNot statedEffective $5610$ $11.12$ $511$ $Black 9.5\%$ , White 4.0%, Mixed race (combination race of Asian, European, and African descent) 85.8%Not statedEffective. $1071$ $13-15$ $51$ Not statedNot statedhool interventionEffective thool intervention $5752$ $11.9$ $49.5$ Not stated $40\%$ lamic based interventionIneffective ombined health and lamic based interventionIneffective Ineffective $477$ $11.14$ $58.5$ Not statedNot statedIneffective $2661$ $12.5$ $47.7$ Not statedNot statedNot statedIneffective $2661$ $12.5$ $47.7$ Not statedNot statedIneffective $170$ $15.5$ $11$ Not statedNot statedIneffective $1807$ $14.5 \pm$ $49.6$ $Uinzhi Tibetan andGuangzhou HanNot stated$

#### Table 2 characteristics of included studies

			5					20		C	ompone	ents		Targ	ets	set	tings	Th	e delive	erer			Pro
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the interventi prevention	on in smoking	itervention duration	Number of sessions	Frequency of contact	Booster-sessions	Follow-up period	sponse rate at final- evaluation	The attrition rate in the intervention arm compared with control	Smoking prevention	Smoking cessation	Preventing substance use	pupils	teachers	Parents / relatives / community	Inside schools	Outside schools	Teachers	peers	Outsider specialists	Training deliverers	Fidelity checked	
Perry, 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	х		x	х	х	x	х	х	x		Y	Y	Y
Motamedi, 2016, South- Africa	Effective		Not stated	12	One / year	6	3 years	90%	10% in both arms	х	х	х	х			х		х			NC	Y	Y
Lotrean, 2013, Romania	Effective.		2 months	5 weekly	Weekly	NC	9 months	90.2	11% compared with 9.8% in control	х	х		х		х	х	х	х	x		Y	NC	Y
Reddy, 2002. India	School intervention	Effective	Not stated	20	Not stated	NC	1 vear	88.3%	Not stated	Х		Х	х	ĺ		Х		х	x		Y	Y	γ
	School plus family intervention	Effective	1							Х		Х	х		Х	Х	Х						
	Islamic based intervention	Ineffective				20				Х			х			Х							Γ
Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	8 weeks	8	One/ Week	NC	6 months	89.5%	Not stated	Х			х			Х		х		x	Y	NC	N
	Combined health & Islamic intervention	Ineffective						9		х			х			х							
Respicow 2010 South-Africa	Harm management	Effective	Not stated	8 per vear	One / year	NC	2 years	93%	41.2% compared with 14.2% in control	х			х			х		x			v	Y	V V
	life skills intervention	Ineffective			, ,		_ ,ca.c	9	34.2% compared to cohort 15.3%	x			х			х							
Chou, 2006, China	Ineffective		13 weeks	13	Once /Week	NC	1 year	97% at baseline	12.5% compared with 7% in control	х			х			х		х		х	Y	NC	NC
Seal, 2006, Thailand	Ineffective		Not stated	10	Not stated	0	6 months	100%	Not stated	Х		Х	х			Х		NC	NC	NC	NC	NC	NC
Wen, 2010, China	Ineffective		Not stated	Not stated	Not stated	2	6 months	90%	7.95% compared with 32.55% in control	x			х	х	х	х	х	х	x	x	Y	NC	Y
Marsiglia, 2015, Mexico	Ineffective		10 weeks	20	Two /week	NC	8 months	86%	Not stated	Х		х				Х		х			Y	NC	NC
Chen, 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			х	х		х		х	x		Y	Y	NC

- 50 51 52 53 54 55 56 57 58 59 60

#### **Risk of bias**

Attrition and selection were identified as the most relevant 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 [33] and no trial has low risk of bias in all these criteria. Ineffective trials has higher risk of bias ratio than effective trials (Table 3). Only one effective trial [45] has high risk of bias caused by selecting intervention schools purposively based on being cooperative before starting the intervention. The assessment cannot 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.

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 <sup>1</sup>
Perry, 2009, India	L	U	U	L	L	0/5
Motamedi, 2016, South-Africa	н	н	U	L	U	2/5
Lotrean,2013, Romania	L	U	U	L	L	0/5
Reddy, 2002, India	L	U	U	U	L	0/5
Tahlil, 2015, Indonesia	U	L	U	U	L	0/5
Resnicow, 2010, South-Africa,	U	U	U	Н	L	1/5
Chou, 2006, China	L	U	U	Н	L	1/5
Seal 2006, Thailand	L	L	U	U	L	0/5
Wen 2010, China	L	н	Н	Н	L	3/5
Marsiglia, 2015, Mexico	Н	U	U	U	L	1/5
Chen, 2014, China	L	U	U	Н	L	1/5
H = high risk of bias,	U = unclea	r risk of bias,	L = low risk o	of bias		

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

<sup>&</sup>lt;sup>1</sup>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.

#### **Cultural appropriateness**

Most (10/15) intervention arms were based on effective interventions originally developed in highincome 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 [40, 44, 49] 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 who understand what is 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 third (10/15) of interventions considered using cultural 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 during designing nine arms (socio-cultural 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, demonstrated cultural tailoring which is defined as using all the above cultural appropriateness strategies.

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 [30, 51]. Mearures for deep cultural adaptation were most recognised in the effective interventions. Whereas all the ineffective interventions, except one [48], involved either unclear or surface cultural adaptation of the imported interventions. This was 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) weak consideration of local socio-cultural 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 [45, 52], both were effective.

#### **Theoretical constructs**

The design of all effective interventions, except one [41], was informed by at least one theory but insufficient details were available on how. **Error! Reference source not found.** 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 [42, 48] as social consequences were added. Only effective interventions explained consequences of secondary smoking. Interventions that combined explaining the health, environmental, social and emotional consequences of smoking were effective[40, 45]. 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: selfawareness, 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 [45] **(Skills domain).** 

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### Table 4 Summary of cultural appropriateness of the included interventions

									Cult	tural a	ppro	priat	eness	5							
			of	D	imensi	on	A	pproac	:h			stra	tegy				Stage			How	
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the int smoking preventi	ervention in on	tervention country origin	Surface	Deep	Unclear	Bottom-Up	Top-Down	Both	Linguistic	Peripheral	Evidential	Constituent-involving	Sociocultural	Cultural tailoring	Design	Implementation	Evaluation	Informally	qualitative data	Surveys
Perry, 2009, India	Effective		USA		Х				Х	Х	Х	Х	Х	Х	Х	Х	Х			Х	
Motamedi, 2016, South- Africa	Effective		USA		x				х	х	х	x	х	х	x	х	x	x		х	x
Lotrean, 2013, Romania	Effective.		Netherland		Х				Х	Х	Х	Х	Х	Х		Х			Х	Х	
	School intervention	Effective	Partly from			Х			Х	Х	Х		Х			Х	X			Х	Х
Reddy, 2002, India	School& family intervention	Effective	USA			х			х	х	х		х			х	x			х	x
	Islamic based intervention	Ineffective		Х					Х	Х			Х	Х		Х				Х	
Tahlil. 2015. Indonesia	Health-based intervention	Ineffective	Indonesia	Х		Z			Х	Х			Х	Х		Х				Х	
(unini) 2013) indonesia	Combined health and Islamic based intervention	Ineffective	muonesiu	х			4		x	х			х	х		х				Х	
Resnicow, 2010 South-	Harm management	Ineffective	Australia		Х				X	Х	Х		Х	Х		Х				Х	
Africa,	life skills intervention	Ineffective	USA		Х				Χ <	X	X		Х	Х		Х				Х	
Chou, 2006, China	Ineffective		USA	Х				Х		X <	Х		Х			Х			Х		
Seal, 2006, Thailand	Ineffective		USA	Х				Х		Х	Х		Х			Х			Х		
Wen, 2010, China	Ineffective		China			Х			Х	Х			Х	Х		Х				Х	
Marsiglia, 2015, Mexico	Ineffective		USA	Х					Х	Х	Х		Х			Х				Х	
Chen, 2014, China	Ineffective		China			Х		X		Х			Х			Х				Х	

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

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#### Table 5 Summary of the theoretical domains of the included studies

				Knowl	edge		Skills		Me dec	Beł	Env	Soc	Beli Cor	Beli	Opt	Inte	Ide	Per	Rei	Em
	The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the inte smoking preventio	rvention in n	Knowledge on consequences	Normative education	Social competence	Social influence	Combined	mory, attention & ision process	navioural regulation	vironmental context & ources	ial influences	iefs about ısequences	iefs on capabilities	timism	entions	ntity / Social role	sonal-goals	nforcement s	otion management
1.	Perry, 2009, India	Effective		Х			Х		Х		Х	Х	Х	Х		Х	Х		Х	
2.	Motamedi, 2016 South-Africa	Effective		Х				Х	Х	Х			Х		Х	Х	Х	Х		Х
3.	Lotrean, 2013, Romania	Effective.		Х			Х		Х			Х	Х	Х		Х	Х		Х	
		School intervention	Effective	Х			Х				Х	Х	Х			Х				
4.	Reddy, 2002, India	School intervention plus family intervention	Effective	х			х				х	х	х			х				
		Islamic based intervention	Ineffective	Х	Х	X							Х			Х				
5	Tablil 2015 Indonesia	Health-based intervention	Ineffective	Х	Х			Х				Х	Х			Х				Х
5.	runn, 2013, maonesia	Combined health & Islamic based intervention	Ineffective	х	х			x	う				х			х				х
e	Posnicow 2010 South Africa	Harm management	Ineffective	Х		Х			x 🗸				Х			Х				
0.	Resilicow, 2010 South-Allica,	life skills intervention	Ineffective	Х				Х	Х 🗕				Х			Х				Х
7.	Chou, 2006, China	Ineffective		Х	Х		Х		Х			Х	Х			Х	Х			
8.	Seal, 2006, Thailand	Ineffective		Х				Х	Х		Х		Х			Х				Х
9.	Wen, 2010, China	Ineffective		Х				Х	Х		Х	Х	Х			Х	Х		Х	Х
10.	Marsiglia, 2015, Mexico	Ineffective		Х			Х		Х				Х	Х		Х				
11.	Chen, 2014, China	Ineffective		Х			Х				Х	Х	Х			Х	Х			

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2	Nine intervention arms used role-plays, group discussion, and activities or videos in raising
5	awareness of smoking consequences to make the contents attractable and memorable after
4	the intervention (Memory and attention domain). Only affective interventions [45, 46]
5	the intervention (ivernory and attention domain). Only enective interventions [43, 40]
7	combined these methods with encouraging pupils to discuss their views on advantages and
8	disadvantages of smoking before deciding to smoke or not (Decision process domain).
9	Six arms aimed to increase barriers and minimize facilitators of smaking in numils' environment
10	Six arms armed to increase barriers and minimize racinitators of smoking in pupils environment
11	(Environmental-context and resources domain). All these arms involved enhancing
12	accessibility to information on smoking consequences inside schools. While pupils' exposure to
13	this information was high only in the effective interventions, this exposure was either low [50]
14	or not evaluated [39, 43] in the ineffective arms. Additionally five arms included policy that
15	prevent nunils teachers parents and visitors from smoking inside schools. In the effective
16	prevent pupils, teachers, parents and visitors nom smoking inside schools. In the enective
17	arms, improving information accessibility and anti-smoking policy went beyond schools to
18	include home [41] or the wider community [40]. This included motivating the community to
19	advocate for national anti-smoking policy [40] or banning tobacco promotion [41].
20	
21	Activities to reduce social influencers of adolescents' smoking (social influence domain) were
22	considered in all the effective interventions, except one [45]. Only effective interventions used
23	peer-pressure to create positive attitude toward non-smoking, or introduced pupils (alone or
24	with teachers or parents) who never smoked as role-models by announcing their names in
25	school's newsletter. These role-models contributed in supporting other pupils to avoid
20	smoking: informally discussed their beliefs about smoking barms and shared their experience
27	of maintaining nano smoking behaviour and refusing smoking offers by friends. The
20	
30	intervention [43] that aimed to change influencers of smoking at home through parents?
31	education on smoking harms without using pupils as role-models or peer-pressure were
32	ineffective even when parents signed contracts not-to-smoke at home. Some ineffective arms
33	aimed to change social norms only through explaining the social refusal of smoking by
34	adolescents or obtaining written commitments from teachers or parents or verbal public
35	commitments from pupils in front of their classmates not-to-smoke.
36	
37	All arms considered correcting pupils' beliefs about smoking consequences, at least on health.
38	Although pupils' beliefs that smoking is harmful have improved after interventions in seven
39	arms only five arms [40, 41, 46, 53] showed translating these beliefs into action by avoiding
40	smoking All arms [40, 45] that involved correcting beliefs about the emotional addictive
41	shoking. All arms [40, 45] that involved correcting beliefs about the emotional, addictive,
42	environmental and social consequences of smoking in addition to harms on health were
с <del>г</del> ЛЛ	effective.
44	Besides increasing awareness and beliefs that smoking is harmful, three arms aimed to
46	besides increasing awareness and beliefs that smoking is narmau, three arms aimed to
47	enhance pupils' beliefs about their capability to avoid smoking. The effective arms [46, 53]
48	enhanced participants' self-confidence in their ability to avoid smoking and supporting their
49	relatives and peers to avoid or quit smoking, trained them on that, and allowed them to
50	practice the acquired skills in role-plays and in the existence of professionals. One effective
51	arm [40] established school-based support groups for the trained participants even after the
52	intervention completion. The ineffective arm [44] trained nunils using filmed real-life
53	sconarios to refuse smaking offers after evaluining smaking harms and encouraged there to
54	scenarios, to reruse smoking oriers after explaining smoking narms and encouraged them to
55	leave smokers when they smoke. However, authors acknowledged that condensing these
56	activities over short period due to time and resources constraints may have contributed to its
57	ineffectiveness.
58	
59	
00	

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 five effective arms[40, 41, 46, 53]. One effective [45] and three ineffective [39, 44, 48] interventions didn't 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 [43, 49, 50], 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 or voluntary. The effective arms [40, 41, 45, 46] 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 [45] was effective. Only this effective arm allowed participants to practice the acquired skills and burnout 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 encouraged pupils to set proximal and distal goals for themselves, then educated them on how smoking hinders achieving their goals and how better 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 practise 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 [40, 46] rewarded pupils (as well as teachers and parents in one arm)[40] 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 [43] rewarded winners of schools' competition for the best anti-smoking presentations and essays, without puplishing 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 [43], showing pictures of smoking-related illnesses [50], or discussing reasons for refusing smoking offers only from pupils' perspective [44].

