Review

Interventions for prevention and treatment of tobacco smoking in school-aged children and adolescents: A systematic review and meta-analysis

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A R T I C L E  I N F O

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Keywords:
Systematic review
Primary health care
Smoking cessation
Smoking prevention
Children
Youth

A B S T R A C T

Objectives. To determine the effectiveness of primary health care relevant interventions to prevent and treat tobacco smoking in school-aged children and adolescents.

Methods. This systematic review considered studies included in a prior review. We adapted and updated the search to April 2015. Titles, abstracts and full-text articles were reviewed in duplicate; data extraction and quality assessments were performed by one reviewer and verified by another. Meta-analyses and pre-specified subgroup analyses were performed when possible. PROSPERO #CRD42015019051.

Results. After screening 2118 records, we included nine randomized controlled trials. The mostly moderate quality evidence suggested targeted behavioral interventions can prevent smoking and assist with cessation. Meta-analysis showed intervention participants were 18% less likely to report having initiated smoking at the end of intervention relative to controls (Risk Ratio 0.82; 95% confidence interval 0.72, 0.94); the absolute effect is 1.92% for smoking initiation, Number Needed to Treat is 52 (95% confidence interval 33, 161). For cessation, meta-analysis showed intervention participants were 34% more likely to report having quit smoking at the end of intervention relative to controls (Risk Ratio 1.34; 95% confidence interval 1.05, 1.69); the absolute effect is 7.98% for cessation, Number Needed to Treat is 13 (95% confidence interval 6, 77). Treatment harms were not mentioned in the literature and no data were available to assess long-term effectiveness.

Conclusion. Primary care relevant behavioral interventions improve smoking outcomes for children and youth. The evidence on key components is limited by heterogeneity in methodology and intervention strategy. Future trials should target tailored prevention or treatment approaches, establish uniform definition and measurement of smoking, isolate optimal intervention components, and include long-term follow-up.

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Abbreviations: CTFPHC, Canadian Task Force on Preventive Health Care; USPSTF, United States Preventive Services Task Force; GRADE, Grading of Recommendations Assessment Development and Evaluation.

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Introduction

Childhood and adolescence are developmental periods characterized by risk taking and experimentation in many areas, including using tobacco. In 2014, almost 25% of American high school students and 8% of middle school students reported using tobacco; 9.2% and 2.5% respectively, reported smoking cigarettes (Arrazola et al., 2015). In 2012–2013, 24% of Canadian youth reported that they had tried a cigarette at least once, with the prevalence ranging from 3% among 6th graders to 43% among 12th graders (Health Canada, 2014). While some young people will never try smoking and some will never take more than a puff or two of a cigarette, there are others who will become regular and perhaps lifelong smokers. In many countries, including Canada and the US, the majority of adult smokers began smoking in their teenage years (Janz, 2012; Substance Abuse and Mental Health Services Administration, 2014; U.S. Department of Health and Human Services, 2012).

In the short-term, children and youth who smoke can experience a variety of negative respiratory effects (U.S. Department of Health and Human Services, 2012) and there is some evidence that nicotine exposure may interfere with healthy brain development (Dwyer, McQuown, & Leslie, 2009; Galván, Poldrack, Baker, McGlennen, & London, 2011). In the long-term, those who continue to use tobacco will have greater risk for developing serious and sometimes fatal smoking related health problems such as lung and other cancers, cardiovascular diseases, oral diseases, and respiratory disorders (U.S. Department of Health and Human Services, 2014).

Estimates from both Canadian and US sources show downward trends in the prevalence of tobacco use and specifically cigarette smoking among children and adolescents over the past two decades (Arrazola et al., 2015; Health Canada, 2013; Janz, 2012; U.S. Department of Health and Human Services, 2012). These reductions are a good sign, however, there is some indication that the deceleration in prevalence has slowed or halted (U.S. Department of Health and Human Services, 2012) and even at these lower rates, across North America there are still millions of children and youth each year who experiment with cigarettes or become regular smokers. This reality reinforces the need for prevention and early treatment that will promote healthy behaviors in children and adolescents and reduce the risk of poor health outcomes later in life.

In 2003 the U.S. Preventive Services Task Force (USPSTF) determined that there was insufficient evidence to recommend for or against interventions to prevent and treat tobacco use in children and youth (U.S. Preventive Services Task Force, 2003). In 2013 the USPSTF released an updated B-grade recommendation encouraging primary care clinicians to provide interventions, such as education or brief counseling, to prevent tobacco use (U.S. Preventive Services Task Force, 2013); recommendations were not made for or against treatment. In the absence of national or provincial/territorial guidelines, current practice for prevention and treatment of child and adolescent tobacco smoking in Canada is left to the discretion of individual practitioners. Recently however, the Canadian Task Force on Preventive Health Care (CTFPHC) decided to produce clinical practice guidelines on this topic, and the present study was conducted to inform these recommendations.

Our aim was to conduct an up-to-date systematic review and meta-analysis of trials to answer the following questions:

- Are behaviorally-based interventions relevant to the Canadian primary care setting that are designed to prevent tobacco smoking effective in preventing school-aged children and youth from trying or taking up tobacco smoking and reducing future tobacco smoking during adulthood? What are the elements of efficacious prevention interventions?
- Are behaviorally-based and non-pharmacological alternative and complementary interventions relevant to the Canadian primary care setting that are designed to help school-aged children and youth stop ongoing tobacco smoking effective in achieving smoking cessation and reducing future tobacco smoking during adulthood? What, if any, adverse effects are associated with these interventions? What are the elements of efficacious treatment interventions?

