



# Treatment of Tobacco Use Disorder and Mood Disorders in Adolescents

Daniel R. Witt<sup>1</sup> · Christi A. Patten<sup>2</sup>

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## Abstract

**Purpose of Review** To update the literature on treatment of tobacco use in the context of comorbid mood disorders among adolescents, focusing on the last 5 years (2013–2017). We review tobacco use prevalence, the association between adolescent tobacco use and mood disorders, and interventions for adolescent tobacco users and those with concurrent mood disorders.

**Recent Findings** Advances were made in behavioral treatments for adolescent tobacco users, but minimal research focused on innovative approaches such as social media, family-based approaches or alternative therapies. There is a dearth of research on adolescents with comorbid mood disorders. Few studies targeted diverse populations. Minimal research was conducted within this patient cohort using nicotine/tobacco products other than cigarette smoking. Research has not been done to clarify the role of depression/mood severity on treatment outcomes.

**Summary** Current gaps in the tobacco treatment science for adolescents with mood disorders are highlighted and directions for future research offered.

**Keywords** Adolescent · Tobacco · Smoking · Nicotine · Depression · Mood disorder · Treatment · Intervention

## Introduction

Tobacco use is the leading cause of preventable morbidity and mortality in the United States (U.S.) across the lifespan [1]. Cigarette smoking primarily begins in adolescence. Very few adults (1%) start to smoke after age 26, and most adult smokers (88%) smoked their first cigarette by 18 years of age [2]. Treatment of adolescent tobacco use therefore is a public health priority to reduce preventable disease burden.

Cigarette smoking among adolescents is strongly associated with mood disorders including elevated depressive symptoms, major depressive disorder (MDD), and bipolar disorders (BDs) [3–5]. Adult smokers with mood

disorders and other psychiatric comorbidity have greater difficulty quitting smoking and poorer smoking treatment outcomes compared to those without [6, 7]. Smoking reduces life expectancy by 10–15 years among those with depression and other mental illnesses [8, 9]. Thus, designing effective smoking cessation interventions for adolescent smokers with mood disorders—a tobacco use disparity group—is a public health priority [10, 11].

The purpose of this review is to provide an update of the literature on treatment of tobacco use in the context of comorbid mood disorders among adolescents, focusing on the last 5 years (2013–2017). We first review the prevalence of tobacco use among adolescents. Second, we cover the association between adolescent tobacco use and mood disorders. Third, we review interventions for adolescents who use tobacco, interventions evaluated among those with concurrent mood disorders, and those targeted to diverse populations. Mood disorders are defined here to include elevated depressive symptoms, MDD, and BDs. We examined findings from systematic reviews and meta-analyses, as well as studies published in the past 5 years. Clinical trial registries ([clinicaltrials.gov](http://clinicaltrials.gov)) were reviewed for any ongoing trials. Literature searches were up to date through February 2018.

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✉ Daniel R. Witt  
witt.daniel@mayo.edu

<sup>1</sup> Mayo Clinic School of Medicine, Mayo Clinic, 200 First St SW, Rochester, MN 55905, USA

<sup>2</sup> Department of Psychiatry and Psychology, Mayo Clinic, 200 First Street NW, Rochester, MN, USA

## Tobacco Use in Adolescents

In 2016, among U.S. adolescents, current use of any tobacco product was 7% for middle school students (6% among females, 8% among males) and 20% among high school students (17% females, 24% males) [12••]. Any tobacco product use was defined to include electronic cigarettes (vape pens, e-pens, e-hookah, and vape sticks), cigarettes, cigars, smokeless tobacco (ST; chew, snuff, snus, and dissolvables), hookahs, pipe tobacco, and/or bidis on at least 1 day in the past 30 days. Tobacco use prevalence decreased from 2013, when 18 and 46% of middle school and high school students, respectively, used any tobacco product [13].