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 study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the ir smoking preven	ntervention in tion	Education	Persuasion	Incentives	Coercion	Training	Restriction	Environmental restructuring	Modelling	Enablement
1.	Perry, 2009, India	Effective		Х	Х	Х		Х	Х	Х	Х	Х
2.	Motamedi, 2016 South-Africa	Effective		х	x			х				
3.	Lotrean, 2013, Romania	Effective		x	x	Х		х			х	
4.	Reddy, 2002, India	School intervention	Effective	Х	x			х	х			
		School intervention plus family intervention	Effective	x	x			х	х			
		Islamic based intervention	Ineffective	Х				Х				
5.	Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	X				Х				
	maonesia	Combined health & Islamic based intervention	Ineffective	x				х				
6.	Resnicow, 2010,	Harm management	Ineffective	X				Х				Х
	South-Africa	life skills intervention	Ineffective	х				Х				
7.	Chou,2006, China	Ineffective		Х				х		Х		
8.	Seal, 2006, Thailand	Ineffective		x				Х				
9.	Wen, 2010, China	Ineffective		Х	х	Х		Х	Х	Х		
10.	Marsiglia, 2015, Mexico	Ineffective		x	x			х				
11.	Chen, 2014, China	Ineffective		х	х			Х	Х	Х		

#### Table 6 Summary of the Presence of BCW Intervention Functions in included studies

Presence of a BCW Intervention Function in an intervention arm is indicated with an X

The included interventions showed limited use of the *restrictive function* but 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 antismoking policy went beyond school boundaries to the wider environment through disseminating the national anti-smoking policy and enhance its implementation by community members [40], or advocate banning tobacco advertisements through pupils-signed petition directed to the government [41]. The two ineffective arms [50, 54] established smoking control committee aiming to support antismoking 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 [40] declared teachers and parents plus pupils who never smoked as role-models. The effective interventions used peer-educators, who never smoked, to: chair, stimulate, summarize 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[50] or deliver [43] 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 [40, 53]. The effective arm [40, 53] encouraged social norm against smoking through establishing smoke-free initiatives run by 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 [43] or producing school-posters discouraging smoking [49, 50]. Two ineffective arms [43, 50] established school smoking-related committee but the role of this committee was unexplained. One ineffective intervention [49] reported doing additional efforts to prevent pupils' exposure to smoking at home without explaining how.

Only two arms, one [40] was effective, considered the *enablement intervention function*, through improving pupils' capability (beyond training and education) and opportunity to remain never-smokers. The effective arm [40] offered smoking prevention, quitting, and counselling services at schools for smoker and non-smoker parents, teachers, and pupils. Whereas in the ineffective arm [55] 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 [45] or combined with either restriction [41] or modelling function only [46] or with all other functions except the coercion function [40].

# Enhancing capability, motivation, and opportunities to avoid initiating smoking

The effective interventions enhanced Pupils' **psychological capability** to maintain non-smoking behaviour through the followings: 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 recognize, analyse and react to direct and indirect pressures to smoke from peers, family, advertisements and adults. 6) Building pupils' confidence 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 minimized in the effective interventions through 1) Establishing and enforcing anti-smoking policies that prohibit smoking inside schools by teachers, parents, and visitors before pupils. 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. 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. 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 recognized 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 7,712 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 limited publications resulting from limited experience and inaccessibility to international databases or language barriers. Other systematic reviews [14, 23, 56-60]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 recognized barriers [42, 57, 61].

Although self-reporting is a valid and stable indicator for identifying smoking status in many contexts [62, 63], its sensitivity and specificity vary per age, gender, and culture [64]. Adolescents, especially girls, might under-report their smoking where smoking is culturally unacceptable [65-67]; or over-report that where smokers are considered mature and

 impressive [32, 64, 68-70]. 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 [69] but is challenged by the constrained resources available in LMICs, as other studies have identified [14, 17, 41, 43, 71, 72].

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 [73]. 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 evaluation could have minimized bias in interpreting the effectiveness of these complex-interventions and explaining why the effectiveness varies across contexts [73, 74].

Other limitations of the review are that three trials were excluded because the findings is 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' utilization of these modern methods [75, 76]. Researchers should explore the feasibility, acceptability, and effectiveness of using these modern methods in school-based interventions in LMICs.

Using standardized 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. Standardizing 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 improving adolescents' psychological capability to remain never-smokers and reducing their social and physical opportunities and reflective and automatic motivations to smoke were considered in the effective interventions more than the ineffective trials. In the effective interventions, this is achieved through raising awareness of various consequences of smoking using engaging methods and accessible information sources. Improving refusal skills of smoking offers, through demonstration, practise, and feedback on performance. Advising pupils on how to recognize, analyse and react to direct and indirect pressure to smoke. Enhancing pupils' self-confidence and ability to make a conscious decision to remain neversmokers, make that a personal goal, and obtain social support for that. Restricting smoking inside schools. Repeatedly presenting smokers in negative images. Social rewarding of neversmokers and using them as role-models. Peers' education and pressure against smoking. Encouraging pupils to consider parents' disapproval of smoking. Facilitating useful free time usage and negative emotions control. It was 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.

#### **Contributorship statement**

MB, HE, and BB conceived the review. MB, AA, and HA completed screening and extraction of data. MB, HE, BB, and RH devised the analysis plan and AA and HA provided support for analyses. MB 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 is the guarantor of the paper.

#### **Competing interests: None.**

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#### Data sharing statement

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) upon reasonable request.

#### Ethics Approval Statement

There was no ethical approval required for this study as it did not include primary data collection.

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#	Key words	No of hits	The PICO
#1	exp "tobacco use"/ or exp smoking/ or Nicotine/		
#2	(Tobacco OR smok* OR cigar* OR Shisha OR water pipe OR		
	Argeela OR nicotine).tw.		
#3	#1 OR #2		Tobacco use/ smoking
#4	(Health* adj2 (promot* OR educat* OR improvement)).tw		
#5	(prevent* OR Control OR program* OR interven* OR		
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	Campaign* OR communicat* OR marketing OR advertis* OR		
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#6	(educat* OR promot* OR teach* OR advise* OR counsel* OR		
	encourage* OR train* OR behavio#ur change* OR		
	campaign).tw		
#7	(anti smok* OR smok* free ) OR (freedom adj3 smoking)		
#8	((Cessation OR reduc* OR abst?in* OR stop* OR quit* OR		
	anti OR free* OR discourag* OR prevent*) adj3 (cigar* OR		
	smok*)).tw		
#9	Psychotherapy, Group/ OR Counseling/		
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#17	#15 OR #16		School-based
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			adolescents/Adolescents
#19	randomized controlled trial.pt. OR controlled clinical trial.pt.		A
	OR randomized.ab. OR placebo.ab. OR drug therapy.fs. OR		5
	randomly.ab. OR trial.ab. OR groups.ab.		
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#21	Meta-analysis OR Systematic review		
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#23	#18 and #22	1,840	RCT studies on School-based
			prevention / Tobacco
			/Adolescents
#24	limit to humans	1,241	

#### Supplement 1: The full electronic search strategy employed in Medline database, as an example.



#### Supplement 2: The effect size of the included interventions in a funnel plot



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Section and Topic	ltem #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1 and 4
		The title and the aim clearly state that this is a systematic review	
ABSTRACT	1		
Abstract	2	See the PRISMA 2020 for the Abstracts checklist.	page 2
2		Yes the PRISMA 2020 for Abstracts checklist was followed to structure the abstract	
INTRODUCTIO	ON		
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 4
		Tobacco use is a global epidemic as its rate, estimated to be 22% among adults, continues to increase annually (WHO, 2014a, WHO, 2019). Smoking is one of the major risk factors for Non-Communicable Diseases (NCD) that cause 70% of global deaths (WHO, 2018). 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 (WHO, 2015). These harms are preventable therefore, preventing smoking and its consequence is a global concern, and over half a trillion US Dollars are spent annually on tobacco control measures (WHO, 2008). Smokers in LMICs represent 80% of the smokers worldwide (WHO, 2015). Three-quarters of the global NCD deaths happen in LMICs, mainly (82%) before the age of 70 years (WHO, 2014b, WHO, 2019). The global data indicates poor implementation of effective preventive measures in LMICs compared with high-income countries (WHO, 2019). Tobacco products are affordable and accessible in many LMICs where tobacco taxation and restriction of tobacco promotion and advertisement are poorly implemented (WHO, 2015, WHO, 2013a, WHO, 2013b). Over the past four decades, school-based interventions have been used to prevent adolescents from smoking initiation in many countries(Thomas et al., 2017, de Kleijn et al., 2015, Thomas et al., 2013, Thomas and Perera, 2006, Thomas, 2002, Georgie et al., 2016, Schreuders et al., 2017, de Kleijn et al., 2015, Thomas et al., 2013, Thomas and Perera, 2006, Thomas, 2002, Georgie et al., 2016, Isensee and Hanewinkel, 2012, Wiehe et al., 2005, Bauld et al., 2009b, Buhler, 2016, Shackleton et al., 2018) or smoking cessation (Kumar et al., 2021), or not systematic review (Huriah and Lestari, 2020). 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	
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 4, The
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# PRISMA 2020 Checklist

Section and In Topic #	ltem #	Checklist item	Location where item is reported
		<ul> <li>This systematic review aims to identify the used approaches and strategies for ensuring cultural appropriateness, intervention functions, and theoretical constructs of the effective and ineffective school-based smoking prevention interventions that were implemented in low and middle income countries.</li> <li>The objectives are: <ol> <li>To determine the <i>effectiveness</i> of school-based interventions in preventing adolescents' smoking in LMICs;</li> <li>to explore the <i>cultural appropriateness</i> of school-based smoking prevention interventions that are implemented in LMICs;</li> <li>to determine the <i>theoretical constructs, intervention functions, and smoking prevention curriculum</i> that has been used in LMICs to prevent adolescents' smoking through schools;</li> <li>to identify the association between the effectiveness of SBSPIs in LMICs and the involved: approach and strategies for ensuring cultural ensuring ens</li></ol></li></ul>	paragraph of the introduction section.
METHODS		ensuring curtural appropriateness, intervention functions, smoking prevention curriculum, and theoretical constructs.	
Eligibility criteria	5	<ul> <li>Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.</li> <li>Eligibility Criteria The following criteria were used for considering studies for this review: Types of Studies <ul> <li>Inclusion criteria</li> <li>RCTs as they are strong sources of evidence on effectiveness (Bowling, 2014);</li> <li>Baseline smoking was measured before starting the intervention;</li> <li>The Intervention was implemented in in a country classified as a low or middle (lower-middle, or upper-middle) income country at the time of implementing the intervention; according to the World Bank (WB) classification of countries by income (WB, 2017). LMICs were considered because the income and the development level of a country determine the available resources at school and capacity of schools to design and implement school-based interventions within the available resources and thus affect the effectiveness of SBSPIs (Peirson et al., 2016) as well as other behaviour change interventions (Bamberger et al., 2019, Castro et al., 2010, Elliott and Mihalic, 2004). Some school-based interventions need specific resources to be implemented which might not be available in LMICs, the review focused on LMICs in order to identify the evidence related to LMICS. Some systematic reviews of school-based behaviour change intervention recommended conducting systematic reviews that focus on developing countries or LMICs as many effective strategies might not be feasible, accessible and affordable in LMICs (Shackleton et al., 2016b, Nishio et al., 2018, Thomas et al., 2013) where resources limitations are important barriers there (Bauld et al., 2009a). For example: using interventions based on the internet, computer or mobile phone might not be applicable for poor countries, like Egypt, where electricity and internet are not accessible at most schools, totally or partially (CAPMS, 2017)</li> </ul> </li> </ul>	The 1 <sup>st</sup> and 2 <sup>nd</sup> paragraphs on page 5

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# PRISMA 2020 Checklist

Section and Topic	ltem #	Checklist item	Location where item is reported
		<b>NB:</b> The World Bank classification of countries by income is selected because it is not only an indication of the relative wealth of a country as it is also used as an indirect indication of the country development, as the significant change in the global economic landscape challenge using the old classification of developing countries (Fantom and Serajuddin, 2016).	
		<ul> <li>Exclusion criteria</li> <li>Full-text articles are not available in English or Arabic language (after contacting the author).</li> </ul>	
		Types of participants	
		<ul> <li>Inclusion criteria</li> <li>Pupils at adolescence age (10-17 years), according to WHO (2014c) definition of adolescence age, were targeted at any stage of the intervention. Adolescence age was considered because many articles only include the mean or median of age without specifying the range of age-targeted by the intervention; smoking initiation age varies across countries therefore different age groups were targeted by SBSPIs that aim to prevent smoking initiation; school enrolment age varies across countries. Although most SBSPIs in high-income countries target pupils at the age of 13-15 years (Thomas et al., 2013), this review was not limited to interventions that target pupils aged 13-15 years and SBSPIs that targeted pupils at all adolescence years were considered to avoid bias and missing important information related to preventing smoking initiation through schools.</li> <li>Exclusion criteria</li> <li>School-based Intervention that only targeted the smoking behaviour of teachers or parents.</li> </ul>	
		<ul> <li>Inclusion criteria</li> <li>School-based interventions or programs that aim to prevent smoking among pupils, regardless of:</li> <li>✓ The complexity of the intervention and if the intervention targets smoking alone or in addition to other tobacco-use or risky behaviour</li> <li>✓ Who delivered the intervention (teachers, peers, parents, researchers, health professionals, undergraduate or graduate students or others)</li> <li>✓ What the control groups received (no intervention, the standard or regular school education activities, different type of intervention, others). Studies with no control groups were not included.</li> <li>◆ Exclusion criteria</li> <li>Pregnancy-related intervention</li> <li>Clinical-based interventions</li> <li>Interventions that focus only on smoking cessation, passive smoking, alcohol or illicit drug</li> <li>If the intervention activities are based on colleges, university or nursery setting</li> <li>Intervention that only involves family-based or community-based activities even if pupils were recruited through activities are based or community-based activities even if pupils were recruited through</li> </ul>	
		schools. For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

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3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 22			<ul> <li>Types of outcome measures</li> <li>Inclusion criteria</li> <li>The primary outcome was the impact of the intervention on the smoking status of pupils who were never-smokers at baseline</li> <li>The smoking status was assessed using either self-reported smoking or any bio-medical validation test such as Saliva thiocyanate or cotinine or expired air carbon monoxide levels (Prokhorov et al., 1993, Patrick et al., 1994).</li> <li>The outcome was measured after a minimum follow-up of six months after completion of the intervention. The six month follow-up period was considered because 1) this is the minimum period recommended for assessing changes caused by complex health interventions (Higgins and Green, 2008); 2) it has been used in all Cochrane reviews of SBSPI (Thomas et al., 2013, Thomas and Perera, 2006, Thomas, 2002). 3) This period was used in nine of the 15 systematic reviews that were used to inform the search strategy of this review. Whereas different periods were used in six reviews as follow: three reviews considered six months follow-up period after starting the intervention (Peirson et al., 2016, Hale et al., 2014, Hefler et al., 2017) but none of them was a Cochrane review or provided justification for this selection; one review required at least one-year follow-up after the intervention ended (Wiehe et al., 2005) and two reviews considered studies with short follow-up period, at least six weeks after intervention completion (Georgie et al., 2016, Sussman et al., 2014).</li> <li>Exclusion criteria</li> <li>No smoking outcome data were reported for example: only reporting changes in awareness or intention to smoke;</li> <li>Data on pupils' smoking status before implementing the intervention was unavailable, after contacting the authors.</li> <li>No study was excluded based on the year of publication. Only three studies were excluded, one from Brazil, China and Mexico each, because the full-text was not available in English or Arabic. Another SBSPI trial (Al-sheyab et al., 2016) was excluded a</li></ul>	
<ul> <li>33</li> <li>34</li> <li>35</li> <li>36</li> <li>37</li> <li>38</li> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> </ul>	Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. The following databases were searched, using several search filters1: - Medline (Ovid) - Embase (Ovid) - PubMed (Ovid) - Global Health (Ovid) - PsycINFO (Ovid) - CINAHL(Ebsco)	The 1st paragraph in the search strategy and trial selection section pages 4 and 5