Methods

Protocol and registration

The protocol was registered with the International Prospective Registry of Systematic Reviews (PROSPERO #CRD42015019051). The review was prepared in accordance with CTFPHC methods (http://canadiantaskforce.ca/methods/methods-manual/) and PRISMA-P guidelines for systematic reviews about...
health care interventions (Shamseer et al., 2015). Similar methods have been used and reported elsewhere by our review group (e.g., Peirson et al., 2015).

**Data sources and search strategy**

This review considered studies identified in a recent USPSTF review on the same topic (Patnode, O’Connor, Whitlock, Perdue, & Soh, 2012) [AMSTAR (Shea et al., 2007) rating of 10/11]; these studies were either included in that review or were excluded by the USPSTF for study quality. The USPSTF evaluated trials considered and included in three previous reviews (Christakis, Garrison, Ebel, Wiehe, & Rivara, 2003; Grimshaw & Stanton, 2006; Thomas, Baker, & Lorenzetti, 2007) that covered the tobacco prevention literature through July 2002 and the tobacco cessation literature through August 2009 (the USPSTF only considered studies published in or after 1980). The USPSTF then searched for English citations in MEDLINE, PsycINFO, the Cochrane Central Register of Controlled Trials, the Cochrane Database of Systematic Reviews, PubMed, and the Database of Abstracts of Reviews of Effects starting January 2002 to September 14, 2012 for prevention and starting January 2009 to September 14, 2012 for cessation. We used the same strategies to update the search from January 30, 2012 to April 15, 2015 and we included an additional database (Embase) and allowed citations in English and French. The USPSTF’s search for studies of behavioral treatments was limited to randomized controlled trials; therefore we performed a separate harms search in the same databases and with the same dates as the other treatment searches, but without limits on study design. The search strategy for MEDLINE is included in the Appendix. We also conducted a manual search of recent on-topic systematic reviews to look for relevant primary studies not captured by our database search.

**Study selection**

Citations found through our updated search, as well as citations from the USPSTF review (Patnode et al., 2012) were uploaded to a web-based systematic review software program (DistillerSR, 2015) for screening. Titles and abstracts were reviewed independently by two raters and any citation included by either rater went on to full text relevance testing. Full text screening was done independently by two people with consensus required for inclusion or exclusion. Conflicts were discussed and a third team member was consulted if necessary.

**Selection criteria**

The selection criteria reflect our interest in the prevention and treatment of tobacco smoking among children and youth in the context of primary care. These criteria are generally consistent with the conditions set forth in the USPSTF’s review on this same topic (Patnode et al., 2012), but in some cases were narrowed. For example, the USPSTF included smokeless tobacco products but we limited to combustible tobacco products; the USPSTF included nicotine replacement therapies but we did not; and the USPSTF accepted a single, brief contact per year or brief written materials as acceptable comparisons while we considered this as low intensity intervention and required comparison groups to have no content specifically designed or intended to prevent or treat tobacco smoking in school-aged children and youth.

**Types of interventions**

Interventions had to focus on preventing tobacco smoking (behavioral approaches, e.g., education, counseling) or treating tobacco smoking (behavioral,
Types of studies

For benefit outcomes we accepted only randomized controlled trials with at least 30 participants per arm for baseline measures. Studies that reported harms of treatment interventions could be randomized controlled trials or use any comparative observational design, and include any number of participants. Interventions delivered to pre-existing groups (e.g., teams, classes) or that used known peers as counselors were excluded. Multi-component interventions were included only if the majority of the content focused specifically on prevention or treatment of tobacco smoking. Delivery of intervention could be via personal contact, technology-based messaging, or print media, and any duration or intensity was acceptable. Finally, interventions had to have been conducted in very high human development index countries.

Types of participants

Included studies recruited school-aged children (5–12 years) and youth (13–18 years) and/or their parents. Prevention participants had never smoked tobacco or were not currently smoking tobacco (as defined by each study, e.g., no smoking in past 30 days). Treatment participants were self-reported smokers or met the study’s definition of current tobacco smoking (e.g., smoked in past 30 days). Interventions could be delivered to parents as long as the target population for prevention or treatment was children and youth. Studies were excluded if they focused on pregnant adolescents or on children or teens with cognitive deficits, mental or physical health issues, and/or substance use disorders.

Types of outcome variables

Studies had to provide data for at least one of the following outcomes: incidence of tobacco smoking (prevention focus), incidence of stopping tobacco smoking (treatment focus), prevalence of tobacco smoking in adulthood (prevention and treatment), or any harms of treatment interventions (e.g., anxiety, pain, discomfort, infection). Benefits had to be assessed at least six months after the start of the intervention; there was no minimum follow-up for harms.

Data collection and methodological quality

For each study, one team member completed full data extraction (study characteristics and outcome data) and study assessment (risk of bias) using standardized forms; a second person verified all data and ratings. For study characteristics reviewers extracted the following information: country; objective; methods (e.g., design, eligibility, follow-up); description of participants (e.g., sample size, age, baseline smoking status); outcome measures; description of the intervention (e.g., setting, interventionists, intensity, duration, components) and comparator; and funding. From each study we extracted the number, proportion, or percentage of participants in each arm who had started (prevention) or stopped (treatment) smoking tobacco at the follow-up assessment as well as the total sample size for both intervention and control groups. The Cochrane Risk of Bias Tool (Higgins et al., 2011a, b) was used to assess the methodological quality of all randomized controlled trials, at both outcome and study levels. These ratings contributed to assessments of the quality of the evidence. Disagreements were resolved through discussion or in consultation with a third team member if necessary.