A recent representative survey of 13,651 U.S. adolescents aged 12–17 years indicated that, overall, 13% had ever smoked cigarettes [14•]. At 21% ever smoked, American Indian and Alaska Native (AI/AN) youth had the highest prevalence of ever smoking compared to all other racial/ethnic groups in this survey. From the National Youth Tobacco Survey, current cigarette smoking in 2016 was 2% (2% females, 3% males) among middle school students and 8% among high school students (7% females, 9% males) [12••]. Another representative survey (2009–2010) found prevalence of current smoking among youth aged 12–17 years was highest in AI/AN youth (14%) and multi-racial youth (11%) compared to White (10%), Asian (8%), Native Hawaiian (8%), or Black (5%) adolescents [15]. Cigarette smoking prevalence is also concentrated among youth residing in rural areas and those with lower socioeconomic status [3, 16].

In 2016, current electronic cigarette use was 4% among middle school students (3% females, 5% males) and 11% for high school students (10% females, 13% males), making electronic cigarettes the most commonly used nicotine-containing smoked product among adolescents [12••]. Among middle school students, 2% currently smoked cigars, 2% used ST, 2% used hookahs, and < 1% smoked bidis [12••]. The corresponding prevalence for high school students was 8, 6, 5, and < 1%. Poly-tobacco use (use of two or more products) was 3% of middle school students (3% females, 4% males) and 10% of high school students (8% females, 11% males) [12••].

Chronic tobacco use is strongly associated with many adverse health outcomes including increased morbidity (e.g., malignant neoplasms, cardiovascular and metabolic diseases, pulmonary diseases, and both maternal and fetal perinatal disease), mortality, and economic costs [1]. Chronic tobacco use into adulthood may have lasting adverse consequences for brain development [3, 17•]. There is also documented addictive potential for tobacco products, especially when users have not reached neurodevelopmental maturity and adolescents often have difficulty quitting successfully [3].

The addictive phenomenon is characterized by the DSM-V as tobacco use disorder (TUD): presence of  $\geq 2$  symptoms ranging from development of tolerance and increased use to

unsuccessful attempts at quitting, among a total of 11 criteria [18]. Generally, smoking within 30 min of waking, smoking daily, smoking more cigarettes per day, and waking at night to smoke are associated with TUD [19, 20]. Tobacco initiation at an earlier age is a risk factor for greater severity of nicotine dependence and difficulty quitting, as well as adverse health consequences [3, 21].

In a systematic review of longitudinal population-based studies on the predictors of smoking cessation in adolescent smokers [22], five factors robustly predicted quitting across studies: not having friends who smoke, not having intentions to smoke in the future, resisting peer pressure to smoke, being older at first use of cigarette, and having negative beliefs about smoking. Other studies highlight the role of addiction and mental health concerns, along with parental and social network influences in the success of adolescent quit attempts [23–27].

## Tobacco Use and Mood Disorders in Adolescents

### Depression

Between 2009 and 2012, 8% of the U.S. population aged 12 and over reported moderate or severe depressive symptoms in the previous 2 weeks; depression was most prevalent among females and persons aged 40–59 and among non-Hispanic black persons and Hispanic persons compared to non-Hispanic white persons [28]. Among adolescents ages 12–17 years, prevalence was 6% [28]. MDD is prevalent among between 3 and 8% of adolescents, with a lifetime prevalence of approximately 20% by the end of adolescence [29, 30].

Among adolescents, strong correlations between comorbid depressive symptoms and MDD with tobacco use (including TUD) are well documented [3, 4, 31–34]. Among adolescent smokers in substance use treatment, having a comorbid mood disorder increased vulnerability to continued smoking at 12-month follow-up [35]. In addition, among 535 adolescent smokers ages 12–18, elevated depressive symptoms were associated with unsuccessful quit attempts at 1-year follow-up [36].

