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Complete List of Authors:	Stevenson, Jeremy; Flinders University, College of Medicine and Public Health Miller, Caroline; South Australian Health and Medical Research Institute, Population Health; The University of Adelaide Faculty of Health and Medical Sciences, Public Health Martin, Kimberley; The University of Adelaide Faculty of Health and Medical Sciences, Public Health Mohammadi, Leila; Flinders University of South Australia, College of Medicine and Public Health Lawn, Sharon; Flinders University, College of Medicine and Public Health
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lTitle: The relationship between youth tobacco consumption and common psychological disorders: A review

Jeremy Stevenson[1], Caroline L Miller[2,3], Kimberley Martin[3], Leila Mohammadi[1], Sharon Lawn[1]

[1]Flinders University, College of Medicine and Public Health, Adelaide, Australia

[2]Health Policy Centre, South Australian Health and Medical Research Institute, Adelaide, Australia

[3]University of Adelaide, School of Public Health, Adelaide, Australia

Corresponding Author: Professor Sharon Lawn, Flinders University, Room 2.11, Health Sciences Building, GPO Box 2100, Adelaide, 5001, South Australia, Australia

Email: sharon.lawn@flinders.edu.au

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ABSTRACT

Objective: To investigate reciprocal temporal relationships between tobacco consumption and psychological disorders for youth.

Design: Review

Data sources: Five databases (PubMed, Embase, Scopus, CINAHL, PsycINFO) on 26th September 2019 and updated on 11th May 2021, indexing tobacco, mental illness, and longitudinal.

Study selection: Methods used consensus and multiple reviewers.

Interventions: Cohort studies (n=49) examining tobacco and selected psychological disorders (depression, anxiety, bipolar, psychosis, borderline personality disorder) among youth, and systematic reviews (n=4) of these relationships met inclusion criteria.

Primary and secondary outcome measures: Effect of tobacco on psychological disorders and effect of psychological disorders on tobacco.

Data extraction and synthesis: Independent extraction by the first author and checked by final author. Joanna Briggs Institute Critical Appraisal Tools were used for all studies. Included studies had moderate-to-high appraisal scores. We synthesized findings using vote counting for effect direction and descriptive data.

Results: Fifty-three studies were included in the review. Thirteen of 15 studies showed a positive effect of tobacco on depression ($p < .001$). Six of 12 studies showed a positive effect of depression on tobacco ($p = .016$). Six of eight studies showed a positive effect of tobacco on anxiety ($p = .016$). Eleven of 18 studies showed a positive effect of anxiety on tobacco ($p = .003$). No effect between tobacco and bipolar, or tobacco and psychosis was found. No studies examined tobacco and borderline personality disorder.

Conclusions: Reciprocal relationships existed between tobacco and both depression and anxiety for youth, though causality is unconfirmed. No positive effect was found between

tobacco and psychosis, perhaps because nicotine has conflicting effects on psychosis. For other relationships examined, evidence was weak because of low numbers of studies. More research to inform prevention and early intervention is needed.

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ARTICLE SUMMARY

Strengths and limitations of this study

- This review has synthesised, in depth, 53 studies for evidence of the reciprocal temporal relationships between tobacco consumption and psychological disorders for youth.
- The review has performed an analysis of the quality of the studies and identified knowledge gaps and methodological concerns that require further research.
- The included studies were very heterogeneous, preventing meta-analysis of the results.
- Psychological disorders were classified into broad categories; however, it is possible that young people's experiences of these disorders differ in how they relate to tobacco use.

INTRODUCTION

Tobacco consumption is associated with a myriad of economic, social, and health problems for young people [1]. One of the health problems associated with tobacco consumption is psychological disorders, and their co-occurrence can dramatically worsen the overall clinical course, physical health and psychosocial outcomes for the person [2-4]. Tobacco contributes substantially to the reduced life expectancy observed among people who experience mental health disorders. Furthermore, people living with mental illness have shorter life expectancy than those without, and this is largely attributable to smoking-related illnesses [5, 6]. Youth (10-24 years of age) with psychological disorders are overrepresented among those who consume tobacco [7]. However, it is unclear if the relationship between tobacco and psychological disorders is causal or merely associational. If the relationship is indeed causal, the direction of this relationship is poorly understood [8]. Furthermore, it is unclear whether the 'tobacco-psychopathology' relationship is different depending on the specific type of psychological disorder experienced by the young person (e.g., perhaps tobacco use causes depression but not anxiety).

