REVIEW PAPER

Behavior Change Techniques and Delivery Modes in Interventions Targeting Adolescent Gambling: A Systematic Review

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Abstract

Background Adolescent gambling can lead to significant harms, yet participation rates continue to rise. Interventions targeting gambling reduction have been implemented in this population. However, it is not clear which behavior change techniques (BCTs) and modes of delivery (MOD) are most effective at reducing gambling.

Objective The objective of the study was to identify 'promising' BCTs and MODs by systematically reviewing interventions targeting adolescent gambling behavior. 'Promising' was defined as those present in at least 25% of all interventions and in at least two effective interventions.

Methods Three databases were searched (PsycINFO, Medline, and Scopus) from database inception to May 2021. Interventions were eligible if they were randomized controlled trials; targeting adolescents (aged 10–25 years); and assessing gambling behavior post-intervention. BCTs were identified using the Behavior Change Technique Taxonomy v1.

Results From the initial 3,315 studies, the removal of duplicates and ineligible articles resulted in sixteen studies included in the review. Eleven of these reported successfully reducing gambling behavior. Eighteen BCTs and six MODs were used across the interventions. The BCTs identified as promising were '4.2. Information about antecedents', '4.4. Behavioral experiments', '5.3. Information about social and environmental consequences', and '5.6. Information about emotional consequences'. Promising MODs were 'face-to-face', 'computer', and 'playable electronic storage'.

Conclusions The study reviewed the content of interventions targeting adolescent gambling behavior. Four BCTs were identified as promising and should therefore be adopted in future interventions. To facilitate the delivery of these techniques, the study also identified three promising MODs. Interventions developed using these BCTs and MODs may successfully reduce adolescent gambling behavior.

Keywords Gambling · Behavior change techniques · Delivery mode · Adolescents

Introduction

Gambling in adolescents has emerged as an increasing public health concern (Calado et al., 2017; Volberg et al., 2010). A systematic review undertaken by Calado et al. (2017) found that up to 12% of adolescents had gambling-related problems. Reported prevalence rates of problem gambling in adolescents are approximately 2–3 times higher than in adult populations (Shaffer & Korn, 2002; Williams et al., 2012a); however, several researchers contend that certain situational and methodological issues have caused the rates to be over-inflated (Delfabbro & King, 2020). Irrespective of the accuracy of prevalence rates, problem gambling has many associated harms and specific to adolescents, research has shown that gambling can lead to financial issues, relationship problems, and poorer mental and physical health (Hardoon et al., 2004; Livazović & Bojčić, 2019; Shaffer & Hall, 2002). Adolescent gambling is also associated with the adoption of other detrimental health-related behaviors such as alcohol consumption (Svensson & Sundqvist, 2019), substance abuse (Cook et al., 2015), risky driving (Proimos et al., 1998), and delinquent behaviors (Kryszajtys et al., 2018).

The accessibility of online gambling platforms has enabled adolescents to undertake the behavior more readily (Griffiths & Parke, 2010). Internet gambling has demonstrated increasing popularity (Caillon et al., 2019), particularly in younger demographics (Hollén et al., 2020), with technology such as mobile apps facilitating this mode (Armitage, 2021). In addition to availability and convenience, adolescents are easily able to circumvent gambling age restrictions and bet anonymously (Canale et al., 2016; Delfabbro et al., 2009), or access illegal offshore betting sites (Messerlian et al., 2004). Gambling can begin as a form of entertainment but can quickly lead to significant problems in adolescents (Derevensky & Gilbeau, 2015). Retrospective studies of clinical samples have shown that gambling onset typically occurs during the adolescent years and earlier onset is associated with greater problem severity (Burge et al., 2004). Similar findings were reported in a systematic review and meta-analysis of longitudinal studies that identified earlier gambling onset, number of gambling activities, and problem gambling severity as significant early risk factors for the subsequent development of gambling problems (Dowling et al., 2017). Moreover, despite age restrictions, the prevalence of gambling problems has been shown to be higher in adolescents than adults (Dowling et al., 2017; Nowak & Aloe, 2014). It is therefore important that effective interventions exist to address and change gambling behaviors during adolescence (Oh et al., 2017).

Behavior Change Techniques and Mode of Delivery

Interventions promoting behavior change include strategies and methods to modify the behavior. Behavior change techniques (BCTs) are the "…observable, replicable, and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour; that is, a technique is proposed to be an 'active ingredient'" (Michie et al., 2013, p. 82). They are the specific methods intervention designers employ to modify the behavior of interest. Michie et al. (2013) identified 93 unique BCTs in the BCT Taxonomy Version 1 (BCTTv1). Understanding the use of BCTs in intervention can help provide evidence of effectiveness. This can, in turn, inform the development of interventions in the future. For example, interventions demonstrating utility of a particular BCT would imply

change efforts should also adopt the strategy whereas a BCT lacking in effectiveness would suggest developers refrain from its use. As an example, Michie et al. (2009) identified BCTs including 'Self-monitoring', 'Prompting intention formation', 'Goal setting', and 'Feedback' to be most effective in interventions promoting physical activity.

BCTs play an important role in behavior change, but intervention effectiveness is not only influenced by the content and strategies included. Another important component of behavior change interventions is the mode of delivery (MOD). The MOD concerns the way the intervention is delivered and the format features (Dombrowski et al., 2016; Marques et al., 2021). Thus, BCTs apply to *what* is delivered and the MOD relates to *how* this is achieved. Interventions can adopt a myriad of MODs such as face-to-face, online, telephone, or leaflets. Crucially, the effectiveness of an intervention can be influenced by the MOD (Marques et al., 2021). That is, whether behavior change is achieved can depend on how the intervention is communicated in practice. Therefore, it is important to examine both the content and delivery modes of interventions.