The causal pathways and relationships between depression and smoking are complex [37, 38•]. Among adolescents, the use of tobacco—in addition to other drugs—is associated with depression, and, as our own work suggests [39], longitudinal studies suggest bidirectional causality, with substance abuse leading to and occurring as a consequence of depression [40, 41]. Epidemiological data from adolescents indicates that smoking is independently associated with the onset of depression, after controlling for other disorders, and that lifetime

MDD at baseline was the only predictor of smoking onset after controlling for other disorders [42–44].

## Bipolar Disorder

BD is a complex syndrome with a prevalence of 2–2.6% worldwide [45, 46]. The disorder is associated with psychiatric comorbidities which include personality disorder, anxiety disorder, substance use disorder, and medical comorbidities including obesity, diabetes, and hyperlipidemia [47, 48]. BD-related disorders can be devastating—9–15% of patients commit suicide [49, 50]. The disease is particularly difficult to diagnose accurately and promptly in clinical practice, and both BD types I and II spend most of the duration of their illness in a depressive phase [51, 52]. Despite subtle differences between the two major diagnostic criteria used throughout the world today—the DSM-5 and the International Classification of Disease (ICD)—BDs are delineated by presence of both depressive and manic episodes [53, 54]. Clinical research indicates that onset of BDs in childhood or adolescence does occur, yet disagreement still exists about diagnostic criteria and prognosis for childhood (< 13 years), adolescent (13–18 years), and adult (> 18 years) onset [55, 56].

The lifetime prevalence of daily smoking among adults with BD is 83%, much higher than among adults with no mental illness (39%), or those with lifetime MDD (59%) [57]. In adolescents, there is a similar prevalence of ever-smokers in BD and general age-matched cohorts in the U.S. [16, 58], but a higher prevalence of daily smoking in the BD patient population [59]. It is unclear whether increased use of tobacco is a result of a more severe BD phenotype or part of a causal pathway that elicits worse BD clinical presentation in adolescence [60]. The high prevalence of smoking and low quit rates in BD patients likely contributes to the observed higher rates of cardiovascular, respiratory, and cancer morbidity and mortality in patients with BD [61–63]. Thus, understanding how to apply the appropriate treatment to adolescents with comorbid tobacco use and mood disorders is of considerable import.

## Treatment of Tobacco Use among Adolescents

Table 1 provides an overview of the evidence for different pharmacological and psychosocial treatments for adolescents overall and those with mood disorders. Within each, studies are described that target diverse populations. Recommended treatment outcomes among adolescents include smoking reduction (cigarettes smoked per day) and smoking abstinence at the end-of-treatment (EOT) and up to 6 months follow-up [94].

## Pharmacological Interventions

In the adult population, seven first-line pharmacological agents have been approved by the Food and Drug Administration (FDA) for tobacco treatment (bupropion, varenicline, and nicotine replacement therapy (NRT) patch, gum, lozenge, nasal spray, and inhalers) and two second-line agents (clonidine and nortriptyline) exist without FDA indications [95–97]. Patients' odds of achieving abstinence are approximately doubled when using any of the seven medications during a quit attempt, and adding counseling to medication treatment increases abstinence rates by approximately 50% over medication alone.

Adolescents experience craving and withdrawal symptoms during quit attempts [21], and thus pharmacotherapy has been evaluated as a treatment approach. Results from randomized controlled trials (RCTs) with adolescents indicate short-term benefit of NRT patch and from bupropion SR (at the 300 mg/day dose) particularly when combined with behavioral treatment (Table 1) [64, 98]. However, long-term abstinence remains a significant challenge. One RCT and one uncontrolled pilot study evaluated varenicline. In the last 5 years, only one pharmacotherapy trial was published; this study evaluated efficacy of NRT patch [69]. Therefore, based on the available evidence, NRT and other medications for adolescent tobacco use are not recommended or FDA approved [95]. Compliance and attrition are key barriers to evaluating efficacy of pharmacological treatment for young smokers [99]. Scherphof and colleagues [69] found that more NRT patch compliant participants had significantly higher prolonged abstinence rates at EOT compared to less compliant participants; a similar finding was found in a trial of bupropion therapy [100].