Several reviews have attempted to evaluate the relationship between tobacco and psychopathology [9-12], but these have several limitations including: 1) a lack of focus on youth; 2) the sample is mostly or entirely from North America, 3) only a small number of psychological disorders are examined; and 4) the existing studies and reviews are now quite dated. Given these limitations, we sought to produce an updated review that focuses specifically on youth and samples from a broader international population. Furthermore, we included more psychological disorders to facilitate comparison: anxiety, depression, bipolar disorder, psychosis, and borderline personality disorder. We chose these psychological disorder categories because they affect a substantial percentage of youth [13]. The broad

objective of our review was to examine the reciprocal temporal relationship between tobacco consumption and the selected psychological disorders for youth.

METHODS

Eligibility criteria

The inclusion criteria were studies with: 1) a focus on adolescents and youth 10-24 years of age; 2) systematic review of observational longitudinal studies OR observational longitudinal studies conducted since most recent systematic review OR all longitudinal studies if there is no relevant systematic review for the specific disorder; 3) measured tobacco consumption in any form (e.g., smoking, smokeless, snus), 4) measured psychological disorder categories of at least one of anxiety, depression, bipolar, psychosis, or borderline personality disorder; 5) English language; and 6) published in a peer-reviewed journal. Under the anxiety category, we included various types including social anxiety, panic, agoraphobia, and generalised anxiety. Under the bipolar category we included mania as this symptom is mostly associated with bipolar. Under the psychosis category we included schizophrenia and general psychotic symptoms. We included 'nicotine dependence' as a measure of tobacco consumption because these constructs are strongly related [14, 15]. Studies were excluded if the methods used meant that tobacco consumption could not be distinguished from other drug use (e.g., cannabis) and if the population was very specific (e.g., pregnant women). Our search strategy was based on advice from an expert University-based librarian and was also informed by previous systematic reviews identified during the early formulation of the current study [10,11].

Search strategy and study selection

The original search was conducted by KM using PubMed, Embase, Scopus, CINAHL and PsycINFO on 26th September 2019 and updated by LM on 11th May 2021. Initial searches were very broad and focused on keyword categories of tobacco and psychological disorders (for more information see supplementary materials). The screening and review process were managed within COVIDENCE software. After the initial search and de-duplication, JS and SL shared the initial screening and full-text reviews. JS and SL then discussed any conflicts in order to reach consensus about inclusion or exclusion. Where consensus could not be reached or the decision remained uncertain, final eligibility was resolved by CM.

For the updated search SL and JS each screened all new titles/abstracts with CM resolving conflicts, then SL did all full-text reviews, with JS checking 20% of excluded studies – agreement was 100%.

[Figure 1: PRISMA flow diagram]

Quality assessment, data extraction and data synthesis

To assess the quality of the included studies, we used the Joanna Briggs Institute (JBI) Critical Appraisal Tools for cohort studies and systematic reviews [16]. JS appraised all studies while SL appraised a random sample of 20%. Data extraction was conducted by JS and checked by SL in order to produce three tables: 1) Table 1 for descriptive information about the cohort studies, 2) Table 2 for vote counting of the direction of effects for cohort studies, and 3) Table 3 for descriptive information about the systematic reviews. For the 'results' column of Table 1, we extracted the most adjusted results in order to reduce the risk of confounding.[17] We did vote counting for effect direction (Table 2; counting the number of studies with positive vs negative effect direction) based on recent recommendations by Cochrane on conducting synthesis without meta-analysis [18]. To use this approach, we combined similar predictors (e.g., nicotine dependence, cigarette smoking, and other tobacco

use combined into 'tobacco') and outcomes (e.g., social anxiety, panic, and agoraphobia combined into 'anxiety') and classified effect direction as one of the following: 1) a positive/negative effect if at least 70% of findings showed consistency in this direction, 2) a conflicting effect if consistency was less than 70%, or 3) an 'unclear' effect if direction was not reported (for a similar method, see Thompson et al. [19]). For data synthesis, we evaluated each relationship individually (e.g., tobacco>depression; depression>tobacco; tobacco>anxiety etc; where the '>' symbol refers to the direction of the relationship). In this synthesis, we attempted to integrate all information from both the cohort and review studies (e.g., descriptive information and vote counting).