Table 1
Summary of study features — populations.

<table>
<thead>
<tr>
<th>Author (year), Country</th>
<th>Baseline age (years)</th>
<th>Sex (% female)</th>
<th>Race</th>
<th>SES</th>
<th>Baseline smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curry et al. (2003), USA</td>
<td>Range 10–12 assessment cohort mean 11</td>
<td>Assessment cohort 52%</td>
<td>84% Caucasian</td>
<td>68% annual family income ≥ $45K; 76% parents post-secondary education</td>
<td>Most never smoked 6.7% had experimented 1.2% had smoked ≤ 30 days</td>
</tr>
<tr>
<td>Fidler et al. (2001), UK</td>
<td>Range 10–15</td>
<td>Overall 53%</td>
<td>NR</td>
<td>NR</td>
<td>Prevention: never smokers, treatment: smoke ≤ 30 days treatment: smoked ≤ 30 days</td>
</tr>
<tr>
<td>Hiemstra et al. (2014), Netherlands</td>
<td>Range 9–11 overall mean 10</td>
<td>IG 57%</td>
<td>98% Dutch</td>
<td>25% families low SES, 27% middle, 48% high</td>
<td>No criteria for participation but only never smokers included in analysis</td>
</tr>
<tr>
<td>Hollis et al. (2005), USA</td>
<td>Range 14–17 overall mean 17</td>
<td>CG 49%</td>
<td>Overall 59%</td>
<td>78% Caucasian</td>
<td>Prevention: never or former (no smoking ≤ 30 days) treatment: smoked ≤ 30 days</td>
</tr>
<tr>
<td>Hovell et al. (1996), USA</td>
<td>Range 11–19 overall mean 14</td>
<td>Overall 54%</td>
<td>73% Caucasian</td>
<td>70% reported a parent graduated college</td>
<td>Never or not current; those who smoked ≥ 30 days were excluded from analysis</td>
</tr>
<tr>
<td>Kertala et al. (1999), Finland</td>
<td>Overall mean 13</td>
<td>Overall 49%</td>
<td>NR</td>
<td>NR</td>
<td>Prevention: those who do not smoke treatment: those who smoke</td>
</tr>
<tr>
<td>Phert et al. (2008), USA</td>
<td>Range 13–17 overall mean 17</td>
<td>IG 55%</td>
<td>91–92% Caucasian</td>
<td>NR</td>
<td>Prevention: never smokers, non-smokers (1–2 puffs ≥ 1 year ago) or former smokers (smoked ≤ year but not ≤ 30 days) treatment: current regular or occasional smokers</td>
</tr>
<tr>
<td>Redding et al. (2014), USA</td>
<td>Range 14–17 overall mean 16</td>
<td>Overall 100%</td>
<td>83–85% Black</td>
<td>Economically disadvantaged areas</td>
<td>Prevention: never smoked ≥ weekly</td>
</tr>
<tr>
<td>Stevens et al. (2002), USA</td>
<td>Range 9–12 overall mean 11</td>
<td>IG 50%</td>
<td>NR</td>
<td>&gt;56% reported annual family income ≥ $50K</td>
<td>Treatment: smoke ≥ weekly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CG 46%</td>
<td></td>
<td>95% never smoked</td>
<td></td>
</tr>
</tbody>
</table>

IG = intervention group, CG = control group, NR = not reported.
## Table 2
Summary of study features — interventions.