## Psychosocial Interventions

Clinical practice guidelines [95] and recent systematic reviews and meta-analyses [64] have concluded there is sufficient evidence to recommend behavioral counseling for adolescent smokers. Specific counseling strategies found to be effective are stage-based (trans-theoretical, TTM); motivational interviewing (MI) and motivational enhancement (ME) interventions (e.g., the 5 R's [95]: relevance, risks, rewards, roadblocks, repeat), along with social and cognitive approaches such as cognitive behavioral therapy (CBT) [64]. A systematic review and meta-analysis of primary care relevant behavioral interventions (e.g., counseling, education) for adolescent smokers aged 13 and older found that those receiving an intervention were 34% more likely to quit smoking at EOT compared with controls [101]. A 2017 Cochrane review suggested that group-based counseling is more effective than individual counseling, mixed delivery methods, or computer/text messaging modes [65]. Nonetheless, results are mixed

**Table 1** Tobacco use treatments evaluated among adolescents and those with mood disorders: 2013–2017 update

Smoking cessation treatment	Evidence among adolescent smokers	Evidence among adolescent smokers with mood disorders
<i>Pharmacotherapy</i>		
Nicotine replacement therapy (nicotine patch, nicotine gum, nicotine nasal spray)	Not recommended. Several RCTs have been conducted indicating limited efficacy [27, 64–68] Recent trials: • Scherphof, 2014. [69, 70] RCT of NRT patch vs. placebo. Weekly CBT counseling sessions. Significantly higher abstinence for patch at 2 weeks, but not at EOT or 6 or 12 months.	None.
Bupropion	Not recommended. Few RCTs conducted findings indicate efficacy of 300 mg/d dose combined with behavioral treatment [27, 64, 65, 67, 71] Recent trials: None	None.
Varenicline	Not recommended [65, 67, 72]. One trial evaluated pharmacokinetics, safety, and tolerability [73]. One trial evaluated varenicline vs. bupropion on smoking reduction [74]. Recent Trials: None Trials underway: • NCT01509547	None.
<i>Behavioral</i>		
Cognitive behavioral therapy (social learning or cognitive behavioral theories) including Not on Tobacco (NOT) group-based CBT program	Recommended. Sufficient evidence from several RCTs [64, 65, 67, 72]. Recent Trials: • Bailey, 2013 [75]. All received 10 weeks standard CBT group counseling + NRT patch. Randomized to extended duration CBT (14 more wks) vs. none. Higher abstinence with extended CBT at 6 months (21 vs. 7%). • Minary, 2013 [76]. Four CBT group sessions + NRT patch did not increase the 12 month abstinence vs. control (6 vs. 11%). • Horn, 2013 [77]. NOT + exercise (see below) Trials underway: • NCT03291132 • NCT03021655	None.
Motivational interviewing (MI)/ motivation enhancement (ME)	Recommended. Sufficient evidence from several RCTs [27, 64, 65, 67, 72]. Recent Trials: • Guo, 2013 [78]. ME phone and text message intervention higher abstinence rates at EOT (23% vs. 2%) and 4 months (21 vs. 3%) than controls. • Mason, 2015 [79•]. MI text message intervention (see below). • Saw, 2017 [80]. Uncontrolled study of community peer-based outreach and MI intervention + quitline referral was feasible and 6-month abstinence rate of 12.5%. Trials underway: • NCT02758028	• One RCT: Brown, 2003. [81] MI counseling (2 sessions) with NRT patch among 191 psychiatric inpatients. No differences in abstinence at EOT or 12 months vs. brief advice control.
Trans-theoretical model (TTM) including computer expert systems tailored to stage of change	Recommended. Sufficient evidence from many RCTs [64, 65]. Recent trials: • Redding, 2015. [82] TTM computer-assisted program + counseling. No differences in abstinence rates vs. control.	• One RCT: Prochaska, 2015 [83•]. TTM computer-assisted program + MI counseling + NRT patch. Sixty racially diverse psychiatric outpatients. No intervention effect on abstinence vs. usual care control at EOT or 12 months.
Contingency management	Insufficient evidence to recommend this approach. Only two RCTs in adolescents. Recent trials: • Krishnan-Sarin, 2013 [84]. CM or CM + CBT higher abstinence rates than CBT alone at EOT but not at 1 or 3 months. • Reynolds, 2015 [85]. Home-based CM delivered via internet was feasible and effective for reducing urinary cotinine levels vs. control at 6 weeks follow-up.	None.

