



# **Characteristics and impact of theory of planned behavior interventions on smoking behavior: A systematic review of the literature.**

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## **► To cite this version:**

Olivier Lareyre, Mathieu Gurlan, Anne Stoebner-Delbarre, Florence Cousson-Gélie. Characteristics and impact of theory of planned behavior interventions on smoking behavior: A systematic review of the literature.. Preventive Medicine, 2020, <10.1016/j.ypmed.2020.106327>. <hal-03166742>

**HAL Id: hal-03166742**

**<https://univ-montpellier3-paul-valery.hal.science/hal-03166742v1>**

Submitted on 15 Dec 2022

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Characteristics and impact of theory of planned behavior interventions on smoking behavior:  
A systematic review of the literature

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**Word Count (Abstract):** 244

**Word Count (Manuscript):** 4497

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**Abstract**

Theoretical frameworks such as the theory of planned behavior (TPB) can be applied to design and evaluate smoking behavior interventions. The present systematic review aimed to: (i) determine the characteristics of TPB-based interventions and their reported impact on smoking behavior and TPB variables, (ii) evaluate the level of methodological quality in the included studies, and (iii) assess the quality of the theoretical implementation. Studies were eligible for inclusion if the intervention targeted smoking behavior, was explicitly based on the TPB, and if smoking behavior or intention was measured at least at post-intervention. Relevant articles were identified through searches on databases and internet search engines, responses to messages sent on thematic forums, consultation of prominent authors, and manual searches on key websites and key TPB-publications. Seventeen studies met the inclusion criteria. A majority of studies (65%) targeted the student population (i.e., elementary school, high school, university). Interventions minimally included the provision of health messages. The proportion of studies that reported a significant impact on smoking behavior, intention, attitude, subjective norm, or PBC ranged between 42% and 50%. Regarding methodological quality, unclear or high risks of bias were notably found regarding the selection of participants, data collection methods, withdrawal and drop-outs, and blinding. Regarding theoretical implementation, the reciprocal link between intervention techniques and TPB variables targeted remain unclear for a majority of studies. To better inform tobacco prevention and TPB research, future studies should more systematically use rigorous methods when designing, implementing, and reporting TPB-based interventions.

**Keywords:** tobacco, health promotion, psychosocial theories, systematic review

## Introduction

Despite years of progress supported by the World Health Organization (WHO) Framework Convention on Tobacco Control to guide national policies, 19% of the world population is currently smoking, causing 8 million deaths every year (World Health Organization, 2019). In order to prevent tobacco smoking, many countries are supporting actions of tobacco control for a long time, with nonetheless a high variability in the effectiveness of the implemented interventions (e.g., Rice et al., 2017). Applying theory to design and evaluate behavior change interventions is currently viewed as good practice (Conner & Norman, 2015). As highlighted by some authors (Michie & Prestwich, 2010), implementing theory-based interventions provides several benefits, including the identification of key constructs to target and the selection of appropriate intervention techniques to use. Moreover, collecting empirical data from theory-based interventions can also aid in the understanding of the underlying mechanisms (proposed by the theory) implied in the effectiveness of interventions (Michie et al., 2018). In this context, using theory to design interventions is advocated to contribute to the development of potentially efficient and replicable programs, to aid in the understanding of mechanisms of behavior change, and to provide a basis for theorists to refine their models (Rothman, 2004).

To design interventions, many theories of behavior change are available (Michie et al., 2014). One popular model that has received wide attention in health behavior research is the theory of planned behavior (TPB) (Ajzen, 1991). The TPB is a model of rational decision-making that proposes that behavior is determined by a number of potentially changeable cognitions. More precisely, the model proposes that behavioral intention (i.e., an individual's motivation to act) is the immediate antecedent of behavior. Intention, in turn, is determined by attitude (i.e., favorable or unfavorable evaluation of the targeted behavior), subjective norm (i.e., perceived social pressure from important others about performing the behavior and level of adoption of the behavior by important others) and perceived behavioral control (PBC) (i.e., perceived ability to perform the behavior). This latter construct is also hypothesized to directly predict behavior. Numerous reviews and meta-analyses have reported the validity of the TPB to explain various health behaviors such as physical activity, dietary behavior, or alcohol consumption (Cooke et al., 2016; Hagger et al., 2016; McDermott et al., 2015; McEachan et al., 2011). Concerning smoking behavior, if studies could vary with regard to the behavioral outcome (e.g., smoking reduction, smoking cessation) or the kind of products explored (e.g., cigarettes only, drugs including tobacco), previous meta-analyses and reviews

have also reported the validity of the TPB in those different contexts (McEachan et al., 2011; Topa & Moriano, 2010).

Otherwise, the TPB has also been used as a theoretical framework for designing health behavior interventions. Previous reviews and meta-analyses have reported that TPB-based interventions appear efficient in various behavioral domains, including the reduction of sexual risk behaviors (Tyson et al., 2014), or the promotion of physical activity (Gourlan et al., 2016). However, information concerning the efficacy of TPB-based interventions specifically in the domain of smoking behavior remains sparse. Hardeman et al. (2002) systematically reviewed the application of the TPB in behavior change interventions. They noted that at this time only two papers out of 30 addressed smoking behavior and that those papers did not examine the impact of TPB-based interventions on smoking behavior per se but solely evaluated the interest of subjects to participate in a program of smoking cessation. More recently, Steinmetz et al. (2016) reported in their meta-analysis a significant global effect of TPB-based interventions to promote change in various health behaviors and change in TPB variables. However, interventions targeting smoking behavior were regrouped within “alcohol and drugs” studies, which preclude the possibility of establishing a detailed synthesis of TPB-based interventions specifically in the smoking domain.