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Focus</th>
<th>Other behaviors</th>
<th>Components</th>
<th>Mode</th>
<th>Youth or family</th>
<th>Intensity</th>
<th>Contact time</th>
<th>Primary care role</th>
<th>Agent(s)</th>
<th>Setting(s)</th>
<th>Length (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curry et al. (2003)</td>
<td>Prevention</td>
<td>No</td>
<td>Education/information counseling/advice booster sessions</td>
<td>F2F phone computer</td>
<td>Family</td>
<td>High</td>
<td>NR</td>
<td>Recruitment delivery</td>
<td>Physician or pediatrician health counselors</td>
<td>Primary care home</td>
<td>14</td>
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<td></td>
<td>print</td>
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<td>videos</td>
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</tr>
<tr>
<td>Fidler et al. (2001)</td>
<td>Prevention</td>
<td>No</td>
<td>Education/information</td>
<td>Print postal</td>
<td>Youth</td>
<td>Low</td>
<td>None</td>
<td>Recruitment messenger</td>
<td>Primary care providers</td>
<td>Home</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Print postal</td>
<td></td>
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</tr>
<tr>
<td>Hiemstra et al. (2014)</td>
<td>Prevention</td>
<td>No</td>
<td>Education/information</td>
<td>F2F phone computer</td>
<td>Family</td>
<td>Low</td>
<td>None</td>
<td>Recruitment delivery</td>
<td>Researchers sent materials</td>
<td>Home</td>
<td>12</td>
</tr>
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<td></td>
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<td>print</td>
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</tr>
<tr>
<td>Hollis et al. (2005)</td>
<td>Prevention &amp; treatment</td>
<td>No</td>
<td>Education/information counseling/advice motivational interviewing boosters</td>
<td>F2F phone computer</td>
<td>Youth</td>
<td>High</td>
<td>~15 min</td>
<td>Recruitment delivery</td>
<td>Primary care providers health counselors</td>
<td>Primary care</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>print</td>
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<tr>
<td>Hovell et al. (1996)</td>
<td>Prevention</td>
<td>No</td>
<td>Education/information counseling/advice environment change Counseling/advice</td>
<td>F2F</td>
<td>Youth</td>
<td>High</td>
<td>NR</td>
<td>Recruitment delivery</td>
<td>Dentists</td>
<td>Dental clinic</td>
<td>24</td>
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<td>print</td>
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<td></td>
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</tr>
<tr>
<td>Kentala et al. (1999)</td>
<td>Prevention &amp; treatment</td>
<td>No</td>
<td>Counseling/advice motivational interviewing boosters</td>
<td>F2F photos</td>
<td>Youth</td>
<td>Low</td>
<td>~5 min</td>
<td>Delivery</td>
<td>Dentists</td>
<td>Dental clinic</td>
<td>24</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F2F phone</td>
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</tr>
<tr>
<td>Phert et al. (2008)</td>
<td>Prevention &amp; treatment</td>
<td>No</td>
<td>Counseling/advice motivational interviewing boosters</td>
<td>F2F photos</td>
<td>Youth</td>
<td>High</td>
<td>~70 min</td>
<td>Recruitment delivery</td>
<td>Primary care providers health counselors</td>
<td>Primary care</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F2F phone</td>
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<tr>
<td>Redding et al. (2014)</td>
<td>Prevention &amp; treatment</td>
<td>Condom use</td>
<td>Education/information counseling/advice</td>
<td>F2F computer</td>
<td>Youth</td>
<td>High</td>
<td>NR</td>
<td>Recruitment delivery</td>
<td>Health counselors</td>
<td>Family planning clinic</td>
<td>9</td>
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<td>print postal</td>
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</tr>
<tr>
<td>Stevens et al. (2002)</td>
<td>Prevention</td>
<td>Alcohol use</td>
<td>Education/information counseling/advice</td>
<td>F2F</td>
<td>Family</td>
<td>High</td>
<td>NR</td>
<td>Recruitment delivery</td>
<td>Primary care providers</td>
<td>Primary care home</td>
<td>36</td>
</tr>
<tr>
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<td>computer print</td>
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</tr>
</tbody>
</table>

F2F = face to face, NR = not reported.
Quality of the evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) system (GRADE Working Group, n.d.; GRADEpro, 2008) was used to assess the strength and quality of the evidence for all outcomes. GRADE rates the quality of a body of evidence as high, moderate, low, or very low. Each level reflects a different assessment of the likelihood that further research will impact the estimate of effect (e.g., high = further research is unlikely to change confidence in the estimate of effect; very low = the estimate of effect is very uncertain). A GRADE quality rating is based on an assessment of five conditions: (1) methodological quality, (2) statistical heterogeneity, (3) directness of the body of evidence to the populations, interventions, comparators and/or outcomes of interest, (4) precision of results, and (5) indications of reporting bias.

Statistical analyses and synthesis of results

To perform meta-analyses for the binary outcomes of benefit (incidence of smoking, incidence of stopping smoking) we utilized the number of events, proportion, or percentage data from included trials to generate the summary measures of effect in the form of risk ratios (RR) using DerSimonian and Laird random effects model with Mantel–Haenszel method (DerSimonian & Laird, 1986). The data from cluster-randomized trials were adjusted for clustering or design effect before inclusion in meta-analyses (Higgins et al., 2011a, b). The intracluster correlation coefficient was obtained from existing literature (Patnode et al., 2012). The data from smoking prevention studies were adjusted for baseline smoking prevalence if the overall sample included a proportion of smokers at baseline in each arm. In addition, for outcomes that showed statistically significant prevention or treatment effects, we calculated absolute risk reduction (ARR) or absolute risk increase (ARI) and number needed to treat (NNT). NNTs were calculated using the absolute numbers provided by the GRADE analysis, estimated using the control group event rate and risk ratio with the 95% confidence interval obtained from the meta-analysis (Schünemann et al., 2011). Analyses were performed using Review Manager (2014); GRADEpro (2008) software packages. When studies did not provide data necessary for pooling, results are described narratively.

Further pre-specified subgroup analyses based on baseline age (5–12 years, 13–18 years), baseline smoking status [never, former, regular (daily or weekly), occasional], intervention intensity [high (e.g., ≥2 meetings with a health professional of any length or one long session, such as a half-day or full-day workshop), low (e.g., 1 brief meeting with a health professional or provision of written materials)], and study risk of bias rating [high, unclear, low] were conducted where possible to evaluate statistical stability and potential differences in intervention effect. Cochran’s Q (α = 0.05) was employed to detect statistical heterogeneity and the I² statistic was used to quantify the magnitude of statistical heterogeneity across studies, where I² of 30–60% represents moderate heterogeneity and 50–90% represents substantial heterogeneity (Deeks et al., 2011).

For questions about features of efficacious interventions, we identified these interventions from studies in the incidence of smoking and incidence of stopping smoking meta-analyses that showed statistically significant effects in favor of the intervention group. For these studies we summarized key features of the target populations (e.g., age, sex, baseline smoking status) and the interventions (e.g., components, modes of delivery, intensity, duration).