**Table 1** (continued)

Smoking cessation treatment	Evidence among adolescent smokers	Evidence among adolescent smokers with mood disorders
Internet (web)	<ul style="list-style-type: none"> <li>• Kong, 2017 [86]. Open-label study indicated mobile phone delivered CM is feasible.</li> </ul> Mixed efficacy findings with poor utilization of programs [87]	None
Text messaging	Recent trials: none. Promising emerging findings, but limited RCTs [27]. Recent trials: <ul style="list-style-type: none"> <li>• Haug, 2013 [88]. SMS Coach using TTM and ME. No difference vs. control on abstinence but greater reductions in cpd.</li> <li>• Shi, 2013 [89]. Cluster RCT of TTM-based text messaging intervention vs. information only control among Chinese youth. No effect on abstinence but intervention associated with greater smoking reduction at EOT.</li> <li>• Skov-Ettrup, 2014 [90]. Web-based smoking cessation program with optional text message support. Randomized to either tailored or untailored text messages. Significantly higher EOT abstinence rate for tailored messages.</li> <li>• Guo, 2013 [78]. ME phone and text message intervention (see above).</li> <li>• Mason, 2015 [79]. Urban African American youth. RCT of MI-based peer-network counseling text messages vs. attention control text messages. Greater smoking reductions vs. control at EOT but abstinence outcomes not reported.</li> </ul>	None.
Social media (e.g., Facebook, Snapchat, Instagram, Twitter)	None.	None.
Family therapy	Recent trials: none.	None.
Exercise, mindfulness/stress reduction, yoga, meditation, t'ai chi	One trial: <ul style="list-style-type: none"> <li>• Horn, 2013 [77]. Three-arm randomized study of NOT + Exercise vs. NOT alone vs brief advice control. NOT + Exercise greater abstinence at 6 months vs. control but not significantly different than NOT alone.</li> </ul> Trials underway: <ul style="list-style-type: none"> <li>• NCT03021655</li> </ul>	None.
<i>Targeted populations</i> American Indian/Alaska Native (AI/AN) youth	Two pilot RCTs: <ul style="list-style-type: none"> <li>• Bowen, 2012 [91]. Culturally adapted web site mostly for smoking prevention among AI youth attending a summer camp. Only 6 of 113 participants were baseline smokers of which 2 quit at follow-up.</li> <li>• Patten, 2014 [92]. Group-based, culturally tailored CBT program for AN youth. Not effective compared to delayed treatment control condition at EOT or 6 months.</li> </ul>	None.
Black youth	One study: <ul style="list-style-type: none"> <li>• Mason, 2015 [79]. Text messaging RCT</li> </ul>	None.
Asian youth	Two studies: <ul style="list-style-type: none"> <li>• Chun, 2012 [93]. Non-randomized design of CBT vs. education among Korean males. No difference in abstinence rates but CBT group had lower nicotine dependence severity at EOT.</li> <li>• Shi, 2013 [89]. Text messaging RCT (see above).</li> </ul> Trials underway: <ul style="list-style-type: none"> <li>• NCT02758028</li> <li>• NCT03291132</li> <li>• NCT03021655</li> </ul>	None.
LGBTQ youth	None.	None.