The present systematic review aims to identify and synthesize knowledge concerning the efficacy of TPB-based interventions on smoking behavior of minors or adults in studies using quasi-experimental (pre- and post-tests) or randomized controlled trial designs, through three objectives: First, to determine the characteristics of TPB-based interventions and their reported impact on smoking behavior and TPB variables (i.e., attitude, subjective norm, PBC, intention). Regarding the existing reviews and meta-analyses (e.g., Hardeman et al., 2002; Steinmetz et al., 2016), this work appears as the first to inform on the efficacy of TPB-based interventions specifically on smoking behavior. Moreover, the present review will also provide a detailed insight into the ways and contexts in which the TPB was used to change smoking behavior. Second, to evaluate the level of methodological quality of the included studies (e.g., design, data collection methods). This point appears of particular importance as it gives some crucial information about the validity of the results presented and the robustness of the conclusions that can be drawn from this review. Third, to assess the quality of the theoretical implementation in the included studies. As pointed out by some authors (Michie & Prestwich, 2010), implementing a theory-based intervention protocol is a rigorous scientific process that can be evaluated to determine to what extent the theory was used to develop the

intervention, to explain intervention effects, and to provide considerations for future theory-based research. Nevertheless, Prestwich et al. (2014) reported in a meta-analysis that theories were rarely used extensively to develop or evaluate physical activity and healthy eating interventions. This review will explore how the TPB was implemented in smoking interventions.

## **Method**

### *Inclusion and exclusion criteria*

Studies were included in the present systematic review if they met the following criteria: (i) the primary component or one of the components of the intervention targeted smoking behavior, (ii) the intervention implemented was based on the TPB (i.e., TPB had to be explicitly named in the text), (iii) smoking behavior or intention related to smoking behavior was measured at least at post-intervention time point. The exclusion criteria were (i) studies only evaluating the intention of subjects to participate in a program, (ii) interventions which could target one or several variables included in the TPB (e.g., attitude, PBC) but not explicitly citing the model, and (iii) results published in another language than English or French. Of note, the studies could be either experimental (using pre- and post-tests) or randomized controlled trials, the intervention could combine the TPB with other theoretical frameworks and could be oriented toward smoking prevention and/or treatment. No restriction was either placed upon the mode of delivery of the intervention (e.g., face to face, internet) or upon the age of participants (e.g., adolescents, adults).

### *Search strategies*

A comprehensive investigation was completed using four search strategies. First, studies were identified by searching through the MEDLINE, PsycINFO, and PsycARTICLES, Academic Search Premier, Eric, Francis, Pascal, Psychology and Behavioral Sciences Collection, and SocIndex databases (last search November 19, 2019). Mesh and text-words were used in MEDLINE. Additional searches were carried out on the search engines of Google Scholar (scholar.google.com), Researchgate (researchgate.net), and the National Institute of Health (nih.gov) (more details in Supplementary File 1). Second, additional manual searches were also carried out. More precisely, references were screened in the bibliography section of Ajzen's website, in the registry of clinical trials website, in Cochrane Reviews related to tobacco retrieved from the Cochrane Library, and in relevant published TPB reviews, meta-analyses, books, and book chapters (more details in Supplementary File 2). Third, messages

were sent on thematic forums of the American Psychological Association, on the listserv of the Society for Personality and Social Psychology, and on Researchgate forum discussion. Fourth, e-mails were sent to prominent authors of the TPB (i.e., Armitage, Ajzen, Conner, Godin, Hardeman, McEachan, Rhodes, Taylor, West). References of articles retrieved from thematic forums and e-mails sent by prominent authors were also screened manually.

The titles and abstracts found in the electronic databases were initially and independently screened by two trained reviewers ( [REDACTED] ) to determine their adequacy with this systematic review. Similarly, those two reviewers also independently screened references from the additional manual searches and from articles retrieved from thematic forums and e-mails sent by prominent authors. The final selection was based on full-text reading and performed by four trained reviewers ( [REDACTED] ). Any disagreements were resolved by discussion.

#### *Coding procedure*

Descriptive data were extracted by (i) study population and design: Year, country of the intervention, number of participants analyzed, gender, sample characteristics (e.g., smokers, university students), (ii) characteristics of the intervention: Objective (i.e., prevention to maintain non-smoking, treatment to reduce, abstain or quit smoking, combined intervention to reduce smoking prevalence in a group), components implemented (e.g., education/information, skill training), mode of delivery (e.g., internet, face to face), length, number of sessions, (iii) outcomes: Presence of a measure of smoking behavior and/or TPB variables, significant impact of the intervention (i.e.,  $ps < .05$  for the statistical tests performed) on smoking behavior and/or TPB variables.