Results

Search results

We identified 2118 unique citations [2094 from our search and 24 from the USPSTF review (Patnode et al., 2012)] for screening (Fig. 1). We excluded 1938 articles at title and abstract, leaving 180 for full-text review, of which 171 were subsequently excluded. We identified no additional studies through a hand-search of the on-topic and recent systematic reviews. Nine studies (Curry et al., 2003; Fidler & Lambert, 2001; Hiemstra et al., 2014; Hollis et al., 2005; Hollist et al., 1996; Kentala, Utriainen, Pahkala, & Mattila, 1999; Phert et al., 2008; Redding et al., 2014; Stevens et al., 2002) met the inclusion criteria for this review; seven of these studies (Curry et al., 2003; Fidler & Lambert, 2001; Hollis et al., 2005; Hollist et al., 1996; Kentala et al., 1999; Phert et al., 2008; Stevens et al., 2002) appeared in the 2013 USPSTF review (Patnode et al., 2012), and two (Hiemstra et al., 2014; Redding et al., 2014) were located by our updated search.

Study characteristics

All nine included randomized controlled trials provided data about the effectiveness of interventions to prevent tobacco smoking; four of these studies (Hollis et al., 2005; Kentala et al., 1999; Phert et al., 2008; Redding et al., 2014) provided data on the effectiveness of treatment interventions. No studies were found that answered the questions about reducing future tobacco smoking during adulthood. Likewise, no studies were found that reported any harms of treatment interventions. Tables 1, 2, and 3 provide an overview of the key features of the populations, interventions and design elements across the nine included trials. Each study is described in more detail in a supplemental file.

Study quality

Overall risk of bias was rated high in five studies (Curry et al., 2003; Fidler & Lambert, 2001; Kentala et al., 1999; Redding et al., 2014; Stevens et al., 2002) and unclear in four studies (Hiemstra et al., 2014; Hollis et al., 2005; Hollist et al., 1996; Phert et al., 2008). The domain ratings for each study are shown in Table 4.

Prevention of tobacco smoking

All nine included trials answered the question regarding the effectiveness of interventions to prevent school-aged children and youth from trying or taking up tobacco smoking (Curry et al., 2003; Fidler &

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### Table 3

Summary of study features – methods.

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Comparator</th>
<th>Smoking outcome</th>
<th>Biochemical verification</th>
<th>Assessment point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curry et al. (2003)</td>
<td>RCT</td>
<td>Usual care</td>
<td>Smoked even a puff ≤ 30 days</td>
<td>None</td>
<td>6 months post-intervention completion</td>
</tr>
<tr>
<td>Fidler et al. (2001)</td>
<td>RCT</td>
<td>No intervention</td>
<td>Smoked since baseline</td>
<td>None</td>
<td>Immediate post-intervention</td>
</tr>
<tr>
<td>Hiemstra et al. (2014)</td>
<td>RCT</td>
<td>Usual care</td>
<td>Ever smoked</td>
<td>None</td>
<td>Immediate post-intervention</td>
</tr>
<tr>
<td>Hollis et al. (2005)</td>
<td>RCT</td>
<td>Attention control: diet intervention</td>
<td>Smoked ≤ 30 days</td>
<td>None</td>
<td>Immediate post-intervention</td>
</tr>
<tr>
<td>Hollist et al. (1996)</td>
<td>RCT</td>
<td>Usual care</td>
<td>Used tobacco ≤ 30 days</td>
<td>None</td>
<td>Immediate post-intervention</td>
</tr>
<tr>
<td>Kentala et al. (1999)</td>
<td>RCT</td>
<td>Usual care</td>
<td>Ever smoked</td>
<td>None</td>
<td>Immediate post-intervention</td>
</tr>
<tr>
<td>Phert et al. (2008)</td>
<td>RCT</td>
<td>Usual care</td>
<td>Prevention: maintained abstinence treatment: report quitting since baseline</td>
<td>None</td>
<td>Immediate post-intervention</td>
</tr>
<tr>
<td>Redding et al. (2014)</td>
<td>RCT</td>
<td>Usual care</td>
<td>Prevention: smoked since baseline</td>
<td>None</td>
<td>3 months post-intervention completion</td>
</tr>
<tr>
<td>Stevens et al. (2002)</td>
<td>RCT</td>
<td>Attention control: safety behaviors</td>
<td>Ever smoked</td>
<td>None</td>
<td>Immediate post-intervention</td>
</tr>
</tbody>
</table>
Lambert, 2001; Hiemstra et al., 2014; Hollis et al., 2005; Hollis et al., 1996; Kentala et al., 1999; Pbert et al., 2008; Redding et al., 2014; Stevens et al., 2002). Fig. 2 presents a forest plot for the seven studies that could be pooled (Fidler & Lambert, 2001; Hiemstra et al., 2014; Hollis et al., 2005; Hollis et al., 1996; Kentala et al., 1999; Pbert et al., 2008; Redding et al., 2014), and Table 5 summarizes the overall and subgroup analyses for this outcome. Intervention participants were 18% less likely to report having tried or taken up smoking at the end of the intervention, relative to controls (RR 0.82; 95% CI 0.72, 0.94; I² = 26%), the absolute effect between groups for smoking initiation was 18% less likely to report having tried or taken up smoking at the end