Recent trials are those published in the last 5 years (2013–2017). Trials underway are those registered at [www.clinicaltrials.gov](http://www.clinicaltrials.gov). For studies targeting special populations, any trials available were described

*NRT* nicotine replacement therapy, *EOT* end of treatment, *cpd* cigarettes smoked per day, *CBT* cognitive behavior therapy, *CM* contingency management, *MI* motivational interviewing, *ME* motivational enhancement



across intervention studies and overall suggest moderate benefit [98•].

An earlier (2009) study by Petersen and colleagues of proactive, MI-based telephone counseling was the first to demonstrate a long-term treatment effect on smoking cessation in a large sample of high school students [102]. Unfortunately, at 7-year follow-up, there was no evidence that intervention effectiveness was sustained into young adulthood [103].

Mixed and multicomponent approaches have been explored in several studies, making it difficult to disentangle the benefits of any one approach. For example, an efficacious group-based intervention known as Project EX [104] combines both ME and CBT skills development.

Only in the past 5 years have promising findings emerged for contingency management (CM) interventions, especially novel means for remote collection of biomarkers (e.g., expired air carbon monoxide) to reinforce smoking abstinence among adolescents. Krishnan-Sarin and colleagues [84] conducted a RCT ( $n = 72$ ) comparing CM alone, CBT alone, or combined CM + CBT. CM alone and combined CM + CBT produced higher rates of abstinence than CBT alone at EOT but there were no differences at 1 or 3 month follow-up. A secondary analysis of this trial found that among highly impulsive adolescents, the two CM conditions combined were effective than CBT alone [105]. In a small, single-arm pilot study ( $n = 14$ ), remote delivery of CM via mobile phones was feasible (86% of the CO videos and 67% of the saliva cotinine videos submitted on time), acceptable (positive perceptions of the CM procedures), and 47% achieved smoking abstinence at the 1 month follow-up [86]. Home-based delivery of CM via the Internet was also feasible in another pilot study focused on adolescent smokers in rural Appalachia ( $n = 62$ ) with reduced urinary cotinine levels in the treatment arm vs. control at 6 weeks post-treatment [85].

Among adults, there are increasing numbers of studies evaluating alternative and complementary approaches to smoking cessation such as, exercise [106], mindfulness and meditation [107], and t'ai chi [108]. Excepting one study of exercise [77], these approaches have not been tested in RCTs with adolescent populations [27].

Due to increases in communication technology, Internet, mobile device, and social media use, a broad set of technology-based forums may enhance the appeal of smoking cessation therapies among youth. Nearly three-quarters of teens have or have access to a smartphone [109]. Facebook remains the most used social media site among U.S. teens aged 13–17 years, with 71% of all teens using the site; 50% use Instagram and 40% use Snapchat [109].

A systematic review of Internet interventions [87•] included RCTs conducted among adolescents with mixed results, primarily due to their low utilization as we found in our web-based study [110]. No studies were published in the last 5 years. Components of effective programs identified were

use of multimedia, tailored approaches, personalized feedback, and interactive features [87•].

Text messaging interventions have been explored in the past 5 years, with promising findings, but there are limited RCTs. Text messaging using a SMS coach or peer network coach reduced cigarettes per day at EOT [79••, 88, 89], and tailored text messages were more effective than non-tailored text messages in conjunction with a web-based intervention [79••, 90].

More research is needed to understand how social media platforms can be used for effective intervention delivery, without compromising security or privacy. Findings have emerged on the feasibility and efficacy use of Facebook for smoking cessation among young adults [111–113], but no trials were published among adolescents.