RESULTS

Publication dates of included studies

We found four systematic reviews for depression and tobacco in youth [9-11,20]. The most recent of these reviews [20] included studies up to November 1st 2018. So, in order to be comprehensive, we also collected depression cohort studies from 2018 onwards. We found two systematic reviews for anxiety and tobacco in youth; but, given the low sample size of anxiety studies in these reviews [11,20], we included anxiety cohort studies from any period. We did not find any systematic reviews for bipolar, psychosis, or borderline personality and tobacco in youth, so no publication date inclusion constraints were applied to studies involving youth who experience these disorder categories.

Quality appraisal

As per the PRISMA flow diagram (Figure 1) [21], our search identified 49 cohort studies and four systematic reviews, giving a total of 53 included studies. For the quality appraisal of included studies, we converted scores on the JBI into percentages in order to facilitate

interpretation. Higher percentage scores indicated higher quality studies, while a score ≤ 50% reflects low quality. For the cohort studies, there was a relatively low level of agreement between the authors (66.2%), whereas the systematic reviews had comparatively high agreement (84.1%). The main issues contributing to disagreement were different interpretations of the JBI criteria, particularly for cohort questions one, four, five, and six, as well as systematic review question four. These differences were resolved through discussion.

Overall, the included studies had moderate-to-high appraisal scores. The quality appraisal of included cohort studies (n = 49) is displayed in Table 1 and in more detail in Supplementary Table S1. Five of the cohort studies were classified as low quality, with the lowest score being 36.4% [22, 23]. The remaining appraisal scores ranged from 45.5% to 81.8%, with four studies scoring above 75% (i.e., high quality). In terms of common strengths, all studies utilized a sufficient follow-up time (Q8) and appeared to use appropriate statistical analysis (Q11). More than 89% of studies measured the exposures and outcomes in a valid and reliable way (Q3 and Q7). Most studies addressed confounders appropriately (Q4 and Q5). In terms of common weaknesses, only 14.3% of studies had samples that were free of the outcome at first assessment (e.g., below cut-off on a depression scale; Q6). Only a small minority of studies divided the sample into groups based on tobacco or psychological symptoms in order to make baseline comparisons, and thus the studies scored very low on Q1 and Q2. Few studies (44.9%) clearly explained strategies to address incomplete follow-up (Q10). These limitations should be considered when interpreting the review findings.

The quality appraisal of included review studies (n = 4) is displayed in Table 3 and Supplementary Table S2. Three reviews were appraised as high quality with percentage scores above 80%. In terms of strengths, all reviews met eight of the eleven criteria,

including: stating the review question clearly and explicitly (Q1), selecting appropriate inclusion criteria (Q2), utilizing a comprehensive search strategy (Q3 and Q4), using appropriate criteria to appraise studies (Q5), using appropriate methods to combine studies (Q8), and making evidence-based recommendations for policy/practice (Q10) as well as future research directions (Q11). In terms of weaknesses, no reviews clearly stated that critical appraisal was conducted by at least two reviewers independently (Q6), and only one review clearly outlined methods to minimize errors in data extraction (Q7) [9].

Table 1 – Descriptive information about cohort studies (n = 49)