Gambling Interventions

Despite immense government and industry investment into gambling harm prevention, very few studies have systematically examined the BCTs and MODs of the numerous interventions developed to support this aim. Humphreys et al. (2021) recently identified the BCTs in web-based interventions targeting multiple health behaviors, including gambling. They found that effective interventions included '2.3. Self-monitoring of behavior', '2.2. Feedback on behavior', '6.2. Social comparison', and '4.1. Instruction on how to perform a behavior'. The authors did note, however, that only a limited number of strategies were included in interventions. In addition to this, Rodda et al. (2018) identified the BCTs included in therapist-delivered and self-help interventions for gambling problems. They found that some of the most frequently used strategies included '2.2. Feedback on behavior', '1.2. Problem solving', and '1.1. Goal setting (behavior)'.

Although these studies are useful in identifying intervention content and MODs, neither focused specifically on adolescents. Therefore, there exists a need to understand the components of interventions targeting adolescent gambling behavior. Moreover, the Humphreys et al. (2021) review was restricted to interventions conducted over the internet. As far as we are aware, no systematic review has identified the techniques and delivery modes adopted in such interventions. This work can appraise the state of current research and facilitate in the future development of effective interventions.

Study Purpose

The present review aimed to address the following questions:

1. What BCTs have been adopted in interventions targeting adolescent gambling behavior?
2. What BCTs have demonstrated the greatest effectiveness in interventions?
3. What modes of delivery have been adopted to deliver BCTs in interventions targeting adolescent gambling behavior?
4. What modes of delivery have demonstrated the greatest effectiveness in delivering BCTs in interventions?

Methods

We followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The study was registered with PROSPERO, CRD42021254657.

Eligibility Criteria

Studies were included if they were randomized controlled trials of interventions targeting a reduction in adolescent (aged 10–25 years) gambling behavior. Gambling behavior was assessed using self-report or objective measures of gambling frequency or gambling expenditure. Studies assessing problem gambling were also included given the importance of this construct in the target literature. The intervention measured differences between the experimental condition and a control group. We excluded studies measuring only gambling cognitions such as urges or desires, unless accompanied by behavioral measures. Studies not published in English language and only including reviews, abstracts, opinion pieces, and letters to the editor were also excluded.

Literature Search and Selection

The following databases were used: PsycINFO, Medline, and Scopus. Searches were limited to articles published in peer reviewed journals between database inception and May 2021. Search terms included the following: (adolescents OR young adults* OR youth OR teenagers* OR students) AND (gambling* OR gamble) AND (intervention OR prevention OR program* OR treatment). Screened studies were imported into EndNote by one reviewer (TSQ). After the removal of duplicates, the lead author (TSQ) then screened the titles and abstracts of the articles identified through the searches. To check the reliability of the screening procedures, a second reviewer (BM) then screened 20% of these articles. Interrater reliability between the two reviewers was perfect ($\kappa=1.00$). Full texts of potentially eligible studies were then screened by the lead author (TSQ), with a second reviewer (BM) again screening 20% of these articles to check reliability. At this stage, reliability was substantial with initial agreement on 83.3% of papers, $\kappa=0.75$. Differences were resolved through discussion. The reference lists of all identified articles were then hand-searched for further relevant studies.

Data Extraction

Two reviewers (TSQ & BM) conducted data extraction using a purpose-designed data extraction sheet. This included the following: (1) General study information (author(s), date, country); (2) Aims; (3) Participants (sample size, age, and gender); (4) Measures (outcome, tool, follow-up period); (5) Intervention (conditions, MOD, provider, intensity, duration, and BCTs used); and (6) Findings.

Coding BCTs and MODs. The BCTTv1 was used to identify specific techniques included in intervention and control conditions. Following these principles, BCTs were extracted as "present beyond all reasonable doubt" (coded ++), or "present in all probability" (coded +). To identify BCTs, we used descriptions provided in the paper and any additional materials made available. The main reviewer (TSQ) coded the techniques present in all studies and,

to check reliability, a second reviewer (DMS) then coded 20% of these. The reliability of BCT coding was found to be high, κ=0.84. All discrepancies were then resolved through discussion. In terms of effectiveness, no gold standard approach exists for identifying BCTs (Michie et al., 2018). We therefore identified the 'promising' BCTs following a method adopted in previous studies (e.g., Ahmed et al., 2021; Brown et al., 2019, 2020; Lorencatto et al., 2012). Specifically, a BCT was defined as promising if it was present in at least 25% of all interventions and was present in at least two effective interventions. This approach can help identify the techniques with the greatest promise amongst those most frequently used (Brown et al., 2019). BCTs included in both the intervention and control condition were excluded. If multiple intervention conditions were included in a study, BCTs in effective arm(s) only were considered. We identified MODs using the ontology developed by Marques et al. (2021). Promising MODs were identified using the same process as the BCTs. That is, MODs included in ≥25% of all interventions and in at least two effective interventions were labeled 'promising'. There were no discrepancies between reviewers.

Quality Assessment

We assessed study quality using the revised Cochrane risk of bias tool for randomized trials (Sterne et al., 2019). We rated the risk of bias in five domains: (1) bias arising from the randomization process; (2) bias due to deviation from the intended interventions; (3) bias from missing outcome data; (4) bias in measurement of the outcome; (5) bias in selection of the reported results. We then classified each intervention as either: (1) low risk of bias, (2) some concerns, or (3) high risk of bias. Interventions were classified as having a low risk of bias when all domains were rated low risk; 'some concerns' of bias were indicated when at least one domain was assigned this rating; and high risk of bias was indicated when at least one domain was rated high risk. One reviewer (TSQ) conducted the assessment on all identified articles and a second reviewer (BM) checked 20% of articles. There were no discrepancies between reviewers.