 $45_{46}^{-1}$  Indicated between brackets 

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Section and Topic	ltem #	Checklist item	Location where item is reported
		<ul> <li>Web of Science (Thomson),</li> <li>Popline (K4 Health)</li> <li>Cochrane Central Register of Controlled Trials –CENTRAL (Wiley)</li> <li>ERIC (Education Resources Information Centre)</li> <li>WHO Regional Databases</li> <li>PubMed central (PMC)</li> <li>Cochrane Database of Systematic Reviews</li> <li>ProQuest Middle East &amp; Africa Database</li> <li>SCOPUS</li> <li>CENTRAL (Cochrane Central Register of Controlled Trials)</li> <li>ICTRP International Clinical Trials Registry Platform (WHO) (International)</li> <li>Tobacco control 1992-</li> <li>Journals of Smoking-Related Disorders</li> <li>ICTRP International Clinical Trials Registry Platform (WHO) (International)</li> <li>DARE (Database of Abstracts of Reviews of Effects)</li> <li>Centre of review and dissemination</li> <li>TRIP database</li> <li>ASSIA (Applied Social Sciences Index And Abstracts)</li> <li>ProQuest dissertations and theses</li> <li>Electronic thesis and dissertation (SATD)</li> <li>Databases searches were supplemented by searching the following websites: <ul> <li>ASSIST (A Stop Smoking In School Trial) intervention model in UK</li> <li>Action on Smoking and Health (ASH)</li> <li>The National Institute for Health and Care Excellence (NICE) website</li> <li>Centre for Tobacco Control Research</li> <li>Cochrane Tobacco Addiction review Group</li> </ul> </li> </ul>	
		<ul> <li>Trials Register of Promoting Health Interventions (TROPHI)</li> <li>UK Public Health Association</li> <li>The European Smoking prevention Framework Approach (EESA)</li> </ul>	
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used. The search was conducted in January 2017 and then updated in November 2019, April 2021 and August 2022. All databases were searched as far back as they allowed. Supplement 1 summarises the key-terms and literature mapping concepts using PICO framework. Terms represented to commonly were searched as the searched as far back as they allowed were searched as far back as they allowed were searched as far back as they allowed. Supplement 1 summarises the key-terms and literature mapping concepts using PICO framework. Terms represented to commonly were searched as far back as the searched as far back as they allowed were searched as far back as they allowed were searched as far back as they allowed searched as far back as they allowed.	The section on search strategy and trial selection pages 4 and

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3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 9 10 11 12 13 14			stated in the published articles. Therefore, eligible articles were filtered later to identify if the intervention was implemented in a country with low or middle income. Supplement 1shows the full electronic search strategy employed in Medline database, as an example. Checking reference lists was used to identify more articles, as recommended by Gough et al (2017). Moreover, authors are contacted to obtain full-text, when unavailable in Arabic or English languages through the University of Leeds Library, or details of interventions, when unclearly explained in the published articles. Furthermore, individual Medline and Web of Science searches were run to track 60 authors who published articles on adolescents' smoking in LMICs, with no date restriction. Grey literature search was limited to understanding contexts where the interventions were implemented.	5.
15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. A stepwise approach was used to identify relevant articles; titles screening was used first to exclude duplicates and clearly irrelevant articles followed by abstracts screening. The eligibility checklist used to screen abstracts is attached in Supplement 1, if the answer to the included questions was yes or unclear, then the full-text was reviewed. The process of screening the identified studies and reasons for exclusion are illustrated in the PRISMA diagram, based on Moher et al (2009). The researcher independently screened all titles, abstracts and full-text for inclusion and exclusion criteria. Thereafter a random sample (10%) of all titles and abstracts of the included and excluded studies were independently screened by another postgraduate researcher. An agreement rate of 90% was achieved and any disagreement was resolved through discussion. Any study that the researcher was unsure about inclusion was collectively discussed with supervisors. Blinding procedures, of authors' name, institutions and journals, was not used in sampling studies for double screening. Studies that were identified through alternative ways, such as checking references list of included studies, were subject to the same inclusion and exclusion criteria and screening process as studies that emerged from database searches. All the record were kept in Endnote and spread sheets throughout the review.	Page 5 the last paragraph in the section of the section on the search strategy and trial selection
<ul> <li>31</li> <li>32</li> <li>33</li> <li>34</li> <li>35</li> <li>36</li> <li>37</li> <li>38</li> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> <li>45</li> </ul>	Data collection process	9	Data extraction was informed by the Cochrane strategy for data extraction (Higgins and Green, 2008). A data extraction form was adapted from the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement (Moher et al., 2010) and TIDieR (Template for Intervention Description and Replication) checklist (Hoffmann et al., 2014). This form was used to extract data from each intervention on the following: 1) study design, aim and objectives, number of arms in the trial, interventions contents, smoking prevention curriculum, intervention functions, theoretical-underpinning and constructs, and what the control group received (what). 2) Participants' number, age, sex and ethnicity, attrition and response rate (Who). 3) delivery methods, intervention deliverer and any training provided for them (how). 4) The year (when) and country of implementation, intervention setting (inside school only or also included activities outside school) and school types (where). 5) the intervention duration, number of sessions, frequency of contact, duration of follow-up after intervention completion and booster sessions (how much). 6) Risk of bias, country of interventions' origin and cultural- appropriateness of intervention, quality of implementation, fidelity and any reported facilitators, challenges or barriers (how well). 7) Justification for using SBSPI (why). 8) Smoking behaviour outcome data, definitions of the identified outcome and main conclusions.	Page 5 the 1st and 2nd paragraphs in the section on Data extraction and management.
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3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20			of SBSPI that could be effective in LMIC. The following theoretical perspectives were used in this study to review SBSPIs that were implemented in LMICs: 1) The middle layer of BCW (Michie et al., 2014) was used to specify intervention functions of the included SBSPIs. 2) The Theory coding scheme (Michie and Prestwich, 2010) was used to identify the theoretical-underpinning of the included studies. 3) Griffin and Botvin (2010) classification of smoking prevention curriculum was used to adapt the Theoretical Domain Framework (TDF) (Atkins et al., 2017) which was then used to explain the theoretical constructs of the included interventions. 4) The findings from the above steps were discussed using the inner layer of BCW, the capability, opportunity, motivation and behaviour (COM-B) model. 5) The cultural- appropriateness of the included interventions was assessed using Kreuter et al. (2003) and Castro et al. (2010) classifications of approaches, dimensions and strategies of cultural-appropriateness. Using these theoretical perspectives allowed identifying the approaches and dimensions of cultural-appropriateness, intervention functions, implementation methods, theoretical-constructs and smoking prevention curriculum that were commonly used in effective SBSPIs in LMICs to enhance pupils' capability, opportunity and motivation to avoid smoking initiation. This provided a full-range of potential options for SBSPIs that were used in low-middle-income settings and facilitated providing rationales for selecting among those options for SBSPI in the Egyptian context.	
21 22 23 24 25 26 27	Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. The effectiveness of each intervention arm was assessed by comparing the smoking behaviour of adolescents in the intervention and control arms, before and after the interventions. All the three trials that included more than one intervention arm also compared the smoking behaviour of adolescents across interventions arms. The outcome of all the included trials was assessed after at least six-months of follow-up	The 2 <sup>nd</sup> paragraph in page 5
28 29 30		10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. No assumption were made, we relied on the paper's content on the effectiveness of the interventions.	Page 5
<ul> <li>31</li> <li>32</li> <li>33</li> <li>34</li> <li>35</li> <li>36</li> <li>37</li> <li>38</li> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> <li>45</li> </ul>	Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. The Cochrane Collaboration's tool for assessing risk of bias in intervention studies (Higgins and Green, 2008) was used to assess whether the included studies have high, low or unclear risk of selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias such as an extreme baseline imbalance between the arms of each study. As recommended by Higgins and Thomas (2018), data were extracted on randomisation, blinding, allocation concealment, selective and incomplete outcome reporting and other bias concerns. Authors were contacted to verify any risk of bias information if not identified in the published articles. If the available data is insufficient to judge the risk of bias, then unclear risk of bias is selected. High risk of bias is selected when the available evidence indicates plausible bias that seriously weakens confidence in the findings. A guideline was used for coding the identified risk of bias; adapted from Glasziou et al. (2001), Higgins and Green (2008), Ryan R (2013) and Higgins and Thomas (2018). Scaling risk of bias was not used in this review, although it offers attractive simplicity, because it involves giving weight to different criteria in the scale padriteisielifficallyt-totypet/fibprofibprom/glite@bowedglite@bowedgliteisielifficallyt-totypet/fibprofibprom/glite@bowedgliteisielifficallyt-totypet/fibprofibprom/glite@bowedgliteisielifficallyt-totypet/fibprofibprofibprofibprom/glite@bowedgliteisielifficallyt-totypet/fibprofibpr	Page 6, the last paragraph in the Data extraction and management section.
44 45 46			Scaling risk of bias was not used in this review, although it offers attractive simplicity, because it involves giving weight to different criteria in the scale padriteisidifficullyt-tlotjps//lbynijbpendighitcassi/gite/dborea/gluichitenian/(thiggins and Green, 2008).	

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# PRISMA 2020 Checklist

3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9 10 11			Furthermore, scaling risk of bias showed unreliable assessments of validity and it is not supported by empirical evidence, therefore, it is discouraged in systematic reviews (Higgins and Thomas, 2018). The researcher independently assessed the risk of bias then another postgraduate researcher independently checked the risk of bias in a random sample (25%) of the included articles. Any disagreements (one case) were resolved by consensus or recourse to the supervisors	
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26	Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. The data extraction form included function checklists that were used in this review to identify the presence or absence of each of the nine intervention functions, the 17 theoretical-domains and the smoking prevention curriculum in each arm of the included SBSPI in LMICs. More than one function, theoretical-domain and curriculum were allowed to be selected for one intervention or activity. For example classroom discussion of the advantages and disadvantages of smoking was coded under the 'education' and 'persuasion' function. To explore cultural- appropriateness of the included SBSPIs, the checklist identified interventions country of origin plus approaches, dimensions and strategies used in adapting each intervention's arm to the culture of the targeted population. To explore the theoretical-underpinning of the included interventions, the checklist included the following five questions: 1) was a theory mentioned at any stage of the intervention; 2) were the relevant theoretical constructs measured; 5) was the theory used to select recipients or tailor interventions; 4) were the relevant theoretical constructs measured; 5) was the theory tested or refined in the interventions. Answers to these questions were coded as yes, no or unclear based on the available information in the included articles. Thereafter, all the named theories in the included interventions were listed.	Page 6, the 2 <sup>nd</sup> paragraph in the Data extraction and management section.
27 28 29 30 31 32 33 34 35 36 37 38	Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). 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.	Page 5 and 6 the Data extraction and management section
<ul> <li>39</li> <li>40</li> <li>41</li> <li>42</li> <li>43</li> <li>44</li> <li>45</li> </ul>		13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. Based on the recommendations by Michie et al. (2014) and Francis et al. (2012), the reviewers referred to the definitions and examples of each intervention function and theoretical-domain to ensure effective utilization of these frameworks in coding the intervention functions and theoretical-domains that were used in SBSPIs. Additionally, a discussion of these definitions and examples was organized before starting data-extraction intervention functions and	Page 5 and 6

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Section and Topic	ltem #	Checklist item
		domains and thus achieve bette

and	ltem #	Checklist item	Location where item is reported
		domains and thus achieve better inter-coder agreement on the extracted dataAuthors were contacted to get more information on their interventions and data was coded only based on the existing evidence on each of the identified criteria/elements.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses. 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 (Michie et al., 2014). The review was concluded with how effective SBSPIs in LMICs enhanced the capability, opportunity and motivation of pupils to avoid smoking initiation. Key findings were summarised in tables to facilitate validity checking and comparison across studies.	Page 5 and 6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. 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 (Atkins et al., 2017): 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 sub-grouped using Griffin and Botvin (2010) 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. (2003), and Castro et al. (2010) classifications. A designed checklist was used to identify the presence or absence of each of the 17 theoretical domains, the nine intervention functions, and the smoking prevention curriculum as well as the two dimensions, the three approaches, the six strategies, and the three 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 summarize key findings and facilitate c	Page 6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). A narrative synthesis of the findings (Popay et al., 2006) 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 meta-analysis. It is For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml recommended to calculate effect size in systematic reviews to facilitate comparing the effectiveness of intervention when	Page 6

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3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9			different statistical test and parameters were used across studies (Nakagawa and Cuthill, 2007, Fritz et al., 2012, Borenstein et al., 2009, Chinn, 2000). Therefore, Revman software (version 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.	
10 11 12 13 14 15 16		13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results. 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. As described above no statistical analysis was done but 25% of the synthesised data were double-checked by another researcher and discussed within a team of 5 researcher	
17 18 19 20 21 22 23 24	Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). The Cochrane risk of bias tool (Higgins and Green, 2008) was used 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. A visual inspection of a funnel plot was used to assess publication bias risk.	
25 26 27 28 29 30	Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. All data were extracted by the researcher then a randomly selected sample (25%) of the included articles was checked independently by another postgraduate researcher. Any disagreements were resolved by consensus or recourse to the supervisors. Time and resources limitation of this study as well as the university restriction of shared work in PhD thesis restricted fully double screening of the included articles.	
31	RESULTS			
32 33 34 35 36 37 38	Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. 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 included in this review (Figure 2); representing 39,455 never-smoked pupils aged 11 to 15 years. Females represented at least 45% of the sample in all trials, except in one (Seal, 2006)they were 11%. See figure 2 at the end of this documents for the Prisma diagram	Page 7 and 8
39 40 41 42		16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. Three interventions were excluded because the full text was only available in Portuguese, Chinese or Spanish languages. Another excluded trial (Al-sheyab et al., 2016) met all the inclusion criteria except one, as pupils were only followed for four months after intervention completion	Page 6
43 44 45 46 47	Study characteristics	17	Cite each included study and present its characteristics. 11-clustered RCTs met the ଆନୁମୋନ୍ନ (୧୩୫୬ and ୩୦୯୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦୦	Page 6