Additionally, the methodological quality of each study was examined using the 14 items from the Effective Public Health Practice Project (EPHPP) (Thomas et al., 2004). This tool has demonstrated content and construct validity (Thomas et al., 2004). In a report assessing over 190 bias assessment tools for intervention studies, the EPHPP was one of six shown to be appropriate for use in systematic reviews (Deeks et al., 2003). The quality categories that were rated included selection bias (items 1-2; i.e., representativeness of the sample, proportion of individuals who agreed to participate), study design (items 3-6; i.e., design of the study, method of randomization), confounders (items 7-8; i.e., presence of significant differences between groups prior the intervention, control of confounders in main analyses), blinding (items 9-10; i.e., outcome assessor aware of the intervention status of participants, participants aware of the research question), data collection methods (items 11-12; i.e.,

reliability – validity of outcome measures), and withdrawals and drop-outs (items 13-14; i.e., information about drop-outs, proportion of completers). For each study, each quality category was rated as “strong,” “moderate” or “weak.” Then, a global quality score was given to each study. More precisely, studies with a “strong” global rating did not have any “weak” for any quality category, studies with a “moderate” global rating had one “weak” rating in one of the quality categories, and studies with a “weak” global rating had two or more “weak” ratings in the quality categories (see Thomas et al., 2004).

Finally, the quality of the theoretical implementation of the TPB in the included studies was coded using 23 items from the Theory Coding Scheme (TCS) (Michie & Prestwich, 2010). The few adaptations of the scale used in the present review as compared to the original work of Michie and Prestwich (2010) (e.g., two items not included as they already represented inclusion criteria) are presented in Supplementary File 3. All items were coded as “yes” or “no.” For each study, four composite scores were created to report the score of: Theoretical basis of the intervention (items 1-9; i.e., mention of the TPB variables targeted, mention of another theoretical model, TPB variables use to select participants – to tailor intervention, interrelationships between intervention techniques and TPB variables), quality of the measure of the theoretical constructs (items 10-15; i.e., assessment of TPB variables, validity and reliability of TPB measures), nature of the results on theoretical constructs (items 16-20; i.e., impact of the intervention on TPB measures, mediational analyses), and feedback and considerations on the theory (items 21-23; i.e., results use to discuss, validate, refine the TPB). An overall theoretical implementation score summing the 23 items was also created for each study.

Two reviewers (■■■■■) independently coded the data for each included study. Results of the coding were then compared. The interrater reliability for the variables coded was at least substantial ( $\kappa > .63$ ), with a satisfactory global mean  $\kappa = .88$  ( $SD = .13$ ) (more details in Supplementary File 4). Any disagreements were resolved by discussion with ■■■■ and ■■■■.

## Results

### *Search results*

Figure 1 displays the process of study selection. The four search strategies used in this systematic review initially returned a total of 8279 articles. Based on the screening of titles and abstracts, a total of 7039 articles were excluded using the following criteria: (i) not an intervention and/or not about tobacco, (ii) other languages than English or French. After



having removed the duplicates between the four search strategies, 536 full-text articles were screened. A total of 519 articles were excluded using the following criteria: (i) not an intervention about tobacco, (ii) intervention not based on the TPB, (iii) neither smoking behavior nor intention is measured at post-test. As a result, 17 studies – involving 17 independent samples – met all inclusion criteria and were included in this review.

### *Characteristics of the studies*

The general characteristics of the 17 included studies are presented in Table 1. The majority ( $n = 15$ , 88%) were published after the year 2010, while 2 (12%) were in 2008. The samples were mixed-sex in 11 studies (65%) and included men exclusively in the remaining 6 studies (35%). The population targeted was described as students (i.e., elementary school, high school, university) in 11 studies (65%). A total of 3 other studies (18%) targeted individuals in contexts of health risks (i.e., in preoperative evaluation, fathers with a sick child, at risk of type 2 diabetes and/or cardiovascular diseases). Last, 3 studies (18%) targeted only smokers in various contexts (i.e., Korean American, public employees).

Regarding the objective of the 17 interventions, 8 (47%) focused on tobacco treatment for smokers, 7 (41%) were combined programs addressed to groups of both smokers and non-smokers and 2 (12%) aimed at preventing initiation among non-smokers. All the programs included an education/information component. This consisted of the provision of health messages related to topics such as deleterious effects of smoking, or benefits of quitting smoking. In 10 studies (59%), the intervention also included skill training components such as learning to manage stress, encouraging self-affirmation or learning to deal with relapse-prone situations through various means (e.g., planning, problem-solving strategies). Interventions were delivered in a variety of ways, most often combining several modes of delivery ( $n = 14$ , 82%), predominantly by face to face ( $n = 10$ , 59%) and printed materials ( $n = 9$ , 53%).

### *Measure and impact of interventions on smoking behavior and TPB variables*

As reported in Table 2, of the 17 included studies, 13 (76%) reported results on smoking behavior, and 12 (71%) on intention. A total of 7 studies (41%) reported results on both smoking behavior and all TPB variables, 3 (18%) only on smoking behavior, and 3 (18%) only on all TPB variables. Of note, no study addressing smoking prevention reported results on smoking behavior, and 6/8 studies on smoking treatment did not report results on at least one variable of the TPB. A significant impact of the intervention was reported in 6/13 studies (46%) on smoking behavior, in 6/12 (50%) on intention, in 6/13 (46%) on attitude, in 5/12

(42%) on subjective norm, and in 6/12 (50%) on PBC (see Table 2). Of note, of the 17 included studies, 1 (6%) reported a significant impact on both smoking behavior and all TPB variables, 3 (18%) reported a significant impact on smoking behavior but not on any TPB variables, and 1 (6%) reported a significant impact on all TPB variables but not on behavior.