Results

Figure 1 presents the flowchart of included papers. A total of 3,315 papers was identified through the search. After removing duplicates, the title and abstract of 2,142 papers were then screened, which led to the removal of 2,081 papers. The remaining 61 papers were then read in full. Full text screening led to 45 papers excluded for the following reasons: participants not meeting age criteria; no measure of behavior; not a randomized control trial; no statistical test performed; and duplicated data. No additional papers were identified in the hand-search, resulting in a total 16 papers included in the review (Broussard & Wulfert, 2017; Calado et al., 2020; Canale et al., 2016; Donati et al., 2014, 2018, study 2; Gaboury & Ladouceur 1993; Huic et al., 2017; Larimer et al., 2012; Martens et al., 2015; Petry et al., 2009; St-Pierre et al., 2017; Tani et al., 2021; Turner et al., 2008a, study 2; Turner et al., 2008b; Walther et al., 2013; Williams et al., 2010).
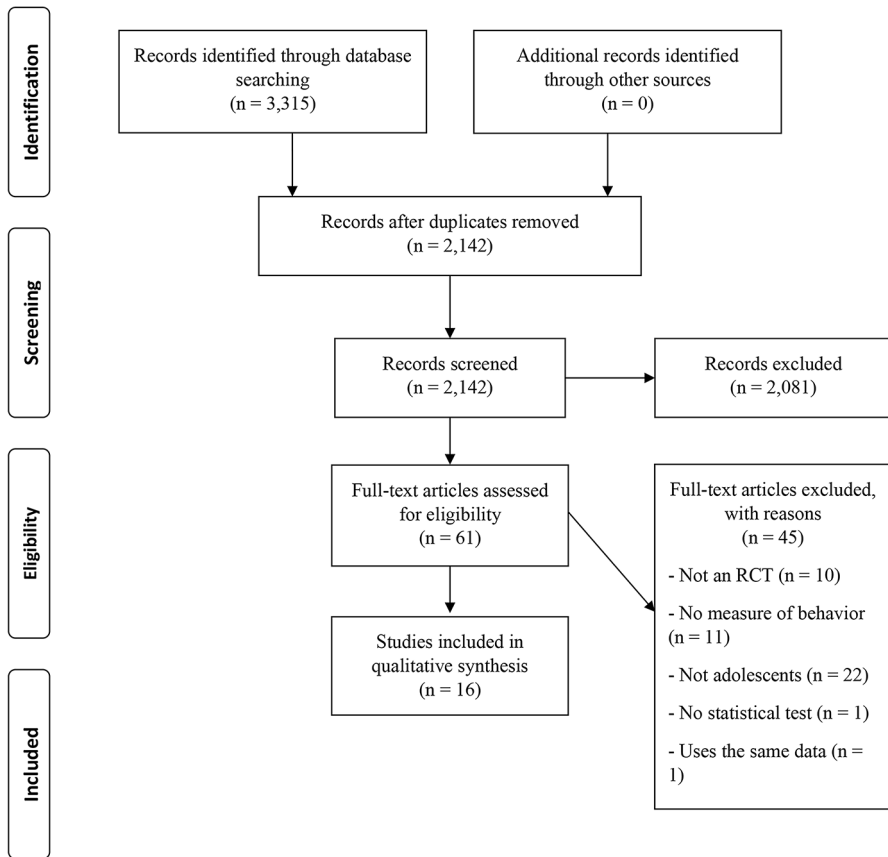
Fig. 1 Flow diagram

Study Characteristics and Quality Assessment

Table 1 shows the characteristics of the eligible studies. Studies were conducted most frequently in Canada (Gaboury & Ladouceur 1993; St-Pierre et al., 2017; Turner et al., 2008a, study 2; Turner et al., 2008b; Williams et al., 2010), with four undertaken in the USA (Broussard & Wulfert; Larimer et al., 2012; Martens et al., 2015; Petry et al., 2009), four in Italy Canale et al., 2016; Donati et al., 2014, 2018, study 2; Tani et al., 2021), and one in Croatia (Huic et al., 2017), Portugal (Calado et al., 2020), and Germany (Walther et al., 2013). A total of 6,703 participants were included in the studies (min=34; max=2,109). The interventions were delivered by researchers, psychologists, therapists, students, research assistants, and teachers. Where reported, intervention duration ranged from 1 to 7 weeks, with the number of sessions also varying from 1 to 7. The follow-up assessment period ranged from imme-

Table 1 *Study characteristics*

General study information	Aims	Participants	Measures	Intervention	Findings
Broussard & Wulfert ([2017](#)). USA	Tested the effects of a digital slot machine intervention on a gambling analogue task	90 college students *Age*: mean=19.6 *Gender*: males=45; females=45	*Outcome(s)*: gambling frequency *Tool(s)*: slot machine *Follow-up*: immediately post-intervention	*Delivery mode*: video game *Provider*: researcher *Intensity and duration*: 1×10 min *BCTs used*: 4.4. Behavioral experiments Control group received a handout unrelated to gambling	Intervention condition played significantly fewer trials than the control
Calado et al. (2020). Portugal	Evaluated a youth gambling prevention program	111 students *Age*: mean=17.6 *Gender*: males=46, females=65	*Outcome(s)*: gambling frequency; gambling expenditure *Tool(s)*: researcher-generated questions; DSM-IV-MR-J *Follow-up*: immediately and 6-weeks post-intervention	*Delivery mode*: face-to face *Provider*: researcher *Intensity and duration*: 5×1-hour, once per week *BCTs used*: 3.1. Social support (unspecified); 4.4. Behavioral experiments; 5.3. Information about social and environmental consequences; 5.6. Information about emotional consequences Control group completed assessments only	Gambling frequency significantly decreased in intervention condition immediately after the intervention and these effects were maintained at the 6-week follow-up. No change in control. No change in gambling expenditure in intervention and control