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5 4 5	Section and Topic	ltem #	Checklist item											
6 7 8 9 10 11 12 13 14 15 16 17 18			The included trials w Romania, Thailand, I two-intervention arr included at least one received the same b prevention were disc trials indicated abset Perry et al., 2009) als initiation but one (Pe 2016) also involved s activities inside scho implemented activiti	ere conducte ndonesia and ns and one in control grou ut delayed in cussed only in nce of smokin so reported a erry et al., 20 smoking cess ols. Four arm	ed in the follow I Mexico. Each Icluded three-in Ip who receive tervention after In four trials (Re In g prevention of bsence of anti 09) and four triation and other is (Lotrean et a thools. Booster	ving LMICs: thre trial comprised intervention arn ed a regular scho er intervention of ddy et al., 2002 contents or activ -smoking schoo rials (Marsiglia e er substances-us al., 2013, Reddy -sessions were	e in China, two one interventi ns, so the revie ool curriculum. completion. Co b, Tahlil et al., vities in school l policy. All tria t al., 2015, Sea e respectively. et al., 2002b, V delivered in fo	b each in India, a ion arm except t w included 15 in In one trial(Peri intents of schoo 2015, Wen et al curriculum, of t ils focused prima I, 2006, Reddy e All intervention Wen et al., 2010 ur trials only.	and South three trials nterventic ry et al., 2 l curriculu ., 2010, Pe these two arily on pr et al., 2002 s focused , Perry et	Africa, and one each in s as two compromised on arms. All trials 009) the control group im in relation to smoking erry et al., 2009). These trials(Wen et al., 2010, reventing smoking 2b, Motamedi et al., on face-to-face al., 2009) also				
19 20 21 22 23 24 25 26 27 28 29 30	Risk of bias in studies	18	Present assessments of Attrition and selection the included studies (Higgins and Green, 2 effective trials (Table schools purposively selection and detect Although blinding is reporting of smoking Table 1 Summary of	of risk of bias for on were ident as half of the 2008) and no e 1). Only one based on bein ion bias in mo difficult in be g inside schoo the risk of b	or each included tified as the me tincluded trial trial has low the effective trial of cooperative ost trials due to haviour chang ols was the onl	study. ost relevant sou s included high risk of bias in all (Motamedi et a before starting o insufficient ev ge intervention, y method used to ided studies	rces of bias. Ri risk of bias in a these criteria. al., 2016) has h the interventi idence of blinc findings might for assessing in	sk of bias was a t least one of th Ineffective trial igh risk of bias c on. The assessm ling participants have been influ nterventions' ou	ppraised a e five Coc s has high aused by nent canno , delivere enced by tcomes.	as considerable across thrane risk of bias criteria er risk of bias ratio than selecting intervention ot identify low risk of rs or outcome-assessors. these biases, as self-				
31 32 33 34			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 <sup>2</sup>					
35 36			Perry, 2009, India	L	U	U	L	L	0/5					
37 38			Motamedi, 2016, South-Africa	Н	н	U	L	U	2/5					
39 40		Lotrean,2013, Romania L U U U L L 0/5												
41			Reddy, 2002, India	L	U	U	U	L	0/5					
42 43		Tahlil, 2015,   U   L   U   U   L   0/5     Indonesia   L   U   L   L   L												
44 45			Resnicow, 2010,	F <mark>U</mark> r peer	review <mark>U</mark> nly - ht	ttp://bmiopen.bn	ni.com/site/abo	ut/auidelines.xht	1/5 ml					

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/				Seal 200	)6, Thailand	L	L	U	U	L	0/5			
8				Wen 20	10, China	L	н	н	н	L	3/5			
10 11				Marsigli Mexico	a, 2015,	н	U	U	U	L	1/5			
12				Chen, 2	014, China	L	U	U	H	L	1/5			
13 14				H=hig	h risk of bia	s, <mark>U</mark> = un	clear risk of	bias, $L = 1$	ow risk of	bias				
15 16 17 18	Results of individual studies		19	For all ou (e.g. conf	tcomes, prese idence/credible	nt, for each sti e interval), ide	udy: (a) summa ally using struct	ry statistics for ead ured tables or plot	ch group (whe s.	re appropria	te) and (b) an effe	ct estimate and its pre	ecision	
22 23 24 25 26	г							The prim	hary outcome				Statistical	
28	_	The	e study	y ID							The result		difference	
29 30 31		(1 <sup>st</sup> a c	uthor, country	year, y)	The in	dicator/ the sta	atistical test repo	orted in the article	The gro	intervention up (95% Cl)	The control (95% Cl)	<ul> <li>P value of the difference after the intervention</li> </ul>	after intervention	
32		Perry 20	109 In	dia	Coefficient reg	ression of any t		Baseline	3.42	2 (1.95-4.89)	1.38 (09 – 2.85	) 0.04	Significant	
33	_	i ciry, 20	ло <i>э</i> , п		coefficient leg			Linear rate of char	nges - 0.5	9 (1.63-0.45)	0.94 (-0.10-1.98)			
34		Motame South-Af	di, 201 frica	L6,	OR of initiating the intervention	g cigarette smol on	king in intervention	on versus control af	ter	0	.64*	0.02	Significant	
36	Lotrean, 2013, RomaniaThe OR of smoking initiation in control versus intervention (Logistic regression model)2.23 (1.29 - 3.85)<0.01Significant													
38			Sch	ool	Ever-use of tob	bacco (mixed-ef	ffect regression	Baseline	0.42	(0.30 - 0.54)	0.39 (0.25-0.061	0.001	Significant	
39		Reddy,	inte	ervention	model, F-test)			After the interver	ition 0.57	7 (0.42-0.77)	0.94 (0.73-0.12)			
40		2002,	Sch	ool plus	The rate of eve	er-use of tobacc	co (mixed-effect	Baseline	0.34	(0.22-0.53)	0.39 (0.25-0.06)	0.001	Significant	
41		India	fam inte	nily ervention	regression mo	del, F-test)		After the interver	ition 0.34	(0.26-0.50)	0.94 (0.73-0.12)			

<sup>44</sup> <sup>2</sup>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.
 <sup>45</sup> bias.
 <sup>46</sup>

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3 4 5	Section Topic	and	ltem #	Checklis	st item				Loc whe is re	ation ere item eported					
6 7 8			ls bi in	lamic- ased tervention	The mean score of life time smoking behaviour rate after the intervention $\pm$ SD (1= never to 9 smoked > 100 cigarettes)	1.2 ± 0.07	$1.17 \pm 1.3$	0.16	Insignificant						
9 10 11		Tahlil, 2015, Indone	H ba es in	ealth- ased tervention	The mean score of life time smoking behaviour rate after the intervention $\pm$ SD (1=never to 9 smoked >00 cigarettes)	2.1 ± 2.2	1.17 ± 1.3	0.84	Insignificant						
12 13 14 15		ia	Co ho Is in	ombined ealth & lamic tervention	The mean score of life time smoking behaviour rate after the intervention $\pm$ SD (1=never to 9 smoked >100 cigarettes)	$1.4 \pm 1.0$	1.17 ± 1.3	0.10	Insignificant						
16 17 18 19 20 21	*Statistic	*Statistical details were not provided in the article           Results of         20a         For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.													
23 24	Results of synthese	of es	20a	For each	synthesis, briefly summarise the characteristics and risk of bias amo	ng contributing studi	es.								
25 26					1. Cultural appropriateness				Pag 13	e 12 and					
27 28 29 30 31 32 33 34 35	Most (10/15) intervention arms were based on effective interventions originally developed in high-income countries. In three (Perry et al., 2009, Chou et al., 2006, Marsiglia et al., 2015) 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 in adolescents smoking preventions and community members who have an understanding of what is feasible and acceptable. However, only three arms collected quantitative data on feasibility and acceptability of the contents before implementation.														
36 37				Table 3	summarises approaches, dimensions and strategies used for o	cultural appropriat	eness of each inte	ervention arms.							
38 39 40 41 42 43	Table 3	3 Sum	imary	of cultu	ral appropriateness of the included interventions				I						
44 45	-	The stu	dy ID	T	he effectiveness of the intervention in http://bmjopen.bmj.com	/site/about/gu <b>@lati</b>	nal appropriatenes	S							
46 47															



3 4 5	Section and Topic		ltem #	Che	cklist item																		Loc whe is r	ation ere ite eporte	em ed
6 7	(1 <sup>st</sup> author, ye	/eai	r, cou	ntry)	smoking prevent	ion		D	imensi	on	A	pproa	ch			stra	tegy				Stage			How	
, 8 9 10 11 12 13 14							tervention untry of origin	Surface	Deep	Unclear	Bottom-Up	Top-Down	Both	Linguistic	Peripheral	Evidential	Constituent-involving	Sociocultural	Cultural tailoring	Design	Implementation	Evaluation	Informally	qualitative data	Surveys
15	Perry, 2009, Ir	ndi	ia		Effective		USA		X				Х	Х	X	Х	Х	Х	Х	Х	Х			Х	
16 17	Motamedi, 20: Africa	)16	, Sou	th-	Effective		USA		x				x	х	x	x	х	х	x	х	x	x		х	x
18	Lotrean, 2013,	, R	lomai	nia	Effective.		Netherland		Х				Х	Х	Х	Х	Х	Х		Х			Х	Х	
19					School intervention	Effective	Partly from			Х			Х	х	X		Х			Х	Х			Х	Х
21 22	Reddy, 2002, li	Ind	lia		School& family intervention	Effective	USA			x			x	х	x		х			х	x			Х	x
23					Islamic based intervention	Ineffective		Х					X	х			Х	Х		Х				Х	
24	Tahlil 2015 In	ndc	nesia	4	Health-based intervention	Ineffective	Indonesia	Х					Х	х			Х	Х		Х				Х	
25 26 27		indic	Jineon		Combined health and Islamic based intervention	Ineffective	indonesia	х					x	х			х	х		х				Х	
28	Resnicow, 201	10 5	South	-	Harm management	Ineffective	Australia		X				X	х	X		Х	Х		Х				Х	
29	Africa,				life skills intervention	Ineffective	USA		X				X	X	X		Х	Х		Х				Х	
30 21	Chou, 2006, Cł	hin	na		Ineffective		USA	Х				X		X	X		Х			Х			Х		
32	Seal, 2006, Th	nail	and		Ineffective		USA	Х				X		Х	X		Х			Х			Х		
33	Wen, 2010, Ch	hina	а		Ineffective		China			Х			Х	Х			Х	Х		Х				Х	
34 25	Marsiglia, 2015	.5, I	Mexi	0	Ineffective		USA	Х					Х	Х	X		Х			Х				Х	
35 36	Chen, 2014, Ch	hin	a		Ineffective		China			Х		X		Х			Х			Х				Х	
37	NB: Presence of	of	a Cult	ural ap	propriateness dimension, app	roach, strateg	y, method and	l time	in ar	inte	rventi	ion ar	m is i	ndica	ted w	ith aı	η X.								
38 39 40 41				The	Theoretical constru design of all effective interv	<b>cts</b> rentions, exce <b>Fable 4</b> man	ept one (Redo	dy et	al., 2 d abs	002b	o), wa	as info	orme	ed by	at lea	ast o	ne th mair	neory	but i	nsuff	icien	t	Pag 14	¦e 12 a	and
42 43 44 45 46 47	Table 4 Sun	mn	nary	of th	e theoretical domains of	the include	- http://bmjo	ben.b	mj.cc	m/sit	te/ab	out/g	uide	lines.	html							1			

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Sect Topi	tion and ic	ltem #	Check	klist item																	Loc whe is re	atio ere i epo
				<i>k</i> o	5																	
						Know	ledge		Skills		Me	Beh	Env	Soci	Beli Con	Beli	Opt	Inte	Ider	Per	Rein	Emo
(1	The st L <sup>st</sup> author, y	udy ID ear, coui	ntry)	The effectiveness of the intersection of the i	ervention in on	Knowledge on consequences	Normative education	Social competence	Social influence	Combined	mory, attention & ision process	avioural regulation	ironmental context & ources	ial influences	iefs about isequences	iefs on capabilities	limism	entions	ntity / Social role	sonal-goals	nforcement s	otion management
1.	Perry, 20	09, Ind	ia	Effective		Х			X		Х		X	X	Х	Х		Х	Х		Х	
2.	Motame South-Af	di, 2016 rica		Effective		х				x	х	x			x		x	х	x	x		x
3.	Lotrean, Romania	2013,		Effective.		х			x		х			x	x	x		x	x		х	
				School intervention	Effective	Х			X				X	X	Х			Х				
4.	Reddy, 2	002, Ind	ia	School intervention plus family intervention	Effective	х			Х				x	х	х			х				
		1 F		Islamic based intervention	Ineffective	X	X	Х	ļ!			<b> </b>			X	<u> </u>	ļ!	X	<b> </b>	<b> </b>		
5.	Indonesia	, <sub>בבי</sub>		Health-based intervention	ineffective	<u> </u>	X		<u> </u>	X			+		X	<u> </u>		X	┝──┦	$\left  - \right $		<u> </u>
		~		based intervention	Ineffective	Х	X			X					Х			X				X
6.	Resnicow	v, 2010		Harm management	Ineffective	Х		Х			Х				Х			Х				
	South-Af	rica,		life skills intervention	Ineffective	Х			ļ!	Х	Х	<u> </u>	<u> </u>		Х			Х		$\vdash$		X
7.	Chou, 20	06, Chir	a	Ineffective		Х	Х		X		Х	<b></b>	<u> </u>	X	Х	<u> </u>	ļ!	Х	X	$\square$		<u> </u>
	Seal 200	6 Thail	and	Ineffective		V V	1		1 1	l v l	X		X X	1	X	1	1 1	x	1	1	, ,	X



Section and Topic	ltem #	Checl	dist item																Loc whe is re	ation re ite porte	m ed
9. Wen, 202	10, Chin	a		Ineffective	Х					Х	Х		X	Х	X		Х	Х	Х	Х	
10. Marsiglia Mexico	a, 2015,			Ineffective	х				x		Х				x	x	x				
11. Chen, 20	14, Chin	na		Ineffective	Х				Х				X	Х	Х		Х	Х			
	Tabl	Table	5 illustrat	Intervention functions es the interventions effect	tiveness in V Interver	relation	on to	the	invo ns ir	lved	inter	ventio	n fun	ctions					Pag 17	e 16 a	ind
		<u>c 5 5 </u>	ininary (																		
	(1	The stu 1 <sup>st</sup> autho coun	dy ID or, year, try)	The effectiveness of the smo	e intervention king preventi	in on	Persuasion	Incentives	Coercion	Training	Restriction	nvironmental estructuring	Modelling	Enablement							
	1.	Perry, 20	009, India	Effective		x	x	x		x	x	х	х	x							
	2.	Motame South-A	edi, 2016 frica	Effective		x	x			x											
	3.	Lotrean, Romania	2013, a	Effective		x	x	X		x			x								
	4.	Reddy, 2	2002, India	School intervention	Effective	X	X			Х	X										
				School intervention plus family intervention	Effective	x	x			х	x										
				Islamic based intervention	Ineffective	x				х											
	5.	Tahlil, 20 Indones	015, ia	Health-based intervention	Ineffective	x				х											
				Combined health & Islamic based intervention	Ineffective	x				x											
	6.	Resnicov	w, 2010,	Harm management	Ineffective	x				x				x							
		South-A	irica	life skills intervention	Ineffective	X				Х											
	7.	Chou,20	06, China	Ineffective		x				x		х									
	8.	Seal, 200 Thailanc	06, I	Ineffective For peer review of	only - http://	x pojop	en br	nj.co	um/si	X te/ab	hout/g	yuidelir	nes xh	tml							