### *Methodological quality of interventions*

Results of the EPHPP coding are summarized in Table 3 (see Supplementary File 5 for the detailed result of each item of the EPHPP for each study). Of the 17 included studies, 10 (59%) were rated as “weak” for their global methodological quality score, 5 (29%) as “moderate,” and 2 (12%) as “strong.” When more specifically exploring the quality categories, 14 studies (82%) were rated as “strong” for the study design, since 13 were randomized controlled trials and 1 was a controlled clinical trial. No study was rated as “weak” for this category. Regarding confounders, when applicable (confounders were not assessed for one-group studies), a majority of studies ( $n = 8/14$ , 57%) were rated as “strong,” but 5/14 (36%) were rated as “weak” (i.e., potential confounders not controlled in analyses, or insufficient information available). A total of 7 studies (41%) were rated as “weak” for selection bias (i.e., sample not or insufficiently representative of the targeted population), and 7 as “moderate” (41%) (i.e., insufficient information available). Similarly, 7 studies (41%) were rated as “weak” for data collection methods (i.e., insufficient information about validity and reliability of the tools measuring smoking behavior), and 6 (35%) as “moderate” (i.e., insufficient information whether for validity or reliability). A majority of studies ( $n = 12$ , 71%) were rated as “moderate” for blinding (i.e., insufficient information available). Finally, 5 studies (29%) were rated as “strong” for withdrawal and drop-outs, 5 (29%) as “weak” (i.e., no information available, or follow-up rate < 60%), and 7 (41%) as “moderate” (i.e., follow-up rate between 60% and 79%).

### *Theoretical implementation of interventions*

Results of the TCS for the 17 included studies are summarized in Table 4 (see Supplementary File 6 for the detailed result of each item of the TCS for each study). The mean theoretical implementation score (23 items, maximum score = 19) was 7.41 (SD = 2.85, median = 8), ranging from 1 to 13. Regarding the theoretical basis of interventions (9 items, maximum score = 7), the mean score was 3.24 (SD = 0.90, median = 3). Sixteen studies (94%) mentioned the TPB variables as predictors of smoking behavior. No study has used TPB variables to select participants or to tailor the intervention. Eight studies (47%) explicitly linked all their intervention techniques to at least one TPB variable. There was also a total of

8 studies (47%) that explicitly linked all TPB variables to at least one technique. Concerning the measure of theoretical constructs (6 items, maximum score = 4), the mean score was 2.71 (SD = 1.45, median = 3). It can be noted that 9 studies (53%) reported some evidence of the reliability of every TPB measure (e.g., Cronbach's alphas), and 8 (47%) reported having followed the existing recommendations for the construction of a TPB questionnaire (e.g., Ajzen, 2006b; Francis et al., 2004). Regarding the results of interventions on theoretical constructs (5 items, maximum score = 5), the mean score was 0.76 (SD = 1.20, median = 1). Only 1 study (6%) analyzed and reported that the impact of the intervention on smoking behavior was significantly mediated by a TPB variable. Last, concerning feedback and considerations on the theory (3 items, maximum score = 3), the mean score was 0.71 (SD = 0.47, median = 1). Results were discussed in relation to TPB in 11 studies (65%), but only 1 (6%) provided an appropriate support to the theory, and none used results to make some propositions to refine the theory.

## Discussion

The present systematic review is the first to specifically focus on TPB-based interventions on smoking behavior. A total of 17 studies were identified, which is lower than the number of observational studies identify ( $n \geq 27$ ) when TPB is used to explore determinants of smoking behavior (McEachan et al., 2011; Topa & Moriano, 2010). The publication of the results of the included studies mainly begins after 2010. The use of the TPB to design and evaluate programs targeting smoking behavior appears thus a little bit more recent than for some other health behaviors such as risky sexual behaviors (Tyson et al., 2014) or physical activity (Gourlan et al., 2016). In the current review, all the programs minimally included the provision of health messages. As previously reported in other health contexts (Hagger & Chatzisarantis, 2016; Hardeman et al., 2002), persuasive communication is the most widely component used in TPB-based interventions. Of note, this provision of information was regularly completed with at least another component such as skill training or counseling sessions. Regarding program objectives, it appears that only 2 programs were aimed at preventing initiation among non-smokers. As smoking cessation remains a challenge (U.S. Department of Health and Human Services, 2020), future TPB-based interventions should more consistently focus on preventing its initiation. In addition, the studies addressing smoking prevention did not measure post-intervention behavior, and a majority of the studies on smoking treatment did not measure all TPB variables. In line with the existing recommendations (Michie & Prestwich, 2010), future TPB-based interventions should assess

both smoking behavior and TPB variables, whatever the objective pursued. Last, when measured, no more than half of the studies reported a significant impact on smoking behavior, intention, attitude, subjective norm, or PBC. The efficacy of TPB-based interventions on various health behaviors such as risky sexual behaviors, physical activity or nutrition has been reported elsewhere (Gourlan et al., 2016; Hardeman et al., 2002; Steinmetz et al., 2016; Tyson et al., 2014). Nonetheless, Steinmetz et al. (2016) also reported in their meta-analysis that TPB-based interventions in the “alcohol and drugs” domain, which included smoking behavior, had a less consistent impact compared to other behavioral domains. From all of those results, it appears that despite some evidence of the efficacy of TPB-based interventions in various health domains, the impact of those interventions on TPB variables and smoking behavior remains to be confirmed, and should be further explored.