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
Canale et al. (2016). Italy	Tested a web-based gambling intervention targeting high-school students	168 students *Age*: mean=15; range=14–18 *Gender*: male=58%	*Outcome(s)*: gambling frequency; gambling expenditure; gambling problems *Tool(s)*: SOGS-RA; researcher-generated questions *Follow-up*: 2 months post-intervention	*Delivery mode*: website *Provider*: researcher *Intensity and duration*: 3 weeks *BCTs used*: 2.2. Feedback on behavior; 4.1. Instruction on how to perform the behavior; 4.2. Information about antecedents; 5.3. Information about social and environmental consequences; 5.6. Information about emotional consequences; 14.2. Punishment Control group received personalized feedback only	Intervention condition reduced gambling problems compared to the control. No differences in gambling frequency and expenditure
Donati et al. (2018, study 2). Italy	Tested a school-based intervention targeting gambling-related cognitive distortions and gambling frequency	34 high school students *Age*: mean=16.8; range: 15–19 *Gender*: all male	*Outcome(s)*: gambling frequency *Tool(s)*: SOGS-RA *Follow-up*: immediately and 6 months post-intervention	*Delivery mode*: face-to-face *Provider*: developmental psychologist and two operators from an addiction unit *Intensity and duration*: 2×2-hour, once per week *BCTs used*: 4.2. Information about antecedents; 4.4. Behavioral experiments Control group completed assessments only	Significant reduction in gambling frequency in intervention condition but no change in control

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
Donati et al. (2014). Italy	Tested the effectiveness of an integrative gambling intervention targeting adolescent problem gambling	181 adolescents *Age*: mean=15.9; range=15–18 *Gender*: male=64%	*Outcome(s)*: problem gambling *Tool(s)*: SOGS-RA *Follow-up*: immediately and 6-months post-intervention	*Delivery mode*: face-to face; computer; playable electronic storage *Provider*: developmental psychologist *Intensity and duration*: 2×2-hour, once per week *BCTs used*: 4.2. Information about antecedents; 4.4. Behavioral experiments; 5.3. Information about social and environmental consequences Control group completed assessments only	Significant reduction in the percentage of gamblers and problem gamblers in the intervention condition; however, no comparison with control group reported
Gaboury & Ladouceur. (1993). Canada	Evaluated a gambling prevention program	289 high school students *Age*: mean=16 *Gender*: ns	*Outcome(s)*: gambling frequency; gambling expenditure *Tool(s)*: researcher-generated questions *Follow-up*: immediately and 6-months post-intervention	*Delivery mode*: face-to face; playable electronic storage *Provider*: research assistants *Intensity and duration*: 3×75 min, over 3 weeks *BCTs used*: 5.1. Information about health consequences; 5.3. Information about social and environmental consequences; 6.1. Demonstration of the behavior; 9.1. Credible source; 16.3. Vicarious consequences Control group completed assessments only	No significant differences

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
Huic et al. (2017). Croatia	Pilot evaluation of a school-based gambling prevention program	190 high school students *Age*: mean=15.6; range=14–17 *Gender*: male=67.6%	*Outcome(s)*: gambling frequency; gambling problems *Tool(s)*: researcher generated questions; CAGI *Follow-up*: immediately post-intervention	*Delivery mode*: face-to face *Provider*: two trainers *Intensity and duration*: 6×90 min, weeks ns *BCTs used*: 1.2. Problem solving; 5.1. Information about health consequences; 5.3. Information about social and environmental consequences; 5.6. Information about emotional consequences; 8.1. Behavioral practice/rehearsal Control group had regular school activities	No significant differences

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
Larimer et al. (2012). USA	Evaluated an intervention targeting gambling in at-risk college students	147 college students *Age*: mean=21.2; range=19–25 *Gender*: male=65.3%	*Outcome(s)*: gambling frequency; gambling expenditure; gambling problems *Tool(s)*: GQPN; GPI *Follow-up*: 6 months post-intervention	Two intervention conditions: PFI and CBI *Delivery mode*: face-to face; printed publication *Provider*: trained therapists (graduate students) *Intensity and duration*: PFI: 1×60–90 min; CBI: 4–6 hourly sessions, once per week *BCTs used*: 1.2. Problem solving; 2.2. Feedback on behavior; 2.3. Self-monitoring of behavior; 3.1. Social support (unspecified); 4.1. Instruction on how to perform the behavior; 4.2. Information about antecedents; 5.3. Information about social and environmental consequences; 5.6. Information about emotional consequences; 6.2. Social comparison; 8.1. Behavioral practice/rehearsal Control group completed assessments only	PFI condition reduced gambling frequency and gambling problems compared to control. No differences in gambling expenditure. No differences in CBI condition