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Section and Topic	ltem #	Checklist item												Location where item is reported
	9.	Wen, 2010, China	Ineffective	х	х	х		х	х	x				
	10.	Marsiglia, 2015, Mexico	Ineffective	х	x			x						
	11.	Chen, 2014, China	Ineffective	Х	x			х	х	х				
	Pres	ence of a BCW	Intervention Function in an interventi	on a	ırm	is in	dica	ated	with	n an X		1	1	
	20b	Present results of confidence/credib	all statistical syntheses conducted. If meta-a ale interval) and measures of statistical hetero	naly	sis w eity. I	as de lf cor	one, npari	prese ing gi	ent fo roups	r each , descr	the s ibe tl	sumn he di	nary estimate and its precision (e.g. rection of the effect.	
-		Statistical synth	eses was not conducted.											
	20c	Present results of The effectivene intervention and arm also compa- assessed after a studies identifie Figure 1 shows against the sam handbook for sy funnel with the exaggerated int publication bias language of the published in lan included interve If there is no pu then most of th adolescents' sm	all investigations of possible causes of heter ass of each intervention arm was assesse d control arms, before and after the inter- ared the smoking behaviour of adolescer at least six-months of follow-up, which ra- ed the long-term impact of SBSPI, at leas the funnel plot of the included intervent ple size of this study, in which the study ystematic reviews of interventions (Higg presence of bias because of some small ervention effect estimates of these inter- bublication language. As explained in se- ague other than English and Arabic language ention could be other reasons for the as- blication bias and the included interven- e dots are expected to be located in the poking behaviour positively.	oger d by erver nts a ange t aft ions a er st rven ion, ectio ages ymm tions top	eity con ntior cros d fro er o whi is p nd C udie tion sele n 0, s. Va netry s we left	amoinpar npar s int om s int om s ne y ich d lotte Gree es wi s. Ac ctive two riati y of t rre ef of th	ng st ing t ing t kll th erve ix-m ear o lemo ed or n, 20 cth lo ccoro e out stud on in the f ffect ne fu	tudy r the sine this ention nonth of co constr n the 008, cower ding t tcom diss v n san cunne tive in	esulta moki ree t ns ar ns to mple ates hori Shus met to (S ne rej were nple el plo n pre l plot	s. ing bel rials th rms. Th three- eting in the ef izontal ter, 20 hodolo terne porting exclue sizes a ot (Ster eventing cas neg	navid nat in ne ou yean hterv fect l axis 011), opgica et al g, se ded and h rne e ng ac gativ	our o ncluo utco rs. H venti s. Ac s. Ac al qu l., 20 electi in th hete et al. doles ve ef	of adolescents in the ded more than one intervention me of all the included trials was alf (6/12) of the included ions, see Table 6. mate of each intervention cording to the Cochrane funnel plot is asymmetrical hality which produced 11), suggested the presence of we analysis reporting or the his review because the study rogeneity in the intensity of the , 2011). scents from smoking initiation, fect size is what influence	Page 6 and 20
	20d	Present results of	all sensitivity analyses conducted to assess	the r	obus	stnes	s of t	the sy	/nthe	sized re	esult	S.		Page 6
	In this review, there is heterogeneity across the included studies in defining, measuring, assessing and presenting outcomes of the included interventions. Separating the included studies into subgroups that used similar definitions, measurements and ways of reporting outcomes would have resulted in a very small sample size in each group that might not make significant changes in the findings on effectiveness. Therefore, quantitative synthesis, including meta-analysis and meta-regression, was considered inappropriate in this review and a narrative synthesis of the findings was used. However, the effect size of the interventions was calculated, using the guidance by Borenstein et al. (2009), and Chinn. (2000), in order to outline the effect of													

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3 4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8 9			SBSPIs in preventing smoking initiation as this is recommended to facilitate comparing the effectiveness of intervention when different statistical test and parameters were used across studies included in systematic reviews (Nakagawa and Cuthill, 2007, Fritz et al., 2012). The effect estimates of the include interventions was presented in a funnel plot, see, Figure 1,	
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. Figure 1, demonstrates the effect estimate of each of the included intervention against the sample size of this study. The Revman software version 5.1, which was provided for free by the Cochrane for systematic reviews of interventions (Higgins and Green, 2008, Shuster, 2011), was used to calculate the effect size and draw the funnel plot, in consultation with a professional statistician. Figure 1 The effect size of the included interventions in a funnel plot 0.2 0.4 0.6 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1	Page 6 and supplement 1
32	Certainty of	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
34	evidence		Explained above	
35	DISCUSSION			
36 37	Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	
38			Cultural-appropriateness	
39			The importance of cultural-appropriateness to ensure the transferability of the effectiveness of interventions and integration	
40 41			into the new system or context and the need for guidance to achieve that has been emphasised in the literature (Evans et al.,	
42			2019). Generally, most of the high-quality evidence on SBSPI is based on few high-income countries. For example, the last	
43			Cochrane systematic review of School-based programmes for preventing smoking included only eight RCTs implemented in	
44 45			Livius (Thomas et al., 2013). This review identified only 12 KCTS almed at preventing addressents from smoking initiation through their schools in L版机合新始合物合体的合体的分析的分析的分析。分析的分析合称合体的合体的合体的合体的合体的合体的合体的合体的合体的合体的合体的合体的合体的合	
46		L	an eagle and restriction in Enrice and met and all bring office in the order of the included arms were bused on obor forginally	
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		developed in high-income countries. Accordingly, intervention developers in LMICs, face challenges in balancing the dynamic tension between keeping the fidelity of effective interventions that were imported from another context and cultural-appropriateness of these interventions to the targeted context. This tension could result in either surface cultural-appropriateness or major changes of the effective ingredients of the imported interventions and both may decrease interventions' effectiveness (Castro et al., 2010, Castro et al., 2004, Colby et al., 2013).	
		The deep cultural-appropriateness was considered in 80% of the included effective arms, see Table 3. In contrast, all ineffective interventions, except one, involved either unclear or surface adaptation of contents and activities to the targeted adolescents' culture, although these interventions were based on either literature review of SBSPIs evidence (Tahlil et al., 2015, Wen et al., 2010, Chen et al., 2014) or SBSPIs that showed effectiveness in developed high-income countries (Resnicow et al., 2008, Chou et al., 2006, Seal, 2006, Marsiglia et al., 2015). Targeting adolescents from the same ethnicity but live in different countries using similar SBSPIs without deep cultural-appropriateness does not lead to the same desired outcome, as in the intervention by Marsiglia et al. (2015).	
		Cultural-tailoring is commonly ignored in cultural-adaptation although it enhances the effectiveness of behaviour change interventions (Kreuter et al., 2003). In this review, cultural-tailoring strategy was only used in effective arms. Cultural-tailoring of behaviour change interventions aims to include contents that address shared cultural issues regarding the targeted behaviour with a consideration of cultural-differences between individuals in these issues in order to succeed in changing the behaviour of large proportions of the targeted population (Gould et al., 2017, Kreuter et al., 2003, Kreuter et al., 1999). While the translation of contents is the most obvious form of intervention adaptation, cultural-tailoring is the most challenging form of adaptation (Castro et al., 2010, Castro et al., 2004, Colby et al., 2013). The effectiveness of SBSPIs in LMICs is enhanced by paying attention to cultural-tailoring of contents to ensure addressing individual variance among target groups in term of their beliefs and interests in the included contents and delivery methods, as demonstrated in SBSPIs by Wegner et al. (2008), Caldwell et al. (2010) and Perry et al. (2009). In contrast, paying less attention to individual variance within the target population minimizes interventions' effectiveness even if extensive activities were done to adapt the intervention to the local context through the other five strategies for ensuring cultural- appropriateness, as was the case of Tahlil et al. (2015), Resnicow et al. (2010). The designers of the last two SBSPIs acknowledged that more consideration of the heterogeneity in predictors of smoking (such as ethnicity, knowledge and beliefs) among the targeted adolescents were needed for achieving better outcomes.	
		The theoretical constructs	
		Underpinning behaviour change interventions with theory followed by evaluating the intervention allow testing the appropriateness of this theory in addressing the targeted behaviour which in turn could enable further utilization and adaptation of the theory and the intervention in future (Rothman, 2004). Despite that, articles on behaviour changes interventions do not often refer to theories in designing, adopting, implementing or evaluating interventions, as many reviews identified (Davies et al., 2010, Painter et al., 2008). In this review, only seven of the included SBSPIs in LMICs indicated theory employment at any stage of the intervention behaviour by the effective interventions.	

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Section and Item Topic #	Checklist item	Location where item is reported
	least one theory that informed designing the intervention.	
	In this review, using TDF to identify the theoretical constructs on the included SBSPIs in LMICs helped in overcoming the dilemma of lack and poor reporting of theories-underpinning in the included studies. The involved theoretical domains were mapped against the COM-B model by Michie et al. (2014) to identify what theoretical domains were used by effective SBSPIs to enhance pupils' capability, opportunity and motivation to avoid smoking initiation in LMICs.	
	Intervention functions	
	This is the first review to use the BCW to map the interventions used to prevent smoking prevention in general. So we are not aware of any review or smoking prevention interventions to compare the findings with it.	
23b	Discuss any limitations of the evidence included in the review.	Page 21
	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 limited publications resulting from limited experience and inaccessibility to international databases or language barriers. Other systematic reviews (Nishio et al., 2018, Thomas et al., 2013, Caan et al., 2015, Brown et al., 2014, Hale et al., 2014, MacArthur et al., 2016, Langford et al., 2015)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 recognized barriers (Brown et al., 2014, Kreuter et al., 2016, Tahili et al., 2015). Atthough self-reporting is a valid and stable indicator for identifying smoking status in many contexts (Wills and Cleary, 1997, Bauman and Koch, 1983), its sensitivity and specificity vary per age, gender, and culture (Dolcini et al., 1996). Adolescents, especially girls, might under-report their smoking where smoking is culturally unacceptable (Valladolid-Lopez et al., 2015, Dietz et al., 2015, Patrick et al., 1994); or over-report that where smokers are considered mature and impressive (Ng et al., 2006, Mermelstein et al., 2002, Al-sheyab et al., 2016, Arora et al., 2011, Dolcini et al., 1996). 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 (Mermelstein et al., 2016, Peirson et al., 2016, Thomas et al., 2013, Reddy et al., 2002b, Wen et al., 2010). High risk or poor reporting of fidelity and implementation quality without process evaluation. Better reporting of attrition rates with attrition analysis and adjustment of findings could have helped in better explanations of interventions' effectiveness (Hoffmann et al., 2014). Poor repo	

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Section and Topic	ltem #	Checklist item	Location where item is reported
		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.	
	23c	Discuss any limitations of the review processes used.	
		The review was limited to articles that were published in English or Arabic, therefore, three trials were excluded because the findings is unavailable in English or Arabic.	
	23d	Discuss implications of the results for practice, policy, and future research. This review highlighted the following gaps in the available evidence regarding factors that influence the effectiveness of SBSPIs in LMICs, which should be filled by further studies: More high-quality and long-term RCTs are required for a better understanding of what strategies, intervention functions and theoretical constructs enhance effectiveness on SBSPI in the context of LMICs. More attention should be paid to measures that reduce selection and detection bias. Researchers and designers of SBSPI should use standardized methods for defining, measuring, assessing and reporting changes in adolescents' smoking status before and after the interventions. This would allow quantitative synthesis of the findings on the effectiveness of SBSPIs in LMICs and facilitate comparisons across these interventions. The definitions and methods of the GYTS are recommended to be used in this regard because they are designed to allow global and regional comparison of adolescents' smoking. For accurate assessment of interventions' effectiveness, it is recommended to measure biochemical markers, at least among a random sample of participants when resources are limited, to cross-validate the result of self-reporting of smoking (Mermelstein et al., 2002). This is to avoid over-reporting or under-reporting of participants' smoking status. Misreporting of adolescents' smoking is influenced by their gender and culture (Valladolid-Lopez et al., 2015, Dietz et al., 2015, Patrick et al., 1994) and their attitude toward smoking (Ng et al., 2006, Mermelstein et al., 2002, Al-sheyab et al., 2015, Arora et al., 2011, Dolcini et al., 1996). More research is required on how cultural-appropriateness influences the effectiveness of SBSPIs in LMICs. A meta-analysis of more homogenous RCTs could be conducted to explore the effectiveness of each cultural-appropriateness dimension, strategy and approach. The review identified that SBSPIs in LMICs are ina	The summary is in page 21.
		Financial-incentives for non-smokers or punishments of smokers were not used in any of the included SBSPIs. However, it is worth exploring the feasibility, acceptability and effectiveness of using punishments and financial-incentives in SBSPIs to prevent adolescents from smoking initiation in the context of LMICs. It is also important to analyse the dose-response For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

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<ul> <li>relationships or cost-effectiveness of using incentives in SBSPIs in LMICs where resources are limited.</li> <li>The effectiveness of discussing the positive consequences of non-smoking behaviour on the length and quality of peoples' life, social relationships, income and environment alongside the negative consequences of smoking in preventing adolescents from smoking initiation needs more investigation in LMICs.</li> <li>Normative-education was used only in four arms, all were ineffective, to correct pupils' overestimation of smoking rates among pers. More RCTs are needed to identify the need (or, as well as evaluating the impact of, using normative-education in SBSPIs in LMICs.</li> <li>More information should be gathered on barriers, required resources and cost of developing and implementing SBSPIs in LMICs. Turthermore, evidence on the cost effectiveness of these interventions is required for fundralsing with regard to researching and implementing SBSPIs in LMICs and thus accelerating the global control of the smoking epidemic.</li> <li>None of the included intervention used the internet, smartphones and social media although adolescents, utilization of these methods is increasing globally (Park and Calamaro, 2013, Savci and Aysan, 2017). Accordingly, it might be worth exploring the applicability, acceptability and effectiveness of stask in intervention functions and delivery methods could enable reliable research on intensity and duration of SBSPIs intomeser, frequency and length of sessions). However, this requires a systematic-review and meta-analysis of the global evidence on SBSPIs in order to identify the effectiveness of SBSPIs in LMICs.</li> <li>To enhance the utilization of findings, the following should be considered in the publication about SBSPIs in LMICs.</li> <li>To enhance the utilization of findings of the following should be considered in the publication about SBSPIs in LMICs.</li> <li>Better reporting of attrition rates, running attrition analysis a</li></ul>	Section and Fopic	ltem #	Checklist item	Location where item is reported
			relationships or cost-effectiveness of using incentives in SBSPIs in different contexts along with exploring what alternative incentives could be used in SBSPIs in LMICs where resources are limited. The effectiveness of discussing the positive consequences of non-smoking behaviour on the length and quality of peoples' life, social relationships, income and environment alongside the negative consequences of smoking in preventing adolescents from smoking initiation needs more investigation in LMICs. Normative-education was used only in four arms, all were ineffective, to correct pupils' overestimation of smoking rates among peers. More RCTs are needed to identify the need for, as well as evaluating the impact of, using normative-education in SBSPIs to prevent smoking initiation by adolescents in LMICs. More information should be gathered on barriers, required resources and cost of developing and implementing SBSPIs in LMICs and thus accelerating the global control of the smoking epidemic. None of the included intervention used the internet, smartphones and social media although adolescents, utilization of these methods is increasing globally (Park and Calamaro, 2013, Savci and Aysan, 2017). Accordingly, it might be worth exploring the applicability, feasibility, acceptability and effectiveness of these methods in SBSPIs in LMICs. Some of these issues are explored in study-3 in the Egyptian context. Furthermore, standardization of key aspects of SBSPIs (number, frequency and length of sessions). However, this requires a systematic-review and meta-analysis of the global evidence on SBSPIs in order to identify the effective intervention functions and theoretical constructs that could be used to prevent adolescents' smoking through schools. Qualitative studies were not included in this review because of its focus on the effectiveness of SBSPIs in LMICs. However, another systematic-review and meta-analysis of the global evidence on SBSPIs in order to identify the effective intervention functions and theoretical constr	