### Table 4
Summary of study risk of bias assessments.^[a]

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Sequence generation</th>
<th>Allocation concealment</th>
<th>Blinding participants and personnel</th>
<th>Blinding outcome assessment</th>
<th>Incomplete reporting</th>
<th>Selective reporting</th>
<th>Other risk of bias</th>
<th>Overall risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curry et al. (2003)</td>
<td>U</td>
<td>U</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Fidler et al. (2001)</td>
<td>H</td>
<td>U</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Hiemstra et al. (2014)</td>
<td>L</td>
<td>U</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Hollis et al. (2005)</td>
<td>U</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Hollis et al. (1996)</td>
<td>U</td>
<td>H</td>
<td>U</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>U</td>
</tr>
<tr>
<td>Kentala et al. (1999)</td>
<td>H</td>
<td>U</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Pbert et al. (2008)</td>
<td>U</td>
<td>H</td>
<td>U</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>U</td>
</tr>
<tr>
<td>Redding et al. (2014)</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Stevens et al. (2002)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

^[a] Assessments performed using the Cochrane’s Risk of Bias Tool (Higgins et al., 2011a, b); L = low risk of bias, U = unclear risk of bias, H = high risk of bias.

^[b] Other potential sources of bias: no power calculation or study powered to <70%; statistically significant baseline differences in study groups on important characteristics such as smoking status, age, gender, SES; low compliance rate; contamination (e.g., participants using nicotine replacement therapy on their own while taking part in intervention); industry funding with no statement about other involvement in study aspects; conflicts of interest not appropriately addressed.

Favours Intervention Favours Control

Behaviorally based primary care relevant interventions for treatment of tobacco smoking

Four of the nine included trials answered the question regarding the effectiveness of treatment interventions (Hollis et al., 2005; Kentala et al., 1999; Pbert et al., 2008; Redding et al., 2014). Fig. 3 presents a forest plot for the three studies that could be pooled (Hollis et al., 2005; Pbert et al., 2008; Redding et al., 2014), and Table 6 summarizes the overall and subgroup analyses for this outcome. Intervention participants were 34% or 1.3 times more likely to report having quit smoking at the post-intervention assessment, relative to controls (RR 1.34; 95% CI 1.05, 1.69; I² = 0%), the absolute effect between groups was 7.98% for cessation, and the NNT for one youth to quit smoking was 13 (95% CI 6, 77). All of the studies that included a treatment focus targeted youth (aged ≥13 years) and provided high intensity interventions; therefore we could not perform subgroup analyses based on age.
Levels of tobacco dependence and smoking cessation

We also present the evidence available for the outcome of level of tobacco dependence in adolescents and incidence of smoking cessation or smoking abstinence; only one study provided data for this outcome (Prêt et al., 2008). The level of nicotine dependence and the loss of autonomy over tobacco use were assessed using the modified Fagerström Tolerance Questionnaire (mFTQ) and the Hooked on Nicotine Checklist (HONC) respectively. The percentage addicted per HONC score at baseline was 68.1% for intervention group and 70.9% for control group. The results showed that the likelihood to quit smoking at immediate post-intervention (6 months) was significantly decreased by 32% (OR 68; 95% CI 0.60, 0.79) with higher HONC and mFTQ scores at baseline. However, the effect was no longer significant at 12-months of follow-up.

Future tobacco smoking during adulthood

No data were available to assess the long-term effect of prevention or treatment interventions on tobacco smoking during adulthood.

Harms of non-pharmacological treatment interventions

No studies reported results for adverse effects associated with behaviorally-based or other non-pharmacological interventions designed to help school-aged children and youth stop ongoing tobacco smoking.

Elements of efficacious interventions

Within the prevention focused meta-analysis (see Fig. 2) two studies showed statistically significant effects in favor of the intervention groups (Fidler & Lambert, 2001; Hollis et al., 2005). Fidler and Lambert reported a 35% relative reduction in the initiation of smoking at any point over the previous 12 months among intervention participants compared to youth in a no intervention control group (RR 0.65; 95% CI 0.47, 0.90), and Hollis et al. observed a 24% relative reduction in reported smoking in the past 30 days by youth in the intervention group compared to participants in an attention control group (RR 0.76; 95% CI 0.59, 0.99). Within the treatment focused meta-analysis (see Fig. 3) one study showed a statistically significant effect in favor of the intervention group (Hollis et al., 2005). Hollis et al. reported a 40% relative increase in cessation (no smoking in past 30 days) in the intervention youth compared to controls (RR 1.40; 95% CI 1.07, 1.82).

Table 5
Summary of results for prevention of tobacco smoking.