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
Martens et al. (2015). USA	Tested an intervention targeting gambling behavior in at-risk college students	333 students *Age*: mean=21.9 *Gender*: male=60%; female=40%	*Outcome(s)*: gambling frequency; gambling expenditure; gambling problems *Tool*: G-TLFB; CAGI *Follow-up*: 3 months post-intervention	Two intervention conditions: PFI and EDU *Delivery mode*: face-to face; printed publication *Provider*: researcher *Intensity and duration*: 1×10 min *BCTs used*: 2.2. Feedback on behavior; 4.1. Instruction on how to perform the behavior; 4.2. Information about antecedents; 6.2. Social comparison Control group completed assessments only	PFI condition gambled less money and reported fewer gambling-related problems than the control. No difference in frequency. No differences between the EDU and control, or the PFI and the EDU conditions
Petry et al. (2009). USA	Tested brief interventions targeting gambling behavior in college students	117 students *Age*: mean=20.3 *Gender*: male=99	*Outcome(s)*: gambling frequency; gambling expenditure; gambling problems *Tool(s)*: ASI-G; researcher-generated questions *Follow-up*: 6 weeks and 9 months post-intervention	Three intervention conditions: Brief advice, MET, and MET + CBT *Delivery mode*: face-to face; printed publication *Provider*: trained therapists *Intensity and duration*: Brief advice: 1×10–15 min; MET: 1×50 min; MET + CBT: 1×50 min for MET & 3 weekly for CBT *BCTs used*: 1.2. Problem solving; 2.2. Feedback on behavior; 4.2. Information about antecedents; 6.2. Social comparison; 9.2. Pros and cons Control group completed assessments only	Significant decrease in gambling frequency, expenditure, and problems in all intervention conditions compared to control. However, gambling problems and expenditure significantly decreased in the MET group only compared to the control after 9 months

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
St-Pierre et al. (2017). Canada	Evaluated a school-based gambling prevention program	280 high school students *Age*: mean=15.1; range=13–17 *Gender*: male=140	*Outcome(s)*: gambling frequency *Tool(s)*: GAQ *Follow-up*: 3 months post-intervention	*Delivery mode*: face-to face; playable electronic storage *Provider*: program facilitators and research assistants *Intensity and duration*: 2×25-min, once per week *BCTs used*: 5.1. Information about health consequences; 5.3. Information about social and environmental consequences; 5.6. Information about emotional consequences; 6.3. Information about others' approval; 16.3. Vicarious consequences Control group did not see the video or have the discussion	No significant differences
Tani et al. (2021). Italy	Tested a gambling intervention for students through training teachers about gambling	393 students *Age*: mean=nr; range=13–19 *Gender*: male=84%; female=16%	*Outcome(s)*: gambling frequency; gambling problems *Tool(s)*: SOGS-RA *Follow-up*: 7 months post-intervention	*Delivery mode*: face-to face; computer *Provider*: teacher *Intensity and duration*: 16 hours, weeks ns *BCTs used*: 4.2. Information about antecedents Control group attended classes which no teacher had attended training	Significant decrease in SOGS-RA scores in intervention but not control

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
Turner et al. (2008a, study 2). Canada	Evaluated a school-based educational gambling prevention curriculum	201 high school students *Age*: mean=nr; range=15–19 *Gender*: male=66; female=135	*Outcome(s)*: gambling problems *Tool(s)*: SOGS-RA *Time*: 4–5 weeks post-intervention	*Delivery mode*: face-to face; playable electronic storage *Provider*: teacher *Intensity and duration*: 7 x ~70 min, once per week *BCTs used*: 2.3. Self-monitoring of behavior; 4.2. Information about antecedents; 4.4. Behavioral experiments; 5.1 Information about health consequences; 5.3. Information about social and environmental consequences; 5.6. Information about emotional consequences Control group completed assessments only	No significant differences

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
Turner et al. (2008b). Canada	Evaluated a 1-hour gambling prevention program for students	374 students in grades 5–12 *Age*: nr *Gender*: nr	*Measurements*: problem gambling *Tool(s)*: SOGS-RA *Follow-up*: 7 weeks post-intervention	*Delivery mode*: face-to face; computer *Provider*: researcher *Intensity and duration*: 1×1 h *BCTs used*: 1.2. Problem solving; 4.2. Information about antecedents; 4.4. Behavioral experiments; 5.6. Information about emotional consequences; 16.3. Vicarious consequences Control group completed assessments only	No significant differences
Walther et al. (2013). Germany	Evaluated the effects of a school-based media education program	2,109 sixth- and seventh-grade students *Age*: mean=12 *Gender*: male=50.4%; female=49.6%	*Outcome(s)*: gambling frequency; lifetime gambling *Tool(s)*: researcher-generated questions *Time*: 7 weeks post-intervention	*Delivery mode*: face-to face *Provider*: teacher *Intensity and duration*: 1×90 min *BCTs used*: 4.2. Information about antecedents; 4.4. Behavioral experiments; 5.3. Information about social and environmental consequences; 5.6. Information about emotional consequences Control group attended regular classes	Significant decrease in current gambling in intervention condition compared to control. No change in lifetime gambling

Table 1 (continued)

General study information	Aims	Participants	Measures	Intervention	Findings
Williams et al. (2010). Canada	Evaluated a school-based gambling prevention program	1,686 high school students *Age*: mean=16; range=14–20 *Gender*: male=53%	*Outcome(s)*: gambling frequency; gambling expenditure; gambling problems *Tool(s)*: researcher-generated questions; DSM-IV-MR-J *Follow-up*: 3–7 months post-intervention	Two intervention conditions: standard and booster *Delivery mode*: face-to face; computer; playable electronic storage *Provider*: research assistants *Intensity and duration*: standard: 5 x ~100 min, over 2 weeks; booster: additional 1 session *BCTs used*: 3.1. Social support (unspecified); 4.1. Instruction on how to perform the behavior; 4.2. Information about antecedents; 5.6. Information about emotional consequences Control group completed assessments only	Gambling frequency significantly decreased in the standard and booster conditions but not the control. No significant decrease in problem gambling or gambling expenditure

Note: Addiction Severity Index-Gambling: ASI-G; Canadian Adolescent Gambling Inventory: CAGI; Cognitive behavioral intervention: CBI; Cognitive behavioral therapy: CBT; DSM-IV-Multiple Response-Juvenile: DSM-IV-MR-J; Education: EDU; Gambling Activities Questionnaire: GAQ; Gambling Problem Index: GPI; Gambling Quantity and Perceived Norms Scale: GQPN; Gambling Timeline Followback: G-TLFB; Motivational enhancement therapy: MET; not reported: nr; Personalized feedback intervention: PFI; South Oaks Gambling Screen-revised for Adolescents: SOGS-RA

diately post-intervention to 9 months post-intervention. In terms of behavior change, 11/16 (69%) interventions demonstrated significant reductions in gambling behavior.