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4 5	Section and Topic	ltem #	Checklist item	Location where item is reported
6 7 8			and delivery methods or at least storing these details in a publicly accessible database would allow proper data extraction on the behaviour change techniques used in SBSPIs.	
9	OTHER INFOR	MATIO	N	
11	Registration	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	
12 13 14	and protocol		The protocol of this review was reviewed internally at the University of Leeds as it was part of the Ph.D. by the first author but the protocol was not published in any journal.	
15 16 17 18 19 20 21			The PROSPERO registration of this review was started by the first author in 2016. The review was given PROSPERO registration number was (82267). However, recently we found that this number doesn't exist on the PROSPERO website. When we explored the reason, the PROSPERO team explained that the process of registration was not completed. The first author did not realize that the process needed another step of confirmation to be completed, so the given number is invalid. The PROSPERO team indicated that they can't restore the number as the process was incomplete at the time and they can't register the review after it is completed. Therefore, there is no PROSPERO registration number to be added.	
22		24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	
24			The protocol could be accessed through the author.	
25		24c	Describe and explain any amendments to information provided at registration or in the protocol.	
26 27 28			The original proposal aimed to focus on both LMICS and Arabic countries. This paper provides explanation of the part that is focused on LMICs only	
29	Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	
30			There was no financial support for this review as it was part of the PhD of the 1st author.	
32	Competing	26	Declare any competing interests of review authors.	
33	interests		There is no any competing interests of review authors to be declared.	
34 35 36	Availability of data, code	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	
37	materials		The followings are available upon request from the corresponding author:	
38			- template data collection forms;	
39 40			- data extracted from included studies;	
41			- data used for all analyses	
42 <sup>[</sup>				

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71 For more information, visit: http://www.prisma-statement.org/ For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml 

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Additional records identified through



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#### Table 6 characteristics of included studies

			5					Re		c	ompone	ents		Tar	gets	s	etting	gs	The	e delive	rer			Pro
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the intervent prevention	ion in smoking	tervention duration	Number of sessions	Frequency of contact	Booster-sessions	Follow-up period	sponse rate at final- evaluation	The attrition rate in the intervention arm compared with control	Smoking prevention	Smoking cessation	Preventing substance use	pupils	teachers	Parents / relatives / community	Inside schools		Dutside schools	Teachers	peers	Outsider specialists	<b>Fraining deliverers</b>	Fidelity checked	cess-evaluation done
Perry, 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	х	х		х	х	х	x	; ,	x	х	х		Y	Y	Y
Motamedi, 2016, South- Africa	Effective		Not stated	12	One / year	6	3 years	90%	10% in both arms	х	х	х	х			x			х			NC	Y	Y
Lotrean, 2013, Romania	Effective.		2 months	5 weekly	Weekly	NC	9 months	90.2	11% compared with 9.8% in control	х	х		х		х	x	; ,	x	х	х		Y	NC	Y
	School intervention	Not stated								Х		Х	Х			X								
Reddy, 2002, India	School plus family intervention	Effective	Not stated	20	Not stated	NC	1 year	88.3%	Not stated	х		Х	х		х	X		х	×	х		Y	Ý	Y
	Islamic based intervention	8 weeks								х			х			X								
Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	8 weeks	8	One/ Week	NC	6 months	89.5%	Not stated	х			х			x			x		х	Y	NC	NC
<ul> <li><sup>24</sup> Tahlil, 2015, Indonesia</li> <li>25</li> <li>26</li> <li>27</li> </ul>	Combined health & Islamic intervention	bined health & Islamic Ineffective vention				5				х			х			х								
Development 2040 Courth Africa	Harm management	Not stated	Netster					0201	41.2% compared with 14.2% in control	х			х			x			v					
Resnicow, 2010 South-Africa,	life skills intervention	Ineffective	Not stated	8 per year	One / year	NC	2 years	93%	34.2% compared to cohort 15.3%	х			x			x			×			Y	Y	Y
Chou, 2006, China	Ineffective	-	13 weeks	13	Once /Week	NC	1 year	97% at baseline	12.5% compared with 7% in control	х			х			x			х		х	Y	NC	NC
Seal, 2006, Thailand	Ineffective		Not stated	10	Not stated	0	6 months	100%	Not stated	Х		Х	Х			X			NC	NC	NC	NC	NC	NC
Wen, 2010, China	Ineffective		Not stated	Not stated	Not stated	2	6 months	90%	7.95% compared with 32.55% in control	х			х	х	х	x	; ; ;	x	х	х	х	Y	NC	Y
Marsiglia, 2015, Mexico	Ineffective		10 weeks	20	Two /week	NC	8 months	86%	Not stated	Х		Х				X		ĺ	Х			Y	NC	NC
Chen, 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	х			х	х		x			х	х		Y	Y	NC

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#### A Systematic Review of intervention functions, theoretical constructs, and cultural adaptations of School-Based Smoking Prevention Interventions in Low and Middle-Income Countries

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# A Systematic Review of intervention functions, theoretical constructs, and cultural adaptations of School-Based Smoking Prevention Interventions in Low and Middle Income Countries

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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 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 capabilitymotivation and opportunity model to formulate the conclusion. Risk of bias was assessed using Cochrane Risk of Bias tool.

**Results:** We identified 11 RCTs (n=7,712 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 characterized 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 standardized measurements of smoking to allow meta-analysis in future reviews.

## Funding: Self-funded

**Keywords:** smoking, prevention, school-based intervention, RCTs, LMICs, Systematic review, TDF, BCW, COM-B

## Strengths and limitations of this study

- This systematic review was based on a comprehensive search of randomized control trials 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 7,712 baseline never-smokers and provide 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 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 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 consequence is a global concern, and over half a trillion US Dollars are spent annually on tobacco control measures [5].

Smokers in Low and Middle Income Countries(LMICs) represent 80% of the smokers worldwide [4]. Threequarters 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 RCTs and reviewed in some systematic reviews to identify factors influencing the effectiveness [10-22]. However, only three reviews were focused on LMICs, one is limited to African countries and included non RCTs[23], one explored smoking cessation only[24], and one was not a systematic review [25]. 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)[26] to specify intervention functions. 2) The Theoretical Domain Framework (TDF) [27] was adapted using the classification of smoking prevention curriculum [28] 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, Lukwago [29] and Castro, Barrera Jr [30] 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 school-based smoking prevention interventions that were implemented in Low and Middle-Income Countries.

#### 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 Specialized Register, Trials Register of Promoting Health Interventions (TRoPHI). The search was conducted from inception to August 2022 using terms relating to school-based smoking prevention interventions, see supplement 1, with no date restrictions. Articles were filtered later for 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 [31] was used.

We searched for all RCTs evaluating school-based smoking prevention interventions in LMICs. Trials were included, if interventions targetted 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 remainin 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 [32] met all the inclusion criteria except one, as pupils were only followed for four months after intervention completion.

One researcher (MB) 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 and AA). Any disagreement was resolved through collective discussion and consensus, or referral to other researchers (HE, BB, 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 [27]: 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 sub-grouped using Griffin and Botvin [28] 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, Lukwago [29], and Castro, Barrera Jr [30] classifications.

A designed checklist was used to identify the presence or absence of each of the 17 theoretical domains, the nine intervention functions, and the smoking prevention curriculum as well as the two dimensions, the three approaches, the six strategies, and the three 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 summarize 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 [33] was used, independently by 2 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 data were missing or unclear in the published articles, but missing data were not imputed.

#### **Data synthesis**

A narrative synthesis of the findings [34] 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 [35-38]. Therefore, Revman software (version 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 Supplement 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 [26]. The review was concluded with 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

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prevent Egyptian adolescents from smoking initiation. This review is implemented in response to questions from schools' 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 to 15 years, Table 1summarizes participants' characteristics. Females represented at least 45% of the sample in all trials, except in one [39]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 one intervention arm with the exception of two that comprised two-intervention arms and one included three-intervention arms, so 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[40] 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 [40-43]. These trials indicated absence of smoking prevention contents or activities in school curriculum, of these two trials [40, 43] also reported absence of anti-smoking school policy.All trials focused primarily on preventing smoking initiation but one [40]. Four trials [39, 41, 44, 45] also involved smoking cessation and other substances-use respectively. All interventions focused on face-to-face activities inside schools. Four trials [40, 41, 43, 46] 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 six-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 interventions 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 [47]. However, those who smoked a puff or two were considered never-smokers in one study [45]. Changes in never-smoking rates in the past one[44] or two[39]monthsbefore the survey were used in assessing the outcome of two trials. Two trials [39, 41] did not separate the findings on cigarettesmoking from other tobaccouse. Some trials presented findings as changes in ever-smoking prevalence among those who never-smoked before and after the intervention [39, 40, 48]. Whereas others [41-43, 45, 49, 50] calculated odds-ratio 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.

## Table 1 Baseline characteristics of participants

The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the int smoking prevent	tervention in ion	Number	Age	Sex (females %)	Ethnicity	School type (public %)	Family income
1. Perry, 2009, India	Effective		12484	11.9	48.4	Not stated	Not stated	Not stated
2. Motamedi, 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
3. Lotrean, 2013, Romania	Effective.		1071	13-15	51	Not stated	Not stated	Not stated
	School intervention	Effective						
4. Reddy, 2002, India	School intervention plus family intervention	Effective	5752	11.9	49.5	Not stated	40%	Not stated
	Islamic based intervention	Ineffective						
5. Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	477	11-14	58.5	Not stated	Not stated	Not stated
	Combined health and Islamic based intervention	Ineffective			19			
6. Resnicow. 2010 South-Africa.	Harm management	Ineffective	5266	14	49.5	Black 59.7%, Coloured	100	Not stated but findings
,	life skills intervention	Ineffective				26.4%, White 9.9%		were adjusted forincome
7. Chou, 2006, China	Ineffective		2661	12.5	47.7	Not stated	Not stated	Not stated
8. Seal, 2006, Thailand	Ineffective		170	15.5	11	Not stated	Not stated	Not stated
9. Wen, 2010, China	Ineffective	2343	13.4	45.9	Not stated	50%	Not stated	
10. Marsiglia, 2015, Mexico	Ineffective		431	13	55	Mexican	100%	Not stated
11. Chen, 2014, China	Ineffective		1807	14.5 ± 1.1	49.6	Linzhi Tibetan and Guangzhou Han	Not stated	Not stated

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#### Table 2 Characteristics of included studies

			Compon	ents		Tar	gets	set	ttings	Tł	e delive	erer			
The attrition rate in the intervention arm compared with control	The attrition rate in the intervention arm compared with control	Smoking prevention	Smoking cessation	Preventing substance use	pupils	teachers	Parents / relatives / community	Inside schools	Outside schools	Teachers	peers	Outsider specialists	Training deliverers	Fidelity checked	cess-evaluation done
	Not stated	x	x		x	x	х	x	x	х	x		Y	Y	Y
10	10% in both arms	x	x	x	х			х		х			NC	Y	Y
11% ç	11% compared with 9.8% in control	x	х		х		х	х	х	х	х		Y	NC	Y
	Not stated	X		Х	х			х		v	v		v	· / V	
	Not stated	х		х	х		Х	х	Х	^			T	ľ	
_		X			х			х							$\square$
	Not stated	Х			х	İ		х		х		x	Y	NC	NC
		х			х			x							Process-evaluation done Y Y Y NC Y NC NC NC
41.2 1	41.2% compared with 14.2% in control	х			х			х		x			Y	v	
34.	34.2% compared to cohort 15.3%	x			х			х							
12.5	12.5% compared with 7% in control	x			х			х		х		х	Y	NC	NC
	Not stated	Х		х	х			х		NC	NC	NC	NC	NC	NC
7.95 32	7.95% compared with 32.55% in control	x			х	х	х	х	х	х	х	х	Y	NC	Y
	Not stated	X		Х	İ	Ì		х		Х			Y	NC	NC
Rate but if	Rate was not specified but it is stated it is high	х			х	x		х		х	х		Y	Y	NC
Rate but it	Not stated Rate was not specified but it is stated it is high	x		X	x	x			×	x x	x x x x	x x x	x x x	X     X     Y       X     X     X	X     X     Y     NC       X     X     X     Y     Y

- 60
#### **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 [33] and no trial has low risk of bias in all these criteria. Ineffective trials has higher risk of bias ratio than effective trials (Table 3). Only one effective trial [45] had high risk of bias caused 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.

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 <sup>1</sup>
Perry, 2009, India	L	U	U	L	L	0/5
Motamedi, 2016, South-Africa	н	н	U	L	U	2/5
Lotrean,2013, Romania	L	U	U	L	L	0/5
Reddy, 2002, India	L	U	U	U	L	0/5
Tahlil, 2015, Indonesia	U	L	U	U	L	0/5
Resnicow, 2010, South-Africa,	U	U	U	н	L	1/5
Chou, 2006, China	L	U	U	Н	L	1/5
Seal 2006, Thailand	L	L	U	U	L	0/5
Wen 2010, China	L	Н	Н	Н	L	3/5
Marsiglia, 2015, Mexico	Н	U	U	U	L	1/5
Chen, 2014, China	L	U	U	н	L	1/5
H = high risk of bias,	U = unclear	risk of bias,	L = low risk of	bias		

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

<sup>&</sup>lt;sup>1</sup>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.

#### **Cultural appropriateness**

Most (10/15) intervention arms were based on effective interventions originally developed in highincome 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 [40, 44, 49] 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 whith 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 cultural 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 (socio-cultural 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 adaptationis 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 [30, 51]. Measures for deep cultural adaptation were mostly recognised in the effective interventions. Whereas all the ineffective interventions, except one [48], 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 socio-cultural 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 [45, 52], both were effective.