Authors (year) - country	Target population (n)	Structure - Baseline age, cohort years, #waves	Tobacco measure	Psychological measure/s	Relationship/s examined	Result	Covariates	Quality Score %	Limitations
Ajdacic-Gross et al. [24] (2009) - Switzerland	Stratified sample of participants with psychological disorders (N = 591)	21 years of age; 20-year follow-up; 6-waves	Smoking onset (adolescent vs adult vs never)	SPIKE	Tobacco>bipolar	For heavy smokers, adolescent onset of smoking predicted later bipolar compared to never smokers (OR = 7.1, CI = 1.9-25.9); but for other smokers this relationship was non-significant (OR = 0.9, CI = 0.3-2.7)	Education; gender; smoking parents; conduct problems; school problems; family problems; extraversion; neuroticism; masculinity; regular tobacco use	63.6	Adolescent onset of smoking retrospective; temporal sequencing unclear; high attrition; small bipolar sub-group; CIs unavailable
Ames et al. [25] (2018) - Canada	Youth (n = 662)	12-18 years of age; 10-year follow-up; 6-waves	Smoking status (smoker vs non-smoker)	BCFPI	Tobacco>depression	Adolescent smoking predicted membership in persistent high depression trajectory group versus low stable group (Est. = 1.18, SE = 0.55, P < .05, OR = 3.26, CIs unavailable)	Gender; [illegible]S; earlier levels of smoking and depression; physical health-promoting behaviour; heavy drinking; marijuana use; number of sexual partners; BMI	72.7	CIs unavailable
Berk et al. [26] (2010) - Australia	Youth with schizophrenia (n = 193)	21.9 (SD = 3.6) years of age; 7.5-year follow-up; 3-waves	Smoking status (smoker vs non-smoker)	BPRS-PS	Tobacco>psychosis	Baseline smoking did not predict future psychosis (B = 0.20, p = .871)	Gender; problem illicit drug use; problem alcohol use; duration of untreated psychosis	72.7	Change in smoking status not assessed
Bierhoff et al. [27] (2019) - USA	University students (n = 2397)	20.5 (SD = 1.93) years of age; 2-year follow-up; 6-waves	Prior 30-day tobacco quantity (cigarettes, cigarillos)	PHQ-9; ZSRAS	Depression>tobacco; anxiety>tobacco	Depression (OR = 1.05, CI = 1.02-1.09) and anxiety (OR = 1.02, CI = 1.00-1.04) predicted cigarette quantity; depression (OR = 1.05, CI = 1.02-1.09) and anxiety (OR = 1.03, CI = 1.00-1.06) predicted cigarillo quantity; but depression and anxiety did not predict smokeless tobacco use, e-cigarette use, or hookah use (ORs ranged from 0.95-1.06)	Age; gender; sexual orientation; ethnicity; parental education; school type; ADHD;	36.4	Anxiety only measured at W5; only W6 smoking included in analyses; temporal ordering unclear
Borges et al. [28] (2018) - Mexico	Youth (n = 1071)	12-17 years of age; 8-year follow-up; 2-waves	Tobacco use (never vs use before age 15 vs use at age 15 or older); nicotine dependence	WMH-CIDI	Tobacco>depression; tobacco>anxiety; depression>tobacco; anxiety>tobacco	Early tobacco use predicted future mood disorder (RR = 1.42, CIs = 1.02-1.98); other results with tobacco use were non-significant but data not shown; nicotine dependence predicted future mood disorder (RR = 3.30, CI = 1.66-6.55); mood disorder did not predict future nicotine dependence (RR = 1.50, CI* = 0.55-3.90);	Alcohol use; drug use; gender; age; living with parents; enrolled in school; parents' education; parents' income; number of childhood adversities	72.7	Individual disorders not examined as outcomes; only 2-waves

						anxiety did not predict future nicotine dependence (RR = 1.78, CI* = 0.95-3.60); data unavailable for nicotine dependence predicting anxiety			
Buchy et al. [29] (2014) - USA and Canada	Youth at high clinical risk of psychosis (n = 170)	19.8 (SD = 4.5) years of age; 4-year follow-up; 2-waves	Tobacco use (abstinent vs any use vs severe dependence)	SIPS	Tobacco>psychosis	Tobacco use did not predict transition to psychosis (U = 1752.5, p = .13)	Alcohol use; cannabis use; other drug use	63.6	Small sub-group sample sizes; smoking only measured at W1; only 2-waves
Buchy et al. [30] (2015) - USA and Canada	Youth at clinical high risk of psychosis (N = 735) and healthy controls (N = 278)	18.5 (SD = 4.2) years of age for clinical high risk; 19.6 (4.7) years of age for controls; 2-year follow-up; 3-waves	Tobacco use (abstinent vs use without impairment vs abuse vs dependence)	SIPS; SOPS	Tobacco>psychosis	Smoking severity (U = 11495.5, p = .24) and frequency (U = 11638.0, p = .35) did not predict transition to psychosis	Alcohol use; cannabis use; other drug use	54.5	Small sub-group sample sizes; all participants were help-seekers which may limit external validity
Bulhões et al. [31] (2020) - Portugal	Youth (n = 2010)	13-years of age; 8-year follow-up; 3-waves	Smoking status (never vs former vs current)	BDI-II	Tobacco>depression	Current smoking (vs never) predicted moderate (OR = 1.61, CI = 1.22-2.13) and high (OR = 1.89, CI = 1.18-3.01) depression trajectory groups (vs low). Former smoking (vs never) did not predict moderate (OR = 1.15, CI = 0.87-1.52) or high (OR = 1.08, CI = 0.65-1.78) depression trajectory groups (vs low)	Parents' education	54.5	Minimal covariates; temporal ordering unclear
Chen et al. [32] (2017) - USA	Youth with early-onset schizophrenia (n = 117)	13.9 (SD = 2.34) years of age; 3-year follow-up; 7-waves	Prior 6-month cigarette use (yes or no)	RADS; RCMAS	Tobacco>depression; tobacco>anxiety	Both depression (B = -13.70, SE = 5.03, p < .01) and anxiety (B = -14.41, SE = 5.90, p < .05) interacted with time to predict smoking	Age; gender; race; comorbidity; diagnosis; trauma; ; poverty	45.5	Small sample size; high attrition
Crane et al. [33] (2021) - USA	Youth (n = 1263)	15.6 (SD = 0.6) years of age; 7-year follow-up; 7-waves	Cigarette frequency (#days used in past month)	CESD-20	Depression>tobacco	Depression and time did not interact to predict future cigarette frequency (Est. = 0.00, SE = 0.00, p = .35)	Gender; race; ethnicity	72.7	Minimal covariates
Davies et al. [34] (2018) - UK	Youth (n = 6796)	12 years of age; 8-year follow-up; 4-waves	Smoking frequency (regularly [at least weekly] vs not)	SMFQ; PLIKSi	Psychosis>tobacco; depression>tobacco	Psychosis (OR = 1.11, CI = 0.79-1.56) and depression (OR = 1.23, CI = 0.78-1.95) at age 12 did not predict smoking at age 18	Gender; SES; housing; mother's education; IQ at age 8; SDQ at age 8; baseline levels of psychosis and depression	72.7	Smoking only measured at W3; high attrition
Ferdinand et al. [35]	Children and youth (n = 2600)	4-16 years of age; 14-year	Tobacco use (yes or no)	CBCL; YSR; YASR	Psychosis>tobacco	Auditory hallucinations at W2-5 predicted tobacco use at W6 (ORs ranging from 2.0-3.3);	Gender; age; SES	54.5	Tobacco use not measured at W1