The global methodological quality score was rated as “low” for a majority of studies (59%), and “strong” for only a small minority (12%). For most quality categories, a majority of studies were rated as “low” or “moderate.” The proportion of studies rated as “low” for selection bias and data collection methods was quite high (41%). The presence of these types of biases is known to both threaten external validity (van Heuvelen et al., 2005) and overestimate the beneficial impact of interventions (Bernard et al., 2017). Additionally, the proportion of studies that were rated as “moderate” was quite high for selection bias, data collection methods, and withdrawal and drop-outs (41%), and especially high for blinding (71%). When using the EPHPP (Thomas et al., 2004), a “moderate” rating mostly indicates unclear risks of biases due to insufficient information available. Numerous previous reviews and meta-analyses have reported that the globally low methodological quality found in TPB-based (Tyson et al., 2014), theory-based (Lock et al., 2020), or health promotion interventions (Armanasco et al., 2017), was notably due to a lack of details provided in many studies. From those results, future research should thus more systematically rely on existing recommendations on methodological quality when implementing and reporting interventions (Boutron et al., 2008; Des Jarlais et al., 2004; Thomas et al., 2004). When more specifically considering recommendation toward the measurement of smoking behavior (i.e., data collection methods), given the current knowledge, smoking measurement should be notably based on WHO recommendations (Global Adult Tobacco Survey Collaborative Group, 2011).

Concerning the theoretical implementation, it can be noted that no studies used TPB variables to select participants or tailor the program (items 3 and 4 of the TCS; Michie & Prestwich, 2010). Interventions based on a continuum theory as the TPB are traditionally designed to

simultaneously target the determinants of intention (i.e., attitude, subjective norm, PBC), and contrast with interventions tailored to individual profiles (Weinstein et al., 1998). That said, Ajzen (2006a) also specifies that it may be relevant to focus a TPB-based intervention only on the variable(s) that have a meaningful impact on intention and behavior in a given population. So, to the extent a TPB variable is identified as a key determinant of intention and smoking behavior, such as PBC in adolescents with asthma (e.g., Van De Ven et al., 2007), future TPB-based interventions could focus on this variable, and select and/or tailor the program in function of the level of the participants on the variable. Otherwise, it can be noted that less than half (47%) of the studies did report a precise link between all intervention techniques and at least one TPB variable (item 5 of the TCS), and also less than half (47%) of the studies did report a precise link between all TPB variables and at least one intervention technique (item 8). Those proportions appear in line with previous meta-analyses exploring the efficacy of theory-based interventions on diet or physical activity (Gourlan et al., 2016; Prestwich et al., 2014). Establishing a precise link between all intervention techniques and all theoretical concepts is an important step to identify the factors involved in the efficacy of theory-based interventions (Michie et al., 2008). Future TPB-based interventions are thus invited to systematically develop a precise rationale that consider all the hypothesized relationships between the intervention techniques used to impact smoking behavior and the TPB variables targeted. Regarding the measurement of TPB variables, about half of the studies did not report any information on the reliability (53%) and/or validity of the measurement of theoretical constructs (47%). From this, it appears of particular importance for future research to thoroughly follow the existing guidelines regarding the conceptualization, development and analysis of TPB questionnaires (e.g., Ajzen, 2006b; Francis et al., 2004), to ensure the validity of the results presented regarding TPB variables. Finally, despite the recognized importance of empirically exploring the mediators of behavior change interventions (Lubans et al., 2008), only one study (6%) performed such mediation analyses (items 17-20 of the TCS). As a logical consequence, most studies could not propose an adapted feedback and an in-depth discussion of the TPB (items 22-23 of the TCS). From all of those reports, the contribution of TPB-based interventions to aid in the understanding of mechanisms of smoking behavior change, and to confirm or refine the TPB in this behavioral domain can be currently considered as particularly modest (Rothman, 2004).

Some limitations should be noted for this systematic review. First, as only 17 studies implemented in only 6 countries by a limited number of research teams could be included,

more research appears necessary before any major conclusion can be made regarding TPB-based interventions targeting smoking behavior. Second, the inclusion of only English and French language studies can be considered as another limitation. Third, despite the quite comprehensive investigation of the existing literature (i.e., see Figure 1), a publication bias cannot be totally excluded.