### Targeted Populations

Only five studies targeted diverse populations, and the interventions tested were not effective for smoking cessation. Two of these focused on Asians, one among African Americans, and two targeted AI or AN youth (Table 1). Our study with AN tobacco users (cigarettes and ST use) examined a culturally targeted group-based CBT intervention [92]. The intervention was developed with feedback from AN adolescents to include storytelling from elders [114]. The intervention was not effective for smoking cessation at EOT or at 6-month follow-up compared to a delayed treatment control condition. Shi and colleagues conducted a cluster randomized trial of a TTM-based text messaging intervention among Chinese youth [89]. The intervention was no more effective for smoking abstinence at EOT compared with the control condition but did result in greater smoking reduction. Another study found that among Black adolescents, MI-based, peer-network counseling text messages was more effective than attention control text messages on reductions in smoking but abstinence outcomes were not reported [79••]. Formative work to develop an intervention among adolescent and young adult LGBTQ persons found that participants preferred to use culturally tailored mobile apps for smoking cessation [115].

Recruitment of adolescents into smoking cessation trials is challenging [65], even with online recruitment [90], limiting the reach of intervention. Thrul and colleagues studied the recruitment of 272 smokers across 42 German secondary schools (ages 11–19) using an in-class method of delivery, noting that students with heavier smoking behavior and stronger nicotine dependence are less likely to undertake a successful unassisted quit attempt and the reach of these young smokers with professional cessation interventions is more difficult because they often do not self-present [116•]. Qualitative work suggests that adolescents prefer informal cessation strategies such as oral substitutes, talking with friends, and increasing their exercise [117].

## Treatment of Tobacco Use among Adolescents with Comorbid Mood Disorder

A 2013 Cochrane review indicated that use of bupropion increased long-term cessation in adult smokers with past, but not current, depression [118]. However, the addition of mood management intervention to standard cessation treatment increased abstinence rates in both patients with current and past depression [118]. A 2017 systematic review found evidence for mood management, NRT, and varenicline for adult smokers with current depression [119••]. There is some support for exercise [120] and behavioral activation treatment for adult smokers with current depression [119••, 121••]. Feasibility studies indicate that bupropion and varenicline did not worsen psychiatric symptoms in adult smokers with BD [122–124]. Two RCTs found that varenicline increases smoking cessation and abstinence rates in adult smokers with BD without increased adverse psychiatric symptoms [66, 125]. A pilot investigation found that mood management intervention in conjunction with NRT patch resulted in 2 of 9 BD patients achieving tobacco abstinence and 7 of 9 patients achieving at least 50% reduction in daily cigarette consumption [126].

As shown in Table 1, there is a paucity of research on tobacco cessation treatment of adolescents with mood disorders. The first study by Brown and colleagues (2003) examined MI counseling (2 sessions) and NRT patch among 191 13–17-year-old psychiatric inpatient smokers [81]. Compared with brief advice (5–10 min), there were no differences in abstinence outcomes for the intervention at EOT or 12-month follow-up. The second more recent pilot study enrolled 60 racially diverse adolescent and young adult psychiatric outpatients [83•]. Intervention participants received a TTM computer-assisted program, 12 weeks of MI counseling, and NRT patch. Usual care participants received written materials and brief advice. There were no significant differences on smoking abstinence, smoking reduction, or quit attempts between study conditions at 12-month follow-up. Abstinence rates were greater for girls than boys and for lighter than heavier smokers.

In a review of treatment for adolescents with comorbid substance use and mood disorders, no studies were identified that focused on tobacco use [98•]. Most studies did not support the efficacy of antidepressants over placebo for reduction of depressive symptoms or substance use. Behavioral interventions remain the first-line treatment in this population. Remission of mood symptoms was associated with reduction in drug and alcohol use thus treatments focused on mood management may improve outcomes among adolescent tobacco users [98•]. However, mood management strategies found effective for adult tobacco

users with mood disorders have not been explored for adolescent populations. For example, exercise has been found to reduce depressive symptoms [127], and in our own research to facilitate smoking cessation [106], in depressed adults. Correlational studies among adolescents indicate that higher levels of physical activity, higher energy expenditure, and sports participation are associated with non-tobacco use in adolescents [128], raising the question of whether increased exercise habits and reduced smoking rates may be related via a psychological phenotype (e.g., executive function, impulse control, mood regulation). Loprinzi and colleagues found that among daily adolescent smokers, exercise may help to facilitate smoking cessation via exercise-induced increases in smoking-specific self-efficacy [129].