(2004) - Netherlands		follow-up; 6-waves			visual hallucinations were non-significant predictors (results not shown)			
Fonseca et al. [36] (2021) - Brazil	University students without depression (n = 1034)	16-25 years of age; 3-year follow-up; 4-waves	Smoking status (yes if smoked at least 1 cigarette in previous 30-days)	PHQ-9	Tobacco>depression	Smoking did not predict depression for males (unadjusted IRR = 1.04, CI = 0.61-1.76) or females (unadjusted IRR = 1.49, CI = 0.97-2.27)	Age; SES; living situation; stress; alcohol use; sedentary behaviour; physical activity; sleep duration	54.5	Temporal ordering unclear; no overall statistics combining genders
Gage et al. [37] (2014) - UK	Youth without psychotic experiences at age 16 (n = 1573)	16 years of age; 2-year follow-up; 2-waves	Cigarette quantity (non-smoker vs experimenter vs weekly smoker vs daily smoker)	PLIKSi	Tobacco>psychosis	W1 cigarette use predicted psychotic symptoms at W2 (OR = 1.77, CI = 1.18-2.66)	Psychotic experience at 18 by categorical frequency of cigarette use at 18; family history of depression; mother's education; borderline personality; IQ at age 8; depression at age 12; conduct disorder; peer problems; bullied; cannabis use; illicit drug use; alcohol use	72.7	Tobacco use not measured at W2; psychosis not measured at W1; only 2-waves
Gårdvik et al. [38] (2020) - Norway	Youth (n = 717)	13-18 years of age; 3-year follow-up; 2-waves	Smoking status (yes or no)	K-SADS; DAWBA	Tobacco>depression; tobacco>anxiety	Smoking did not predict mood disorders (RD% = -0.5, CI = -3.0-2.6) but did predict anxiety disorders (RD% = 4.5, CI = 2.0-9.2)	Chronic pain; any somatic disorder; alcohol use; drug use; age; SES	72.7	Only 2-waves; temporal ordering unclear
Goodwin et al. [39] (2004) - New Zealand	Youth (n = 1000)	18-years of age; 2-year follow-up; 2-waves	Nicotine dependence (survey constructed based on DSM-IV criteria)	WMH-CIDI	Anxiety>tobacco	Anxiety disorders were not associated with nicotine dependence (OR = 1.46, CI = 0.93-2.29)	Parental change; interparental violence; sexual abuse; physical abuse; parental history of criminality, alcohol problems, illicit drug use and depression/anxiety; low self-esteem; neuroticism; quality of parental attachment; family stress; early shyness; early conduct problems; early attention problems; gender; prior substance dependence; concurrent major depression; affiliation with deviant peers	72.7	Only 2-waves; temporal ordering unclear; specific anxiety disorders not specified
Goodwin et al. [40] (2013) - Germany	Youth (n = 3021)	14-24 years of age; 10-year follow-up; 4-waves	Nicotine use (yes or no) and smoking trajectory (non-user vs increasing use vs decreasing use vs persistent use; MCIDI/DIA-X)	MCIDI/DIA-X	Bipolar>tobacco; depression>tobacco; anxiety>tobacco	Any depressive disorder, any fear disorder, GAD, and specific phobia were associated with nicotine use (ORs ranged from 1.1-5.7); any depressive disorder predicted subsequent decreasing smoking trajectory (OR = 1.7, CI = 1.1-2.8); panic disorder negatively predicted	Gender; age;	54.5	Difficult to interpret results (e.g., depression predicted binary nicotine use but also predicted decreasing trajectory).