#### **Theoretical constructs**

The design of all effective interventions, except one [41], was informed by at least one theory but insufficient details were available on how theory was incorporated. Table 5 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 [42, 48] 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 [40, 45]. 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: selfawareness, 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 [45] **(Skills domain).** 

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									Cult	ural a	ppro	oriate	eness	5							
			Inte of c	Dimension			Approach					stra	tegy			S	tage			How	
The study ID (1 <sup>st</sup> author, year, country)	The effectiveness of the int smoking preventi	The effectiveness of the intervention in smoking prevention		Surface	Deep	Unclear	Bottom-Up	Top-Down	Both	Linguistic	Peripheral	Evidential	Constituent-involving	Sociocultural	Cultural tailoring	Design	Implementation	Evaluation	Informally	qualitative data	Surveys
Perry, 2009, India	Effective		USA		Х				Х	Х	Х	Х	Х	Х	Х	Х	Х			Х	
Motamedi, 2016, South- Africa	Effective	USA		х				х	х	х	х	х	х	х	х	х	x		х	х	
Lotrean, 2013, Romania	Effective.		Netherland		Х				Х	Х	Х	Х	Х	Х		Х			Х	Х	
Reddy, 2002, India	School intervention School&family intervention	Effective Effective	Partly from USA			x x			x x	x x	x x		x x			x x	x x			x x	X X
	Islamic based intervention	Ineffective		Х		Κ			Х	Х			Х	Х		Х				Х	
Tahlil, 2015, Indonesia	Health-based intervention Combined health and Islamic based intervention	Ineffective Ineffective	Indonesia	x x					x x	x x			x x	x x		x x				X X	
Resnicow, 2010 South-	Harm management	Ineffective	Australia		Х				Χ <	X	Х		Х	Х		Х				Х	
Africa,	life skills intervention	Ineffective	USA		Х				Х	X <	Х		Х	х		Х				Х	
Chou, 2006, China	Ineffective		USA	Х				Х		Х	Х		Х			Х			Х		
Seal, 2006, Thailand	Ineffective		USA	Х				Х		Х	Х		Х			Х			Х		
Wen, 2010, China	Ineffective		China			Х			Х	Х			Х	Х		Х				Х	
Marsiglia, 2015, Mexico	Ineffective		USA	Х					Х	Х	Х		Х			Х				Х	
Chen, 2014, China	Ineffective		China			Х		Х		Х			Х			Х				Х	

### Table 4 Summary of cultural appropriateness of the included interventions

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### Table 5 Summary of the theoretical domains of the included studies

				Kn	owle	edge		Skills		Mei deci	Beh	Env	Soc	Beli Con	Beli	Opt	Inte	Ider	Per	Reii	Emo
	The study ID (1 <sup>st</sup> author, year, country) The effectiveness of the interver smoking prevention		ervention in on	consequences	Knowledge on	Normative education	Social competence	Social influence	Combined	mory, attention & ision process	avioural regulation	ironmental context &	ial influences	efs about sequences	efs on capabilities	imism	intions	ntity / Social role	sonal-goals	nforcement s	otion management
1.	Perry, 2009, India	Effective		Х				Х		Х		Х	Х	Х	Х		Х	Х		Х	
2.	Motamedi, 2016 South-Africa	Effective		Х					Х	Х	Х			Х		Х	Х	Х	Х		Х
3.	Lotrean, 2013, Romania	Effective.		Х				Х		Х			Х	Х	Х		Х	Х		Х	
		School intervention	Effective	Х				Х				Х	Х	Х			Х				
4.	Reddy, 2002, India	School intervention plus family intervention	Effective	x				х				х	х	х			х				
		Islamic based intervention	Ineffective	Х		Х	X							Х			Х				
5	Tahlil 2015 Indonesia	Health-based intervention	Ineffective	Х		Х			Х				Х	Х			Х				Х
5.	Turni, 2013, indonesia	Combined health & Islamic based intervention	Ineffective	x		х			x	う				х			х				х
e	Pospisow 2010 South Africa	Harm management	Ineffective	Х			Х			x 🗸				Х			Х				
0.	Resilicow, 2010 South-Africa,	life skills intervention	Ineffective	Х					Х	Х —				Х			Х				Х
7.	Chou, 2006, China	Ineffective		Х		Х		Х		Х			Х	Х			Х	Х			
8.	Seal, 2006, Thailand	Ineffective		Х					Х	Х		Х		Х			Х				Х
9.	Wen, 2010, China	Ineffective		Х					Х	Х		Х	Х	Х			Х	Х		Х	Х
10.	Marsiglia, 2015, Mexico	Ineffective		Х				Х		Х				Х	Х		Х				
11.	Chen, 2014, China	Ineffective		Х				Х				Х	Х	Х			Х	Х			

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1	
2	Nine intervention arms used role-plays, group discussion, and activities or videos in raising
3	awareness of smoking consequences to make the contents attractive and memorable after the
4	intervention (Memory and attention domain) Only effective interventions [45, 46] combined
5	intervention (wemory and attention domain). Only enective interventions [45, 46] combined
0	these methods with encouraging pupils to discuss their views on advantages and
7 8	disadvantages of smoking before deciding to smoke or not (Decision process domain).
0	
9 10	Six arms almed to increase barriers and minimize facilitators of smoking in pupils' environment
10	(Environmental-context and resources domain). All these arms involved enhancing
12	accessibility to information on smoking consequences inside schools. While pupils' exposure to
13	this information was high only in the effective interventions, this exposure was either low [50]
14	or not evaluated [30, 42] in the ineffective arms. Additionally five arms included policy that
15	of not evaluated [55, 45] in the menecuve arms. Additionally rive arms included policy that
16	prevent pupils, teachers, parents and visitors from smoking inside schools. In the effective
17	arms, improving information accessibility and anti-smoking policy went beyond schools to
18	include home [41] or the wider community [40]. This included motivating the community to
19	advocate for national anti-smoking policy [40] or banning tobacco promotion [41].
20	
21	Activities to reduce social influencers of adolescents' smoking (social influence domain) were
22	considered in all the effective interventions, except one [45]. Only effective interventions used
23	peer-pressure to create positive attitude toward non-smoking, or introduced pupils (alone or
24	with teachers or parents) who never smoked as role-models by appouncing their names in
25	school neuroletters. These role models contributed in supporting other numils to sucid
26	school newsletters. These role-models contributed in supporting other pupils to avoid
27	smoking; informally discussed their beliefs about smoking harms and shared their experience
28	of maintaining non-smoking behaviour and refusing smoking offers by friends. The
29	intervention [43] that aimed to change influencers of smoking at home through parents'
30	education on smoking harms without using pupils as role-models or peer-pressure were
31	ineffective even when parents signed contracts not-to-smoke at home. Some ineffective arms
32	aimed to change social norms only through explaining the social refusal of smoking by
34	allieu to change social norms only through explaining the social refusal of smoking by
35	addrescents or obtaining written commitments from teachers or parents or verbal public
36	commitments from pupils in front of their classmates not-to-smoke.
37	All arms considered correcting pupils' <b>beliefs about smaking consequences</b> , at least on health
38	All arms considered correcting pupils beliefs about smoking consequences, at least on health.
39	Although pupils' beliefs that smoking is harmful had improved after interventions in seven
40	arms, only five arms [40, 41, 46, 53] showed translating these beliefs into action by avoiding
41	smoking. All arms [40, 45] that involved correcting beliefs about the emotional, addictive,
42	environmental and social consequences of smoking in addition to harms on health were
43	effective.
44	
45	Besides increasing awareness and beliefs that smoking is harmful, three arms aimed to
46	enhance pupils' <b>beliefs about their capability</b> to avoid smoking. The effective arms [46, 53]
47	enhanced participants' self-confidence in their ability to avoid smoking and supporting their
48	relatives and poors to avoid or quit smoking, trained them in this, and allowed them to
49	
50	practice the acquired skills in role-plays and in the presence of professionals such as teachers
51	or health professionals . One effective arm [40] established school-based support groups for
52	the trained participants even after the intervention completion. The ineffective arm [44]
55 EA	trained pupils, using filmed real-life scenarios, to refuse smoking offers after explaining
55	smoking harms and encouraged them to leave smokers when they smoke. However, authors
55	acknowledged that condensing these activities over short period due to time and resources
57	constraints may have contributed to its ineffectiveness
58	constraints may have contributed to its menectiveness.
59	
60	

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 five effective arms [40, 41, 46, 53]. One effective [45] and three ineffective [39, 44, 48] interventions didn't 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 [43, 49, 50], 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 [40, 41, 45, 46] 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 [45] 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 encouraged 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 practise 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 [40, 46] rewarded pupils (as well as teachers and parents in one arm)[40]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 [43] 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 [43], showing pictures of smoking-related illnesses [50], or discussing reasons for refusing smoking offers only from pupils' perspective [44].

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 study ID (1 <sup>st</sup> author, year, country)     The effectiveness of the intervention in smoking prevention       1. Perry, 2009, India     Effective			Education	Persuasion	Incentives	Coercion	Training	Restriction	Environmental restructuring	Modelling	Enablement
1.	Perry, 2009, India	Effective		Х	Х	Х		х	Х	Х	Х	Х
2.	Motamedi, 2016 South-Africa	Effective			х			Х				
3.	Lotrean, 2013, Romania	Effective	Effective			Х		Х			х	
4.	Reddy, 2002, India	School intervention	Effective	Х	Х			Х	Х			
		School intervention plus family intervention	Effective	х	x			х	х			
		Islamic based intervention	Ineffective	Х				Х				
5.	Tahlil, 2015, Indonesia	Health-based intervention	Ineffective	X				Х				
	muonesia	Combined health & Islamic based intervention	Ineffective	x				х				
6.	Resnicow, 2010,	Harm management	Ineffective	Х	$\square$			Х				Х
	South-Africa	life skills intervention	Ineffective	Х				Х				
7.	Chou,2006, China	Ineffective	1	Х				х		Х		
8.	Seal, 2006, Thailand	Ineffective		х				х				
9.	Wen, 2010, China	Ineffective		Х	х	Х		Х	Х	Х		
10.	Marsiglia, 2015, Mexico	Ineffective		x	x			х				
11.	Chen, 2014, China	Ineffective		Х	Х			Х	Х	Х		

#### Table 6 Summary of the Presence of BCW Intervention Functions in included studies

Presence of a BCW Intervention Function in an intervention arm is indicated with an X

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 antismoking policy went beyond school boundaries to the wider environment through disseminating the national anti-smoking policy and enhance its implementation by community members [40], or advocate banning tobacco advertisements through pupil-signed petition directed to the government [41]. The two ineffective arms [50, 54] established smoking control committees aiming to support antismoking 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 [40] declared teachers and parents plus pupils who never smoked as role-models. The effective interventions used peer-educators who never smoked to: chair, stimulate, summarize 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 [50] or deliver [43] 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 [40, 53]. The effective arm [40, 53] encouraged social norm 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 [43] or producing school-posters discouraging smoking [49, 50]. Two ineffective arms [43, 50] established a school smoking-related committee but the role of this committee was unexplained. One ineffective intervention [49] reported taking additional efforts to prevent pupils' exposure to smoking at home without explaining how.

Only two arms, one of which [40] was effective, considered the **enablement intervention function**, through improving pupils' capability (beyond training and education) and opportunity to remain never-smokers. The effective arm [40] offered smoking prevention, quitting, and counselling services at schools for smoker and non-smoker parents, teachers, and pupils. Whereas in the ineffective arm [55] this function was limited to the provision of schoolbased 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 [45] or combined with either restriction [41] or modelling function only [46] or with all other functions except the coercion function [40].

# 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 recognize, 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 minimized 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 recognized 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 7,712 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, 23, 56-60] 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 recognized barriers [42, 57, 61].

Although self-reporting is a valid and stable indicator for identifying smoking status in many contexts [62, 63], its sensitivity and specificity vary byage, gender, and culture [64]. Adolescents, especially girls, might under-report their smoking where smoking is culturally unacceptable [65-67]; or over-report where smokers are considered mature and impressive

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[32, 64, 68-70]. 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 [69] but is challenged by the constrained resources available in LMICs, as other studies have identified [14, 17, 41, 43, 71, 72].

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 [73]. 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 minimized bias in interpreting the effectiveness of these complex-interventions and explaining why the effectiveness varies across contexts [73, 74].

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' utilization of these modern technologies [75, 76]. Researchers should explore the feasibility, acceptability, and effectiveness of using these technologies for modern methods in school-based interventions in LMICs.

Using standardized 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.Standardizing 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 recognize, 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.

#### **Contributorship statement**

MB, HE, and BB conceived the review. MB, AA, and HA completed screening and extraction of data. MB, HE, BB, and RH devised the analysis plan and AA and HA provided support for analyses. MB 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 is the guarantor of the paper.

#### **Competing interests:None.**

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#### Data sharing statement

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) upon reasonable request.

#### **Ethics Approval Statement**

There was no ethical approval required for this study as it did not include primary data collection.

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#	Key words	No of hits	The PICO
#1	exp "tobacco use"/ or exp smoking/ or Nicotine/		
#2	(Tobacco OR smok* OR cigar* OR Shisha OR water pipe OR Argeela OR nicotine).tw.		
#3	#1 OR #2		Tobacco use/ smoking
#4	(Health* adi2 (promot* OR educat* OR improvement)).tw		
#5	(prevent* OR Control OR program* OR interven* OR strateg* OR polic* OR technique* OR framework* OR Campaign* OR communicat* OR marketing OR advertis* OR media ).tw		
#6	(educat* OR promot* OR teach* OR advise* OR counsel* OR encourage* OR train* OR behavio#ur change* OR campaign).tw		
#7	(anti smok* OR smok* free ) OR (freedom adj3 smoking)		
#8	((Cessation OR reduc* OR abst?in* OR stop* OR quit* OR anti OR free* OR discourag* OR prevent*) adj3 (cigar* OR smok*)).tw		
#9	Psychotherapy, Group/ OR Counseling/		
#10	#4 OR #5 OR #6 OR #7 OR #8 OR #9		Behaviour change/prevention/promotion
#11	Child/ OR Adolescent/ OR Student/ OR pupil/ School OR Adolescent Behavior		
#12	(Adolescen* OR youth* OR child* OR young* OR Student* OR pupil* OR class* OR Minor* OR juvenile* OR teen* OR youth* OR girls OR boys OR school*).tw.		
#13	#11 OR #12		Adolescents
#14	#3 and #10 and #13	2,4214	prevention OR control & Tobacco & adolescents/Adolescents
#15	school*.tw OR class*.tw.		
#16	(school* adj3 based).tw. OR (class* adj3 based).tw.		
#17	#15 OR #16		School-based
#18	#15 and 17	7,433	School-based prevention OR control & Tobacco & adolescents/Adolescents
#19	randomized controlled trial.pt. OR controlled clinical trial.pt. OR randomized.ab. OR placebo.ab. OR drug therapy.fs. OR randomly.ab. OR trial.ab. OR groups.ab.	9	5
#20	#19 Not exp animals/ not humans.sh.		RCT
#21	Meta-analysis OR Systematic review		-
#22	#20 OR #21		RCT OR meta-analysis OR systematic review
#23	#18 and #22	1,840	RCT studies on School-based prevention / Tobacco /Adolescents
#24	limit to humans	1,241	

#### Supplement 1: The full electronic search strategy employed in Medline database, as an example.



#### Supplement 2: The effect size of the included interventions in a funnel plot



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### Synthesis Without Meta-analysis (SWiM) reporting items

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SWiM reporting	Item description	Page in manuscript	Other*
item		where item is	
		reported	
Methods		1	•
1 Grouping	1a) Provide a description of, and rationale for, the groups used in the synthesis (e.g., groupings of populations,	Page 7	
studies for	interventions, outcomes, study design)		
synthesis			
	All the included studies were included in the analysis. The included studies were categories to effective and		
	ineffective in preventing pupils from smoking initiation. The country of implementation was also identified in all		
	the data synthesis tables. All the included studies were RCTs.		
	1b) Detail and provide rationale for any changes made subsequent to the protocol in the groups used in the		
	synthesis		
	No changes were made to the protocol.		
2 Describe the	Describe the standardised metric for each outcome. Explain why the metric(s) was chosen, and describe any	Page 6	
standardised	methods used to transform the intervention effects, as reported in the study, to the standardised metric, citing		
metric and	any methodological guidance consulted		
transformation			
methods used	Several theoretical perspectives were used to review the included interventions in order to get a comprehensive		
	understanding of SBSPI that were effective LMIC. The following theoretical perspectives were used in to review		
	SBSPIs that were implemented in LMICs: 1) The middle layer of BCW (Michie et al., 2014a) was used to specify		
	the intervention functions of the included SBSPIs. 2). Griffin and Botvin (2010) classification of smoking		
	prevention curriculum was used to adapt the Theoretical Domain Framework (TDF) (Atkins et al., 2017) which		
	was then used to explain the theoretical constructs of the included interventions. <b>3)</b> The findings from the above		