### **Conclusion**

This systematic review appears as the first to specifically focus on TPB-based interventions targeting smoking behavior. The proportion of studies that reported a significant impact on smoking behavior, intention, attitude, subjective norm, or PBC appeared relatively modest (42%-50%). Moreover, numerous flaws have been identified, both regarding methodological aspects and the theoretical implementation of the interventions. Future research should be aware that theory-based interventions have the potential to be truly efficient and to enrich the underlying theoretical frameworks only to the extent rigorous methods are applied when designing, implementing, and reporting the research protocol and the theory-based intervention (Hoffmann et al., 2014; Michie et al., 2018; Peters et al., 2012). As no studies using a factorial design were identified in this systematic review, future studies are also encouraged to develop research protocols using this kind of design (Weinstein, 2007). For example, testing independent effects of manipulating attitude, subjective norm, and PBC as well as their synergetic effect on smoking behavior (e.g., 2\*2\*2 factorial design; Sniehotta, 2009), represents a fruitful perspective to better identify the component techniques and underlying mechanisms involved in the impact of TPB-based interventions on smoking behavior.

**Funding sources:**

[REDACTED]

[REDACTED]

[REDACTED]

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**Conflicts of interest statement:** The authors declare that there are no conflicts of interest.

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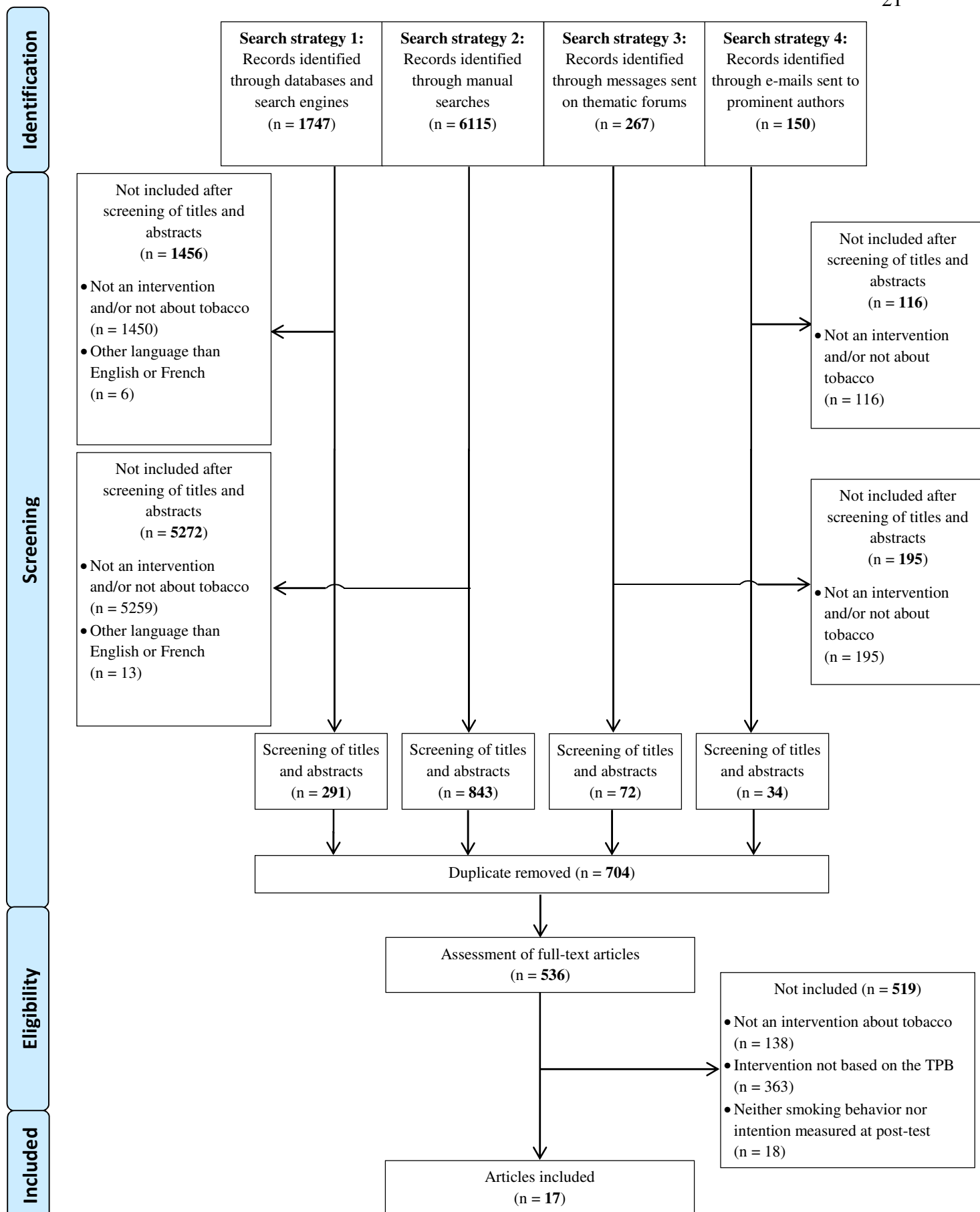


Figure 1. Flow chart of selection process.

Table 1. Characteristics of included studies.