						increasing smoking trajectory (OR = 0.1; CI = 0.0-0.9); all other results non-significant (ORs ranged from 0.7-2.2)			
Griesler et al. [41] (2008) - USA	Youth (n = 1039)	15.7 (SD = 1.4) years of age; 2-year follow-up; 5-waves	Nicotine dependence (CIDI); lifetime cigarettes smoked (0; 1; 2-5; 6-15; 16-25; 26-99; 100+); other lifetime tobacco use	DISC	Anxiety>tobacco; tobacco>anxiety; depression>tobacco; tobacco>depression	Anxiety (OR = 1.0, CI = 0.3-3.4) and mood (OR = 1.7, CI = 0.8-3.7) disorder did not predict nicotine dependence; nicotine dependence did not predict anxiety (OR = 0.8, CI = 0.3-2.0) and mood (OR = 2.4, CI = 0.5-10.7) disorder; lifetime cigarettes smoked did not predict anxiety (OR = 1.0, CI = 0.9-1.0) and mood (OR = 1.0, CI = 0.9-1.0) disorder; other lifetime tobacco use did not predict anxiety (OR = 0.4, CI = 0.2-1.0) and mood (OR = 0.6, CI = 0.1-2.7) disorder	Age; gender; ethnicity; disruptive disorder; novelty seeking; age of onset of smoking; initial sensitivity to tobacco; number of lifetime cigarettes smoked; other lifetime drug use; drug use; peer smoking; sibling smoking; parent smoking; parent depression; parent delinquency; any psychiatric disorder	72.7	Individual disorders not examined as predictors/outcomes; short follow-up period; variables not measured at all waves
Griesler et al. [42] (2011) - USA	Stratified sample of smoking youth (n = 814)	15.7 (SD = 1.4) years of age; 2-year follow-up; 5-waves	Nicotine dependence (zero dependence criterion vs one dependence criterion vs three criteria; CIDI)	DISC	Tobacco>depression;	No specific psychological disorders predicted one dependence criterion (statistics now shown) and only panic disorder predicted full (i.e., three) dependence criteria (HR = 2.2, CI = 1.2-3.9); nicotine dependence did not predict any specific psychological disorders (statistics not shown); anxiety disorder did not predict first nicotine dependence criterion (HR = 1.10, CI = 0.78-1.55), but did predict full nicotine dependence (HR = 1.68, CI = 1.12-2.52); mood disorder did not predict first nicotine dependence criterion (HR = 1.16, CI = 0.86-1.55) or full nicotine dependence (HR = 0.93, CI = 0.63-1.38); one dependence criterion did not predict anxiety (HR = 1.12, CI = 0.52-2.39) or mood (HR = 1.10, CI = 0.54-2.26) disorder; full dependence criteria did not predict anxiety (HR = 0.76, CI	Gender; ethnicity; age of onset of tobacco use; initial sensitivity to tobacco; alcohol and other illicit drug use; parent education; parent smoking; parent depression; parent delinquency; ever tobacco dependent	72.7	Individual disorders not examined as predictors/outcomes; short follow-up period; variables not measured at all waves