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	steps were discussed using the inner layer of BCW, the capability, opportunity, motivation and behaviour (COM-		
	B) model. 5) The cultural- appropriateness of the included interventions was assessed using Kreuter et al. (2003)		
	and Castro et al. (2010) classifications of approaches, dimensions and strategies of cultural- appropriateness.		
	Using these theoretical perspectives allowed identifying the approaches and dimensions of cultural-		
	appropriateness, intervention functions, theoretical-constructs and smoking prevention curriculum that were		
	commonly used in effective SBSPIs in LMICs to enhance pupils' capability, opportunity and motivation to avoid		
	smoking initiation. This provided a full-range of potential options for SBSPIs that were used in low-middle-income		
	settings and provides rationales for selecting among those options for SBSPI to be implemented in the future.		
<b>3</b> Describe the	Describe and justify the methods used to synthesise the effects for each outcome when it was not possible to	Page 6 and 7	
synthesis	undertake a meta-analysis of effect estimates		
methods	No.		
	The data extraction form included function checklists that were used in this review to identify the presence or		
	absence of each of the nine BCW intervention functions, the 17 theoretical-domains and the smoking prevention		
	curriculum in each arm of the included SBSPI in LMICs. More than one function, theoretical-domain and curriculum		
	were allowed to be selected for one intervention or activity. For example classroom discussion of the advantages		
	and disadvantages of smoking was coded under the 'education' and 'persuasion' function. To explore cultural-		
	appropriateness of the included SBSPIs, the checklist identified interventions country of origin plus approaches,		
	dimensions and strategies used in adapting each intervention's arm to the culture of the targeted population.		
	According to Cochrane guidance for systematic reviews of interventions (Higgins and Green, 2008), meta-analysis		
	and regression are used to pool the findings of homogenous studies in order to increase sample size and obtain a		
	better estimation of the impact of interventions. In this review, there is heterogeneity across the included		
	studies in defining, measuring, assessing and presenting outcomes of the included interventions. Separating the		
	included studies into subgroups that used similar definitions, measurements and ways of reporting outcomes		
	would have resulted in a very small sample size in each group that might not make significant changes in the		
	findings on effectiveness. Therefore, quantitative synthesis, including meta-analysis and meta-regression, was		
	considered inappropriate in this review and a narrative synthesis of the findings was used.		
		L	

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### Synthesis Without Meta-analysis (SWiM) reporting items

The following steps were followed to synthesis the data: 1) after extracting the data from each study, all findings were summarised in tables, see the results section. 2) the extracted data was used to produce a narrative descriptive summary of the intervention functions, theoretical-underpinning and constructs and smoking prevention curriculum, that were used in the included interventions in addition to the cultural-appropriateness and effectiveness of these interventions in preventing smoking initiation among pupils. These issues will be discussed in the results section. 3) Thereafter, patterns among the included interventions were identified and discussed in terms of the intervention functions, theoretical constructs and smoking prevention curriculum involved and the effect of these interventions on preventing pupils from smoking initiation. 4) After that the interventions' effectiveness was discussed in relation to variance or similarity between interventions in terms of the included intervention functions, theoretical-constructs, smoking prevention curriculum and culturalappropriateness of interventions. 5) Lastly, the above findings were discussed, in the discussion section, using the framework that links COM-B model with TDF and the matrix that links COM-B model with intervention functions, as they were developed by behaviour change specialists to facilitate discussing and designing behaviour change interventions (Michie et al., 2014a). The review was concluded with how effective SBSPIs in Arabic and/or LMICs enhanced pupils' capability, opportunity and motivation to avoid smoking initiation. The outcomes of the data synthesis process are explained in the results sections. Why we meta-analysis was not done in this review: Although all the included studies aimed to prevent smoking initiation by adolescents, different indicators were used across these studies to assess the impact of interventions on participants' smoking status and there was inconsistency in defining and measuring these indicators. The outcome of most (8/11)

Although all the included studies aimed to prevent smoking initiation by adolescents, different indicators were used across these studies to assess the impact of interventions on participants' smoking status and there was inconsistency in defining and measuring these indicators. The outcome of most (8/11) interventions was assessed by measuring changes in life-time never-smoking rates (Chen et al., 2014, Chou et al., 2006, Resnicow et al., 2010, Lotrean et al., 2010, Reddy et al., 2002, Wen et al., 2010, Tahlil et al., 2015) using the GYTS definition of never-smokers, those who never tried smoking in their life even a puff or two (CDC, 2016). However, one study (Motamedi et al., 2016) considered those who smoked a puff or two as never-smokers. The outcome of two studies was assessed by measuring changes in never-smoking rates in the past 30-days (Marsiglia et al., 2015) or two-months (Seal, 2006) before the survey. Whereas the outcome of one intervention was assessed by measuring changes in the past-month ever-

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smoking rate, the rate of any smoking even a puff or two anytime in the 30-days before the final-	
evaluation (Perry et al., 2009).	
<ul> <li>Most studies separated the findings on cigarette-smoking from other tobacco-use but findings on</li> </ul>	
cigarette smoking in two studies were combined with findings on either smoking other tobacco products,	
like Bidi (Reddy et al., 2002) or using any tobacco products (smoked or smokeless) (Seal, 2006).	
Furthermore, different reference periods were used to assess current smoking status across the included	
studies. While most studies used smoking behaviour in the past-30 days before the survey as a reference	
period for assessing current smoking behaviour of particpnats, few studies referred to smoking in the	
past two (Seal, 2006) or three months before the survey (Wen et al., 2010). Accordingly, even when the	
same definitions used across some of these studies their findings can not be pooled in a meta-analysis	
because they represent different smoking behaviours that are measured over different periods of time.	
<ul> <li>Additionally, there was a discrepancy in presenting findings on the main outcomes of the included</li> </ul>	
interventions. Some studies measured the prevalence of ever-smoking among those who never smoked	
before and after the intervention (Perry et al., 2009, Resnicow et al., 2010, Seal, 2006) whereas other	
studies calculated odd-ratio of ever-smoking rates between intervention and controls (Chou et al., 2006,	
Chen et al., 2014, Motamedi et al., 2016, Reddy et al., 2002, Wen et al., 2010, Tahlil et al., 2015) to	
indicate the intervention's effectiveness on preventing smoking initiation. One study presented the	
findings only as changes of means of eight scores (0= none, 1=one puff, 2=one cigarette or part, 3=two or	
three cigarettes, 4= four or five cigarettes, 5=six to ten cigarettes, 6=elevn to twenty cigarettes, 7=one to	
five packs) that are used to assess current-smoking status; these scores are not the real number of	
cigarettes smoked by participants in the past-30-days before the survey. Changes in means of these	
scores were represented in a growth-curve-model of four waves to estimate intervention's effects on	
frequency and amounts of cigarettes used (Marsiglia et al., 2015). Three studies measured the transition	
from never-smoking at baseline to recent-smoking, smoked at least once in the past-30-days, (Chou et	
al., 2006) or ever-smoking (Wen et al., 2010) or regular-smoking, smoke at least once a week, (Lotrean et	
al., 2010) at the end of the follow-up period. Although it is recommended to use growth-curve-analysis in	
behaviour changes interventions to illustrate the growth and change patterns of the targeted behaviour	
over-time (McArdle and Nesselroade, 2003), only one of the included studies (Perry et al., 2009) used the	
growth-curve , which is derived from a three-levels, linear, random coefficients-regression-model, to	

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	demonstrate the intervention's effectiveness over-time (Perry et al., 2009) in addition to the other study		
	described earlier (Marsiglia et al., 2015) that used means of scores, not real numbers of smoking time or		
	frequency, to estimate changes in smoking status over-time.		
	• The conclusion on interventions' effectiveness was based on the significance of the identified findings on		
	preventing smoking initiation among participants, using P-value and 95% confidence-intervals. When		
	confidence-intervals were unreported in the articles, it was calculated from the published information,		
	when possible (Seal, 2006). In one study (Marsiglia et al., 2015), calculating confidence-intervals was		
	difficult because the findings were only presented in growth-curve-model for tobacco-use. In this case,		
	the authors' conclusion that this intervention was ineffective in preventing pupils from smoking initiation		
	was considered in this review.		
	According to the discussion above, the findings of the included studies can not be pooled together because they		
	represented changes in different smoking indicators which are differently defined, measured, assessed and		
	reported. Separating the included studies into subgroups based on using similar definitions, reference period of		
	assessment and ways of presenting findings would have resulted in small sample-size in each group that might		
	not make significant changes in the findings on effectiveness. Accordingly, narrative data-synthesis was used in		
	this review		
4 Criteria used	Where applicable, provide the criteria used, with supporting justification, to select the particular studies, or a	Page 7	
to prioritise	particular study, for the main synthesis or to draw conclusions from the synthesis (e.g., based on study design,		
results for	risk of bias assessments, directness in relation to the review question)		
summary and			
synthesis	Based on the recommendations by Michie et al. (2014a) and Francis et al. (2012), the reviewers referred to the		
	definitions and examples of each intervention function and theoretical-domain to ensure effective utilization of		
	these frameworks in coding the intervention functions and theoretical-domains that were used in SBSPIs.		
	Additionally, a discussion of these definitions and examples was organized before starting data extraction in		
	order to clarify boundaries between intervention functions and domains and thus achieve better inter-coder		

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	Authors were contacted to get more information on their interventions and data was coded only based on the		
	existing evidence on each of the identified criteria/elements.		
SWiM reporting item	Item description	Page in manuscript where item is reported	Other*
of heterogeneity in	meta-analysis of effect estimates and its extensions to investigate heterogeneity		
reported effects	The funnel plot of the included interventions was used to demonstrate the effect estimate of each intervention against the sample size of this study, in which the study size is plotted on the horizontal axis. According to the Cochrane handbook for systematic reviews of interventions (Higgins and Green, 2008, Shuster, 2011), the funnel plot of the studies in this review is asymmetrical funnel with the presence of bias because of some smaller studies with lower methodological quality which produced exaggerated intervention effect estimates of these interventions.		
	According to (Sterne et al., 2011), the funnel plot suggested the presence of publication bias which could be due to delayed publication, selective outcome reporting, selective analysis reporting or the language of the publication language. Variation in sample sizes and heterogeneity in the intensity of the included intervention could be other reasons for the asymmetry of the funnel plot (Sterne et al., 2011). If there is no publication bias and the included interventions were effective in preventing adolescents from smoking initiation, then most of the dots are expected to be located in the top left of the funnel plot as negative effect size is what influence adolescents' smoking behaviour positively.		
<b>6</b> Certainty of evidence	Describe the methods used to assess certainty of the synthesis findings Authors were contacted to get more information on their interventions and data was coded only based on the existing evidence on each of the identified criteria/elements. Key findings were summarised in tables to facilitate validity checking and comparison across studies.	Page 6	

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	All data were extracted by the researcher then a randomly selected sample (25%) of the included articles was		
	checked independently by another postgraduate researcher. Any disagreements were resolved by consensus or		
	recourse to the supervisors. Time and resources limitation of this study as well as the university restriction of		
	shared work in PhD thesis restricted fully double screening of the included articles.		
	,		
	The researcher independently assessed the risk of bias then another postgraduate researcher independently		
	checked the risk of bias in a random sample (25%) of the included articles. Any disagreements (one case) were		
	resolved by consensus or recourse to the supervisors		
7 Data	Describe the graphical and tabular methods used to present the effects (e.g., tables, forest plots, harvest plots).		
presentation	Specify key study characteristics (e.g., study design, risk of bias) used to order the studies, in the text and any		
methods	tables or graphs, clearly referencing the studies included		
	The findings were presented in the following tables:		
	Error! Reference source not found, summarizes participants' characteristics		
	Frror! Reference source not found, illustrates the characteristics of the included trials		
	Table 1 summarizes the risk of bias in the included studies	Page 10	
	Frrort Reference source not found summarises approaches dimensions and strategies used for cultural	Page 11	
	appropriateness of each intervention arms	Page 12	
	Error Peterence source not found mans the presence and absence of the 17 TDE theoretical domains	Page 14	
	• Error! Reference source not found, illustrates the interventions offectiveness in relation to the involved		
	intervention functions	Page 15	
	intervention functions.	Page 18	
Results		·	
8 Reporting	For each comparison and outcome, provide a description of the synthesised findings, and the certainty of the		
results	findings. Describe the result in language that is consistent with the question the synthesis addresses, and		
	indicate which studies contribute to the synthesis		
	Cultural appropriateness		

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Most (10/15) intervention arms were based on effective interventions originally developed in high-income countries. In three [40, 44, 49] 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 in adolescents smoking preventions and community members who have an understanding of what is feasible and acceptable. However, only three arms collected quantitative data on feasibility and acceptability of the contents before implementation.	Page 13-14	
<b>Error! Reference source not found.</b> 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 third (10/15) of interventions considered using cultural 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 during designing nine arms (socio-cultural 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, demonstrated cultural tailoring which is		
defined as using all the above cultural appropriateness strategies. Theoretical constructs The design of all effective interventions, except one [41], was informed by at least one theory but insufficient details were available on how. Error! Reference source not found. maps the presence and absence of the 17 TDF theoretical least	Page 13, 14	
theoretical domains. Intervention functions Error! Reference source not found. illustrates the interventions effectiveness in relation to the involved intervention functions.	Page 17 and 18	

Discussion		
<b>9</b> Limitations of the synthesis	Report the limitations of the synthesis methods used and/or the groupings used in the synthesis, and how these affect the conclusions that can be drawn in relation to the original review question	Page 21-22
	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 limited publications	
	resulting from limited experience and inaccessibility to international databases or language barriers. Other systematic reviews [14, 23, 56-60]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 recognized barriers [42, 57, 61].	
	Although self-reporting is a valid and stable indicator for identifying smoking status in many contexts [62, 63], its sensitivity and specificity vary per age, gender, and culture [64]. Adolescents, especially girls, might under-report	
	their smoking where smoking is culturally unacceptable [65-67]; or over-report that where smokers are considered mature and impressive [32, 64, 68-70]. 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 [69] but is challenged by the constrained resources available in LMICs, as other studies have identified [14, 17, 41, 43, 71, 72].	
	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 [73]. Poor reporting of fidelity and implementation quality without process evaluation in some	

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studies is another limitation. Assessing the extent of delivering interventions as planned through process	
evaluation could have minimized bias in interpreting the effectiveness of these complex-interventions and	
explaining why the effectiveness varies across contexts [73, 74].	
Other limitations of the review are that three trials were excluded because the findings is 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 trails, 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.	

PRISMA=Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

\*If the information is not provided in the systematic review, give details of where this information is available (e.g., protocol, other published papers (provide citation details), or website (provide the URL)).

review only