As is shown in Table 2, three studies were classified as low risk of bias, thirteen studies had some concerns of risk, and no studies were considered high risk. Ten concerns related to missing outcomes, six to the randomization process and deviation from intended interventions, five to selection of the reported result, and three to measurement of the outcome. The results should therefore be interpreted with caution.

BCTs and MOD

A total of 18 different BCTs were adopted in the intervention or control conditions across all studies (see supplementary material 1 for the BCTs included in each study). The average number of BCTs per study was 4, with a range of 1 to 10. All 18 BCTs were present in the intervention condition and two techniques were identified in the control conditions. With regards to the latter, a single technique was adopted in two controls ('2.2. Feedback on behavior' and '4.2. Information about antecedents'). Note that the study including '2.2.

Table 2 *Quality assessment*

Paper	Randomization process	Deviation from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall
Broussard & Wulfert (2017)	+	+	+	+	+	+
Calado et al. (2020)	+	?	?	?	?	?
Canale et al. (2016)	+	+	?	+	+	?
Donati et al. (2018, study 2)	+	?	+	+	?	?
Donati et al. (2014)	+	+	?	+	?	?
Gaboury & Ladouceur (1993)	?	+	?	?	?	?
Huic et al. (2017)	+	?	?	?	+	?
Larimer et al. (2012)	?	+	+	+	+	?
Martens et al. (2015)	+	+	+	+	+	+
Petry et al. (2009)	+	+	+	+	+	+
St-Pierre et al. (2017)	?	+	?	+	+	?
Tani et al. (2021)	+	?	?	+	+	?
Turner et al. (2008a, study 2)	?	+	+	+	+	?
Turner et al. (2008b)	?	?	?	+	+	?
Walther et al. (2013)	+	+	?	+	+	?
Williams et al. (2010)	?	?	?	+	?	?

Note: +=low risk of bias; ?=some concerns

Table 3 *Frequency of BCTs in intervention conditions*

	BCT in all interventions (Max=16)		BCT in effective interventions (Max=11)	
BCT code & label	*n*	%	*n*	%
1.2. Problem solving	4	25	0	0
2.2. Feedback on behavior	3	19	3	27
2.3. Self-monitoring of behavior	2	13	0	0
3.1. Social support (unspecified)	3	19	3	27
4.1. Instruction on how to perform the behavior	4	25	1	9
4.2. Information about antecedents	11	69	7*	64
4.4. Behavioral experiments	7	44	5*	45
5.1. Information about health consequences	4	25	0	0
5.3. Information about social and environmental consequences	9	56	5*	45
5.6. Information about emotional consequences	9	56	5*	45
6.1. Demonstration of the behavior	1	6	0	0
6.2. Social comparison	3	19	1	9
6.3. Information about others' approval	1	6	0	0
8.1. Behavioral practice/rehearsal	2	13	0	0
9.1. Credible source	1	6	0	0
9.2. Pros and cons	1	6	1	9
14.2. Punishment	1	6	1	9
16.3. Vicarious experiences	3	19	0	0

Note: *Promising BCTs (identified as being present in ≥25% of all interventions *and* in two effective interventions)

Feedback on behavior' in the control also included the technique in the intervention condition. The use of the technique was therefore excluded for that study. In relation to the intervention conditions, the most frequently used BCT was '4.2. Information about antecedents', which was present in 11/16 (69%) of interventions. Other commonly adopted BCTs were '5.3. Information about social and environmental consequences' (9/16, 56%), '5.6. Information about emotional consequences' (9/16, 56%), and '4.4. Behavioral experiments' (7/16, 44%).

In terms of effectiveness, Table 3 shows four BCTs were labeled 'promising'. That is, those BCTs present in at least 25% of all interventions, in at least two effective interventions,

Table 4 *Definitions of identified BCTs*

BCT code & label	Definition
1.2. Problem solving	Analyse, or prompt the person to analyse, factors influencing the behavior and generate or select strategies that include overcoming barriers and/or increasing facilitators
2.2. Feedback on behavior	Monitor and provide informative or evaluative feedback on performance of the behavior
2.3. Self-monitoring of behavior	Establish a method for the person to monitor and record their behavior(s) as part of a behavior change strategy
3.1. Social support (unspecified)	Advise on, arrange or provide social support or non-contingent praise or reward for performance of the behavior
4.1. Instruction on how to perform the behavior	Advise or agree on how to perform the behavior
4.2. Information about antecedents	Provide information about antecedents that reliably predict performance of the behavior
4.4. Behavioral experiments	Advise on how to identify and test hypotheses about the behavior, its causes and consequences, by collecting and interpreting data
5.1. Information about health consequences	Provide information about health consequences of performing the behavior
5.3. Information about social and environmental consequences	Provide information about social and environmental consequences of performing the behavior
5.6. Information about emotional consequences	Provide information about emotional consequences of performing the behavior
6.1. Demonstration of the behavior	Provide an observable sample of the performance of the behavior, directly in person or indirectly
6.2. Social comparison	Draw attention to others' performance to allow comparison with the person's own performance
6.3. Information about others' approval	Provide information about what other people think about the behavior. The information clarifies whether others will like, approve or disapprove of what the person is doing or will do
8.1. Behavioral practice/rehearsal	Prompt practice or rehearsal of the performance of the behavior one or more times in a context or at a time when the performance may not be necessary, in order to increase habit and skill
9.1. Credible source	Present verbal or visual communication from a credible source in favor of or against the behavior
9.2. Pros and cons	Advise the person to identify and compare reasons for wanting (pros) and not wanting to (cons) change the behavior
14.2. Punishment	Arrange for aversive consequence contingent on the performance of the unwanted behavior
16.3. Vicarious consequences	Prompt observation of the consequences for others when they perform the behavior