<table>
<thead>
<tr>
<th>Outcome and subgroup</th>
<th>Subgroups</th>
<th>Test for subgroup differences</th>
<th># of studies (participants)</th>
<th>GRADE quality ratinga</th>
<th>Risk ratio (95% CI)</th>
<th>Absolute risk reduction</th>
<th>Number needed to treat (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of tobacco smoking overall</td>
<td>–</td>
<td>–</td>
<td>7 (15,545)</td>
<td>Moderate</td>
<td>0.82 (0.72, 0.94)</td>
<td>1.92%</td>
<td>52 (33, 161)</td>
</tr>
<tr>
<td>Incidence of tobacco smoking by age group</td>
<td>13–18 years</td>
<td>P = 0.22; I² = 34.8%</td>
<td>3 (3648)</td>
<td>Moderate</td>
<td>0.69 (0.48, 0.98)</td>
<td>1.28%</td>
<td>78 (47, 1172)</td>
</tr>
<tr>
<td>Incidence of tobacco smoking by intervention intensity</td>
<td>Low</td>
<td>P = 0.20; I² = 37.8%</td>
<td>6 (11,898)</td>
<td>Moderate</td>
<td>0.87 (0.78, 0.96)</td>
<td>1.72%</td>
<td>58 (35, 218)</td>
</tr>
<tr>
<td>Incidence of tobacco smoking by study risk of bias rating</td>
<td>High</td>
<td>P = 0.50; I² = 0%</td>
<td>3 (5146)</td>
<td>Moderate</td>
<td>0.75 (0.61, 0.92)</td>
<td>2.06%</td>
<td>48 (31, 158)</td>
</tr>
<tr>
<td>Incidence of tobacco smoking by baseline smoking status</td>
<td>Unclear</td>
<td>P = 0.50; I² = 0%</td>
<td>4 (10,399)</td>
<td>Low</td>
<td>0.88 (0.77, 1.02)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Former</td>
<td>P = 0.63; I² = 0%</td>
<td>1 (379)</td>
<td>–</td>
<td>0.69 (0.39, 1.21)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Fig. 3. Forest plot of the effect of treatment interventions on incidence of stopping tobacco smoking.
The two interventions featured in these studies had a few common elements (Hollis et al. used the same approach for prevention and treatment but they tailored the messaging according to participants’ baseline smoking status). Both interventions focused exclusively on tobacco smoking instead of addressing multiple behaviors, both strategies targeted individual youth, both interventions were 12 months in duration, and both approaches incorporated education/information components. However there were important differences. Fidler and Lambert’s prevention intervention targeted younger (aged 10–15 years) never or not current smokers (defined as smoking less than once a week), while Hollis et al.’s prevention stream included older (aged 14–17 years) never and former smokers (defined as not smoking in past 30 days). Fidler and Lambert’s relatively simple intervention used a low intensity strategy that involved primary care providers mailing information packages containing printed materials addressing smoking related topics directly to their adolescent patients every three months. In contrast, Hollis et al.’s approach was a complex blend of education/information, counseling/advice and motivational interviewing (tailored to each participant’s stage of readiness to begin or quit smoking) delivered over several sessions by multiple interventionists (primary care providers and health counselors) using face-to-face and phone interactions, a multi-media interactive computer program, and printed materials.

Within the meta-analyses, only two studies that used different intervention approaches demonstrated statistically significant effects related to smoking outcomes compared to control. Thus there was insufficient evidence to provide a clear answer to the question about features of effective primary care interventions. A larger pool of published trials that include complete and consistent intervention descriptions based on reliable assessment and reporting tools [e.g., the TIDieR checklist (Hoffmann et al., 2014)] is needed to facilitate analyses to identify the key features that predict intervention effectiveness, to improve knowledge translation about intervention design and implementation, and to support replication of interventions by other researchers and health practitioners.

Comparison with other reviews

Several other recent systematic reviews have examined topics related to smoking prevention or cessation for young people (Carson et al., 2012; Patnode et al., 2012; Stanton & Grimshaw, 2013; Thomas et al., 2013a; Thomas et al., 2013b). One Cochrane review (Carson et al., 2012) focused on tobacco prevention for Indigenous youth but both of the included studies involved school-based (curriculum or classroom) delivery of the interventions which would not provide a comparable context for our interest in primary care relevant strategies. A second Cochrane review (Stanton & Grimshaw, 2013) looked at a wide range of tobacco cessation interventions for youth but again, most studies were conducted in educational settings. A third Cochrane review (Thomas et al., 2013b) found 135 RCTs that examined smoking prevention programs for children and youth, but all of them were school or curriculum-based interventions. A fourth Cochrane review (Thomas et al., 2013a) looked specifically for mentoring interventions to help prevent or reduce adolescent tobacco use, but of the four included studies two were conducted in school settings using known-peer mentors and the other two targeted populations that we excluded from our review (i.e., pregnant teens and teens with substance abuse problems).

The USPSTF (Patnode et al., 2012) started with essentially the same questions we addressed, but their eligibility criteria allowed for inclusion of more studies (e.g., they included studies that compared low intensity with high intensity interventions, interventions that were not tailored to participants’ baseline smoking status, and interventions that did not focus primarily on the use of tobacco). Along with the inclusion of a couple new studies, our more conservative approach for selecting studies, and differentiating between the prevention and treatment evidence led us to different bodies of evidence that produced both similar and dissimilar results. We found an almost identical effect for the preventive benefit of primary care relevant interventions; our results showed an 18% relative reduction in smoking initiation for the intervention group compared with the control group (RR 0.82, 95% CI 0.72, 0.94) and the USPSTF reported a 19% relative reduction (RR 0.81, 95% CI 0.70, 0.93). However, unlike the USPSTF review that included a broader range of interventions and comparison groups and found no treatment effect (RR 0.96, 95% CI 0.90, 1.02), we found a statistically significant benefit (RR 1.34, 95% CI 1.05, 1.69) when we included only targeted cessation.
interventions that were compared with no intervention, usual care, wait list, or attention control groups.

There are common observations of the evidence across the recent reviews for smoking prevention and treatment for young people; the USPSTF, Cochrane reviews and our own. These include: substantial heterogeneity across interventions; use of complex intervention strategies; smoking outcomes are inconsistently defined, measured and reported across studies; most studies are assessed as having unclear or high risk of bias; and published reports often lack important trial and intervention details.