Study	Country	Population	Gender	Number of participants analyzed	Objective of the intervention	Components of the intervention	Mode of delivery of the intervention	Length	Number of sessions
Barati (2015)	Iran	High school students	M	114	Combined intervention to reduce smoking prevalence in a group of both smokers and non-smokers	Education/information, skill training	Internet, videos	6 weeks	NA
Cameron (2015)	United Kingdom	New undergraduate university students	M/F	1495	Combined intervention to reduce smoking prevalence in a group of both smokers and non-smokers	Education/information, skill training, implementation intentions	Internet, videos	24 weeks	NA
Chan (2008)	China	Smoking fathers with sick child	M	1483	Treatment to reduce, abstain or quit smoking	Education/information, implementation of social support, counselling	Wife involvement, printed materials, telephone	12 months	NA
Dehdari (2013)	Iran	College students with positive history of water pipe use	M	90	Treatment to reduce, abstain or quit smoking	Education/information	Face to face (group), printed materials	3 weeks	4
Epton (2013, 2014, 2015)	United Kingdom	New undergraduate university students	M/F	1107	Combined intervention to reduce smoking prevalence in a group of both smokers and non-smokers	Education/information, skill training, implementation intentions	Internet, videos	24 weeks	NA
Fallin (2013)	United States of America	Smoking university students	M/F	NA	Treatment to reduce, abstain or quit smoking	Education/information	Printed materials	NA	NA
Gilliam (2019)	United States of America	High school students	M/F	67	Combined intervention to reduce smoking prevalence in a group of both smokers and non-smokers	Education/information	Game	1 hour	1
Ismail (2016)	Malaysia	Smokers working in public offices	M	99	Treatment to reduce, abstain or quit smoking	Education/information, skill training, social pledge, religious rulings	Face to face (group), printed materials	21 days	1
Kim (2012)	United States of America	Korean American smokers	M/F	30	Treatment to reduce, abstain or quit smoking	Education/information, skill training, implementation of social support, counselling	Face to face (individual), videos	8 weeks	8

Table 1. Characteristics of included studies (*continued*).

Study	Country	Population	Gender	Number of participants analyzed	Objective of the intervention	Components of the intervention	Mode of delivery of the intervention	Length	Number of sessions
Kim (2015)	United States of America	Korean American smokers	M/F	109	Treatment to reduce, abstain or quit smoking	Education/information, skill training, implementation of social support, counselling	Face to face (individual), printed materials	8 weeks	8
Lakerveld (2008, 2011, 2012, 2013)	The Netherlands	Adults at risk of type 2 diabetes and/or cardiovascular diseases	M/F	536	Combined intervention to reduce smoking prevalence in a group of both smokers and non-smokers	Education/information, skill training, counselling	Face to face (individual), telephone	16 months	10
Nazari (2013)	Iran	High school students	M	154	Combined intervention to reduce smoking prevalence in a group of both smokers and non-smokers	Education/information	Face to face (group), printed materials, videos, games	NI	4
Nurumal (2019)	Malaysia	Never-smoking elementary school students	M/F	140	Prevention to maintain non-smoking	Education/information, skill training	Face to face (group), printed materials, videos, games	1 month	3
Record (2014, 2017; 2017; 2018)	United States of America	Smoking undergraduate university students	M/F	283	Treatment to reduce, abstain or quit smoking	Education/information	Printed materials	4 weeks	NA
Shi (2013, 2014)	United States of America	Smokers in preoperative evaluation	M/F	169	Treatment to reduce, abstain or quit smoking	Education/information	Face to face (individual)	5 minutes	1
Zeidi (2013)	Iran	Never-smoking high school students	M	150	Prevention to maintain non-smoking	Education/information, skill training, counselling	Face to face (group), printed materials, game	NI	4
Zhao (2018, 2019)	China	High school students	M/F	156	Combined intervention to reduce smoking prevalence in a group of both smokers and non-smokers	Education/information, skill training	Face to face (group), game	4 weeks	4

Note: F = Female, M = Male, NA = not applicable, NI = not informed.



Table 2. Impact of interventions on smoking behavior and theory of planned behavior variables.

Study	Significant impact of the intervention <sup>a</sup>				
	On smoking behavior	On intention	On attitude	On subjective norm	On perceived behavioral control
Barati (2015)	No	Yes	Yes	Yes	Yes
Cameron (2015)	No	No	No	No	No
Chan (2008)	No	NRR	NRR	NRR	NRR
Dehdari (2013)	Yes	Yes	Yes	Yes	Yes
Epton (2013, 2014, 2015)	Yes	No	No	No	No
Fallin (2013)	Yes	NRR	NRR	NRR	NRR
Gilliam (2019)	NRR	No	No	NRR	NRR
Ismail (2016)	No	NRR	NRR	NRR	NRR
Kim (2012)	Yes	NRR	No	No	No
Kim (2015)	Yes	NRR	No	Yes	No
Lakerveld (2008, 2011, 2012, 2013)	No	No	No	No	Yes
Nazari (2013)	NRR	Yes	Yes	Yes	Yes
Nurumal (2019)	NRR	Yes	Yes	No	No
Record (2014, 2017, 2017, 2018)	Yes	No	No	No	No
Shi (2013; 2014)	No	Yes	NRR	NRR	NRR
Zeidi (2013)	NRR	Yes	Yes	Yes	Yes
Zhao (2018, 2019)	No	No	Yes	No	Yes
<b>Number of “yes”/number of available results (%)</b>	<b>6/13 (46%)</b>	<b>6/12 (50%)</b>	<b>6/13 (46%)</b>	<b>5/12 (42%)</b>	<b>6/12 (50%)</b>

Note: NRR = no result reported, <sup>a</sup> Significant impact of the intervention on the variable is indicated when  $p < .05$  was reported for the statistical test performed.