CM strategies have not been evaluated among adult or adolescent tobacco users with mood disorders. Expectations of smoking reward may promote smoking initiation among depressed adolescents [7•]. Among adolescent smokers without psychiatric comorbidity receiving a CM intervention, reduction of smoking was associated with recovery of function in frontostriatal responses to non-drug reward anticipation [130•]. Treatments that provide non-drug reinforcers (e.g., CM) or increase the salience and motivational value of non-drug rewards, such as behavioral activation therapy [131] or exercise may be helpful among adolescents with mood disorders.

Family norms and behaviors remain a primary influence on adolescent tobacco use [24, 25]. Despite the efficacy of family therapy as a treatment for substance use [132] and mood disorders [133] in adolescents, somewhat surprisingly is that no trials evaluated such an approach among young smokers overall or those with comorbid mood disorders (Table 1).

## Conclusions

This review highlights several gaps in the treatment of adolescent tobacco users with comorbid mood disorders. There is a dearth of research on adolescents with comorbid mood disorders, limited to only two studies. Over several decades, advances were made in the behavioral treatment of adolescent tobacco users, but little research focused on innovative approaches such as social media, family-based approaches, or alternative therapies. Few studies targeted diverse populations. Minimal research has been conducted among adolescents using nicotine/tobacco products other than cigarette smoking.

Simon and colleagues reviewed the treatment of adolescent smokers between 2009 and 2014 [67]. In addition, several reviews and meta-analyses of adolescent tobacco treatment were published in the last 5 years. Our review adds to the field by focusing on adolescents with comorbid mood disorders.

Formative work is needed to develop innovative interventions for adolescents with comorbid mood disorders. Prochaska (2013) conducted qualitative interviews with 14 mental health clinic outpatients aged 16–23 years [134]. All were daily smokers and most additionally smoked cigars. Overall, the factors identified as contributing to their tobacco use included nicotine addiction and mood, peer influences and social situations, addiction, smoking for relaxation, and media influences. More unique factors were parental provision of cigarettes and inconsistent non-smoking rules in the home. The participants preferred non-judgmental and motivational approaches to smoking cessation, along with peer support and engagement in other behaviors (e.g., physical activity, hobbies).

Research has not been done to clarify the role of depression/mood severity on treatment outcomes among adolescents. A large body of literature has found that elevated depressive symptoms in adult smokers predict worse tobacco treatment outcomes [6•]. Our own work suggests that tobacco treatment can be an entrée to discussion of issues that adolescents face at home, school, and with peers. Thus, measuring depression and stress at baseline and examining relationships to treatment outcomes could be clinically meaningful.

There is limited knowledge on tobacco use treatments for diverse adolescent populations. Some have recommended that cultural background, knowledge, attitudes, and beliefs involving tobacco and readiness to quit be considered before recommending a cessation treatment or strategy for adolescents [27]. Interventions targeting electronic cigarette use or other tobacco/nicotine product use in adolescents are warranted. Other systematic reviews [135] found no RCTs in this age group, and only one study targeting young adults (18–24 years) [136].

Developing novel interventions among adolescent and young adult tobacco users as well as disparity populations was recently identified by the Tobacco Control Research Priorities Working Group as priorities for tobacco research [137••]. As highlighted in this review, innovations in tobacco treatments for adolescents with comorbid mood disorder have potential to advance the field of adolescent addiction treatment science [138].

## Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no competing interests.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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