and not included in both intervention and control conditions. These were '4.2. Information about antecedents' (7/11, 64%), '4.4. Behavioral experiments' (5/11, 45%), '5.3. Information about social and environmental consequences' (9/11, 45%), and '5.6. Information about emotional consequences' (9/11, 45%). Definitions of BCTs can be seen in Table 4.

The reviewed studies contained a total of six MODs: face-to-face; website; computer; playable electronic storage (i.e., video tapes, DVDs); printed publication; and video game (see Table 5). Most interventions were delivered using two MODs (n=8), whereas six interventions used a single MOD and two interventions used three MODs. The delivery mode used most frequently was face-to-face (14/16, 88%), followed by playable electronic storage (5/16, 31%), and computer (4/16, 25%). The MODs labeled as promising were face-to-face (9/11, 82%), computer (3/11, 27%), and playable electronic storage (2/11, 18%). Definitions of MODs can be seen in Table 6.

Discussion

The systematic review identified the BCTs and MODs adopted in interventions targeting adolescent gambling behavior. Sixteen studies met the inclusion criteria, eleven of which successfully changed gambling behavior.

Table 5 *Frequency of MODs used in intervention conditions*

	MOD in all interventions (Max=16)		MOD in effective interventions (Max=11)	
MOD	*n*	%	*n*	%
Face-to face	14	88	9*	82
Website	1	6	1	9
Computer	4	25	3*	27
Playable electronic storage	5	31	2*	18
Printed publication	3	19	3	27
Video game	1	6	1	9

Note: *Promising MODs (identified as being present in ≥25% of all interventions *and* in two effective interventions)

Table 6 *Definitions of identified MODs*

Mode of Delivery	Definition
Computer	Electronic mode of delivery that involves presentation of information by a desktop or laptop computer
Face-to face	Human interactional mode of delivery that involves an intervention source and recipient being together in the same location and communicating directly
Playable electronic storage	Electronic mode of delivery that involves presentation of information stored on an object that is inserted into a playing device
Printed publication	Printed material mode of delivery that involves use of a printed publication
Video game	Electronic mode of delivery that involves the intervention recipient playing a computer game
Website	Electronic mode of delivery that involves the intervention recipient interacting with a website

The review found a range of BCTs have been included in adolescent gambling interventions. The BCTs most frequently adopted were educational with strategies attempting to inform adolescents about the antecedents and consequences (emotional, social, and environmental) of problem gambling. For example, Tani et al. (2021) gave information on various problem gambling risk factors and Donati et al. (2014) presented participants with the economic disadvantages associated with gambling. The adoption of such BCTs is likely due to the knowledge within the target population and the purpose of the interventions. Specifically, knowledge of gambling, its potential consequences and other related cognitions may be lacking or erroneous in adolescents (St-Pierre et al., 2015). Such interventions therefore use these BCTs to correct beliefs or introduce new information, in the hope that cognition change influences gambling participation (see Keen et al., 2019). In terms of effectiveness, these BCTs were also three of the four labeled promising. Current findings are consistent with studies demonstrating preliminary effectiveness of educational interventions in reducing gambling behavior (Forsström et al., 2021). Thus, future interventions designed to modify adolescent gambling behavior should seek to include the BCTs '4.2. Information about antecedents', '5.3. Information about social and environmental consequences', and '5.6. Information about emotional consequences'. The final promising technique involved behavioral experiments, wherein participants simulate gambling and experience the immediate consequences in a controlled environment. For example, Calado et al. (2020) demonstrated randomness by having students play and bet on a roulette. Similarly, Broussard and Wulfert (2017) had participants play a slot machine programmed to demonstrate monetary losses over time. Through participation in gambling and experiencing negative consequences, such interventions attempt to dissuade future participation in the behavior. The review therefore suggests that, in addition to the aforementioned three BCTs, interventions should, at a minimum, consider adopting the technique '4.4. Behavioral experiments'. Interventions including these four BCTs could successfully demonstrate a reduction in adolescent gambling behavior.

In relation to the MODs, a range of delivery modes were adopted within the interventions. Most interventions included the face-to-face modality. The use of this delivery mode is again perhaps due to the target population and the potential reach of the setting. Indeed, educational settings where adolescents regularly attend, such as school, college, and university, provide an ideal opportunity for face-to-face intervention delivery. For example, Walther et al. (2013) trained teachers to deliver the intervention face-to-face to participants during class time. Other frequent MODs included technologies such as computers and playable electronic storage; however, these were always combined with a face-to-face component. For example, Williams et al.'s (2010) intervention was delivered mostly in person but utilized a computer to deliver PowerPoint slides. In terms of effectiveness, successful interventions were delivered using these three most frequently adopted MODs. Intervention developers should therefore look to computer, playable electronic storage, and/or face-to-face methods for content delivery, which mirror the playing platforms that adolescents gamble on.