Table 3. Methodological quality synthesis of included studies.

Study	Level of evidence for selection bias	Level of evidence for design	Level of evidence for confounders <sup>a</sup>	Level of evidence for blinding	Level for evidence for data collection methods <sup>b</sup>	Level of evidence for withdrawals and drop-outs	GLOBAL RATING FOR THIS PAPER
Barati (2015)	Moderate	Strong	Strong	Moderate	Weak	Strong	Moderate
Cameron (2015)	Weak	Strong	Strong	Moderate	Moderate	Weak	Weak
Chan (2008)	Strong	Strong	Strong	Weak	Moderate	Strong	Moderate
Dehdari (2013)	Moderate	Strong	Strong	Moderate	Weak	Weak	Weak
Epton (2013, 2014, 2015)	Weak	Strong	Strong	Moderate	Moderate	Moderate	Moderate
Fallin (2013)	Moderate	Moderate	NA	Strong	Strong	Moderate	Strong
Gilliam (2019)	Weak	Moderate	NA	Weak	Weak	Strong	Weak
Ismail (2016)	Moderate	Strong	Weak	Moderate	Weak	Moderate	Weak
Kim (2012)	Weak	Strong	Weak	Moderate	Strong	Moderate	Weak
Kim (2015)	Weak	Strong	Weak	Moderate	Strong	Moderate	Weak
Lakerveld (2008, 2011, 2012, 2013)	Weak	Strong	Weak	Moderate	Moderate	Strong	Weak
Nazari (2013)	Moderate	Strong	Weak	Moderate	Moderate	Weak	Weak
Nurumal (2019)	Strong	Strong	Strong	Weak	Strong	Strong	Moderate
Record (2014, 2017, 2017, 2018)	Weak	Moderate	NA	Moderate	Weak	Weak	Weak
Shi (2013; 2014)	Strong	Strong	Strong	Moderate	Moderate	Moderate	Strong
Zeidi (2013)	Moderate	Strong	Strong	Weak	Weak	Weak	Weak
Zhao (2018, 2019)	Moderate	Strong	Moderate	Moderate	Weak	Moderate	Moderate

Note: NA = not applicable, <sup>a</sup> Confounders were not assessed for one-group studies, <sup>b</sup> Data collection methods were assessed for the measures of smoking behavior when reported or intention when smoking behavior was not reported.

Table 4. Descriptive statistics for the items assessing theoretical implementation.

Category	Item number	Item title	Yes	No	% of "Yes"
Theoretical basis of the intervention	1	Targeted construct mentioned as predictor of behavior	16	1	94%
	2	Intervention based on single theory	13	4	76%
	3	Theory used to select recipients for the intervention	0	17	0%
	4	Theory/predictors used to tailor intervention techniques to recipient	0	17	0%
	5	All intervention techniques are explicitly linked to at least one theory-relevant construct/predictor	8	9	47%
	6	At least one, but not all, of the intervention techniques are explicitly linked to at least one theory-relevant construct/predictor	3	14	18%
	7	Group of techniques are linked to a group of constructs/predictors	3	14	18%
	8	All theory-relevant constructs/predictors are explicitly linked to at least one intervention technique	8	9	47%
	9	At least one, but not all, of the theory relevant constructs/predictors are explicitly linked to at least one intervention technique	4	13	24%
Measure of theoretical constructs	10	Theory-relevant constructs/predictors are measured (a): At least one construct of theory (or predictor) mentioned in relation to the intervention is measured post-intervention.	14	3	82%
	11	Theory-relevant constructs/predictors are measured (b): At least one construct of theory (or predictor) mentioned in relation to the intervention is measured pre and post-intervention.	13	4	76%
	12	Quality of Measures (a): All of the measures of theory relevant constructs/predictors had some evidence for their reliability	9	8	53%
	13	Quality of Measures (b): At least one, but not all, of the measures of theory relevant constructs/predictors had some evidence for their reliability	2	15	12%
	14	Quality of Measures (c): All of the measures of theory relevant constructs/predictors follow the existing recommendations to construct a TPB questionnaire	8	9	47%
	15	Quality of Measures (d): At least one, but not all, of the measures of theory relevant constructs/predictors follow the existing recommendations to construct a TPB questionnaire	0	17	0%

Table 4. Descriptive statistics for the items assessing theoretical implementation (*continued*).

Category	Item number	Item title	Yes	No	% of "Yes"
Results on theoretical constructs	16	Changes in measured theory-relevant construct(s)/predictor(s)	9	8	53%
	17	Mediational analysis of construct(s)/predictor(s) (a): Mediator predicts dependent variable? (or change in mediator leads to change in dependent variable)	1	16	6%
	18	Mediational analysis of construct(s)/predictor(s) (b): Mediator predicts dependent variable (when controlling for independent variable)?	1	16	6%
	19	Mediational analysis of construct(s)/predictor(s) (c): Intervention does not predict dependent variable (when controlling for mediator)?	1	16	6%
	20	Mediational analysis of construct(s)/predictor(s) (d): Mediated effect statistically significant?	1	16	6%
Feedback and considerations on the theory	21	Results discussed in relation to theory	11	6	65%
	22	Appropriate support for theory	1	16	6%
	23	Results used to refine theory	0	17	0%

Note: TPB = theory of planned behavior.