Limitations

There are limitations associated with our review. First, all of the evidence was taken from studies assessed as having unclear or high risk of bias, primarily due to lack of information about or lack of procedures to ensure random sequence generation, allocation concealment and blinding, as well as other sources of potential bias. All of the studies measured smoking behavior using self-report strategies; this method is susceptible to socially desirable responding, therefore the findings may reflect some underreporting of tobacco use. Furthermore, the participants who agreed to take part in these studies may have been more health conscious than the general population and some of the treatment participants may have been more motivated to quit smoking than typical adolescent smokers. For all outcomes there were too few studies to investigate publication bias. These potential methodological biases could have impacted results and effect sizes and therefore raised some concerns about the strength of the evidence included in this review.

Second, limitations in our review approach may affect the generalizability of the findings. In restricting our focus to combustible tobacco products we did not consider interventions specifically directed at preventing or treating the use of smokeless tobacco products or e-cigarettes. We did not include treatment studies that evaluated the effectiveness of drug and nicotine replacement therapies. We only looked at studies that evaluated primary care relevant interventions intended to prevent or treat tobacco smoking in children and youth; we did not include studies of interventions delivered in other settings, that used environmental or policy restrictions, or that focused on parental smoking as a secondary strategy. Finally, studies not conducted in very high human development index countries were excluded from this review as were studies published in languages other than English or French (studies published in French prior to 2013 were excluded).

Conclusion

Serious future health risks associated with smoking tobacco, alongside persistent experimentation and regular smoking by children and youth, reinforce the need for preventive action and early treatment. This review provides a novel synthesis of current research regarding the effectiveness of primary care relevant interventions for preventing and treating tobacco smoking by school-aged children and adolescents. Results of this review, which included mostly moderate quality evidence, suggest that targeted behavioral interventions can help keep young people from trying or taking up tobacco smoking and can assist adolescents who have already started smoking to quit, without any reported harms. However, the available evidence does not provide clarity regarding ideal intervention strategies nor does it examine the long-term impact of these interventions for preventing smoking during adulthood. Future trials should target tailored prevention or treatment, but if combined approaches are implemented then study designs and reporting efforts need to clearly differentiate between prevention and treatment strategies, samples, and results. The generalizability of evidence on potential negative impact of level of tobacco dependence in adolescents on outcome of smoking cessation is limited by paucity of studies and study quality, therefore future high quality research is needed to affirm these findings. Further, future studies should strengthen rigor or at least improve methodological reporting, establish uniform definition and measurement of smoking, isolate optimal intervention elements, and include longer follow-up.

Conflict of interest

The authors declare that there are no conflicts of interests.

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Contributors

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Ethical approval

Not required.

Appendix A. Appendix. Search strategies for MEDLINE-ovid

Prevention

1. Smoking Cessation/
2. "Tobacco Use Disorder"/
3. tobacco.ti,ab.
4. smoking.ti,ab.
5. cigarette*.ti,ab.
6. 3 or 4 or 5
7. prevention & control.fs.
8. prevent*.ti,ab.
9. initiat*.ti,ab.
10. (start* adj3 smok*).ti,ab.
13. 7 or 8 or 9 or 10 or 11 or 12
14. 6 and 13
15. adolescent/or child/
16. children.ti,ab.
17. adolescent*.ti,ab.
18. child.ti,ab.
19. childhood.ti,ab.
20. teen*.ti,ab.
21. youth*.ti,ab.
22. 15 or 16 or 17 or 18 or 19 or 20 or 21
23. (clinical trial or controlled clinical trial or meta analysis or randomized controlled trial).pt.
24. clinical trials as topic/or controlled clinical trials as topic/ or randomized controlled trials as topic/
25. clinical trial*.ti,ab.
26. (control* adj3 trial*).ti,ab.
27. random*.ti,ab.
28. 23 or 24 or 25 or 26 or 27
29. 14 and 22
30. 28 and 29
31. limit 30 to (English or French)
32. limit 31 to ed=20120130-20150415

Smoking cessation in general
1. Smoking Cessation/
2. "Tobacco Use Disorder"
3. tobacco.ti,ab.
4. smoking.ti,ab.
5. cigarette*.ti,ab.
6. 3 or 4 or 5
7. cessation.ti,ab.
8. quit*.ti,ab.
9. "stop*".ti,ab.
10. 7 or 8 or 9
11. 6 and 10
12. 1 or 2 or 11
13. adolescent/or child/
14. children.ti,ab.
15. adolescent*.ti,ab.
16. child.ti,ab.
17. childhood.ti,ab.
18. teen*.ti,ab.
19. youth*.ti,ab.
20. 13 or 14 or 15 or 16 or 17 or 18 or 19
21. 12 and 20
22. (clinical trial or controlled clinical trial or meta analysis or randomized controlled trial).pt.
23. clinical trials as topic/or controlled clinical trials as topic/ or randomized controlled trials as topic/
24. clinical trial*.ti,ab.
25. (control* adj3 trial*).ti,ab.
26. random*.ti,ab.
27. placebo*.ti,ab.
28. 22 or 23 or 24 or 25 or 26 or 27
29. 21 and 28
30. limit 29 to (English or French)
31. limit 30 to ed=20120130-20150415
32. limit 31 to ed=20120130-20150415
33. limit 32 to (case reports or comment or editorial or letter or news)
34. 32 not 33

Appendix B. Supplementary data—Characteristics of Included Studies

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jypmed.2015.12.004.

References