The review identifies the BCTs and MODs most likely to reduce adolescent gambling behavior. However, there may be additional opportunities for intervention developers. Some of the effective BCTs identified by Humphreys et al. (2021) were not used often in our review. For example, '2.3. Self-monitoring of behavior' was only included in two interventions. This technique has also shown effectiveness in changing other health-related behav-

iors such as sedentariness (Compernolle et al., 2019) and alcohol consumption (Crane et al., 2018). Additionally, from the 93 BCTs included in the BCTTv1 taxonomy, we found 75 (81%) were not included in any intervention. This suggests that gambling interventions for adolescents have adopted minimal techniques and designers have at their disposal many other strategies that could be useful. Of course, not all untapped BCTs will be effective and it is up to researchers to establish effectiveness. We recommend new programs adopt the promising BCTs identified here whilst exploratory and experimental work establishes how effective the additional techniques are in modifying adolescent gambling behavior.

In terms of the MODs, other modes exist for intervention delivery. This could be especially useful given the challenges of face-to-face delivery during the outbreak of the COVID-19 pandemic (Quail et al., 2021). Mobile phones have shown to be effective in promoting other health behaviors (Yang & Van Stee, 2019). This MOD may be particularly appealing given the relative cheapness and significant reach of mobile interventions, and the high usage of mobile phones amongst adolescents (Lopez-Fernandez et al., 2014). Additionally, some of the delivery modes that were effective in interventions but not frequently used could prove fruitful. For example, the use of a website, which was only adopted by Canale et al. (2016), showed significant intervention effects in reducing gambling behavior. Similarly, printed publications were not adopted frequently (n=3), yet all interventions including the delivery mode were effective.

It is interesting to note the frequency of BCTs included in interventions. Research synthesizing BCT frequency has found increased effectiveness when interventions include a greater number of BCTs (Webb et al., 2010). However, adopting multiple BCTs does not always lead to effective interventions (Bohlen et al., 2020). In the present study, two interventions were effective whilst using a single BCT whereas successful change was also seen in an intervention using 10 BCTs (albeit the latter may find difficulty in identifying the main change agent). Moreover, some interventions adopting the same number of BCTs showed different effects. Instead of focusing on BCT frequency, it is more important to consider how techniques combine or interact. Techniques may have a synergistic or additive effect, or they may nullify the effects of others (Dusseldorp et al., 2014). Therefore, although we identify the BCTs apparent in interventions, that is not to say each technique contributed equally to effectiveness. However, using the promising BCTs could be a useful starting point and future research should establish the optimal frequency and combinations of techniques. Another consideration is isolating the effective BCTs when they are delivered in combination with ineffective ones. A single component intervention with equal effectiveness as a multi-component intervention is more desirable from both an individual experiential perspective and an economic one.

We also note that, consistent with Keen et al. (2017), only a small number of studies reported measures of behavioral outcomes and instead focused on cognitions. As such, some studies targeting and measuring gambling cognitions only were excluded, some of which were effective in changing such cognitions. For example, Zhou et al. (2019) found that a GameSense prevention program positively manipulated knowledge about gambling and intentions towards gambling in the future. The primary focus on cognitions could be due to difficulty in obtaining behavioral measures (Braverman et al., 2014) or because researchers assume successful change will lead to behavior change. However, although interventions may change cognitions, they have not always managed to change actual gambling behavior (Williams et al., 2012b). Thus, assessing cognition change is no proxy for behavior change,

despite being a necessary first step. Another reason could be due to the sample studied; adolescents and young adults are not legally allowed to gamble. However, given gambling rates in this group (Calado et al., 2017; Emond et al., 2020), interventions should not only measure and modify gambling beliefs, but attention should also be given to actual gambling behavior.

Limitations

There are some limitations to note. First, intervention success depends on other factors aside from the content and delivery mode. For example, the fidelity of delivery can determine whether an intervention is effective (Bellg et al., 2004) and multiple factors can influence intervention uptake (Milat et al., 2013). Second, the approach to identifying 'promising' BCTs may have some attached limitations. For example, the usefulness of a technique used often but showing success on only two occasions could be questioned. However, there is no agreed method for identifying effective BCTs and each approach used to date has limitations (Michie et al., 2018). Following previous work (e.g., Ahmed et al., 2021; Brown et al., 2019, 2020; Lorencatto et al., 2012), the approach used has the potential to identify BCTs that could be effective. Third, some studies only had short-term follow-up meaning it is unclear whether initial behavior change was sustained over time. Interventions should therefore assess intervention effects over a longer period. Fourth, BCT identification relies heavily on accurate reporting in studies. Techniques would be missed in the extraction process if, for example, they were either reported incorrectly, reported vaguely, or not reported at all. As has been noted in other work (e.g., Glasziou et al., 2008; Scott et al., 2020), reporting of intervention content was lacking in some studies. If word counts prevent detailed reports of materials, supplementary files should be used to make intervention content explicit. Finally, the identified studies were limited by the databases used and the inclusion of studies in English language only.

Conclusions

The study reviewed the content of interventions implemented to reduce adolescent gambling behavior. The review findings highlight four specific BCTs that were more effective than others at reducing the behavior. Additionally, the review found that three delivery modes were apparent in successful interventions. Given these findings, we recommend developers strongly consider incorporating these when designing new interventions for this population. The range of BCTs and MODs used across studies was also relatively narrow compared to other areas of behavior change. Future experimentation with BCTs and MODs not represented in the current review is needed, to enhance the efficacy of adolescent harm prevention programs more broadly.

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