						= 0.23-2.49) or mood (HR = 1.82, CI = 0.67-4.96) disorder			
Hu et al. [43] (2012) - USA	Stratified sample of lifetime youth smokers (n = 877)	14.1 (SD = 1.4) years of age; 7-year follow-up; 6-waves	Nicotine dependence (no dependence criteria vs early onset/chronic course vs early onset/remission vs late onset)	DISC	Anxiety>tobacco	Anxiety disorder predicted chronic course, early remission, and late onset nicotine dependence (compared with none, ORs ranged from 3.65-4.55); anxiety disorder did not predict chronic course vs early remission, chronic course vs late onset, or early remission vs late onset (ORs ranged from 1.04-1.09)	Gender; ethnicity; onset age of smoking; smoked 5+ packs per month; maximum number of drinks per month; marijuana use; onset age of marijuana; pleasant initial sensitivity to tobacco; parental nicotine dependence; disruptive mood/anxiety disorder at W5	81.8	Anxiety only measured at W3 and W5; temporal ordering unclear
Hui et al. [44] (2013) - China	Youth with psychosis (n = 1400)	21.2 (SD = 3.4) years of age; 3-year follow-up; 3-waves	Smoking status (non-smoker vs current smoker vs ex-smoker)	CGI-S	Tobacco>psychosis	Smoking predicted relapse of psychosis (HR = 1.42, CI = 1.15-1.76)	Age; schizophrenia diagnosis; length of first psychiatric hospitalisation; adherence; clinical stabilisation	63.6	Difficulty defining relapse; confounder of stressful life events not included
Isensee et al. [45] (2003) - Germany	Youth (n = 3021)	14-24 years of age; 3.5-year follow-up; 3-waves	Smoking quantity (never vs occasional vs non-dependent regular vs dependent regular)	MCIDI/DIA-X	Tobacco>anxiety; anxiety>tobacco	Smoking predicted future agoraphobia, SAD, specific phobia, panic attacks without disorder, and unspecified phobia (ORs ranged from 2.4-3.7), but did not predict panic disorder (ORs ranged from 0.1-3.6); no psychological disorders or symptoms predicted smoking (ORs ranged from 0.3-2.6)	Gender; age; PTSD; alcohol and illicit drug disorders; eating disorders	72.7	Small sample sizes for certain disorders
Johnson et al. [46] (2000) - USA	Youth (n = 688)	~16 years of age; 6-year follow-up; 2-waves	Smoking quantity (less than 1-pack per day vs more than 1-pack per day)	DISC	Tobacco>anxiety; anxiety>tobacco	Smoking predicted future agoraphobia, GAD, and panic disorder (ORs ranged from 5.53-15.58) but not SAD (OR = 0.44, CI = 0.04-4.62); anxiety disorders did not predict future smoking (statistics unavailable)	Gender; age; difficult childhood temperament; parental education; parental smoking; parental psychopathology; adolescent alcohol and drug use; adolescent anxiety and depressive disorders	72.7	Only 2-waves; small sample sizes for certain disorders
Jones et al. [47] (2018) - UK	Youth (n = 3328)	13.9 (SD = 2.7) years of age; 5-year follow-up; 6-waves	Cigarette use (yes or no)	PLIKSi	Psychosis>tobacco; tobacco>psychosis	Cigarette use did not predict subsequent psychosis (ORs ranged from 0.73-1.78); psychosis did not predict subsequent cigarette use (ORs ranged from 0.86-1.60)	Gender; mother's education; emotional and behavioural problems at 4 years of age; mother's smoking during pregnancy	63.6	High attrition
Kalan et al. [48] (2020) - Lebanon	Youth waterpipe (N = 228) and cigarette smokers (N = 139)	14.3 (SD = 1.2) years of age; 6-year follow-up; 8-waves	Nicotine dependence initial symptoms; nicotine dependence full diagnosis	DSS	Depression>tobacco	For waterpipe smokers, depression did not predict initial nicotine dependence symptoms (unadjusted HR = 1.03, CI = 0.98-1.09) but did predict full nicotine dependence	Gender; BMI; SES; age	54.5	Small sample size

						diagnosis (HR = 1.13, CI = 1.02-1.25). For cigarette smokers, depression did not predict initial dependence symptoms (unadjusted HR = 1.00, CI = 0.94-1.06) or full nicotine dependence diagnosis (unadjusted HR = 0.96, CI = 0.85-1.09)			
Kendler et al. [49] (2015) - Sweden	Males from conscript registry (n = 233,879)	18.5 (SD = 8.4) years of age; 8-year follow-up; 5-waves	Smoking quantity (none vs light vs heavy)	Registry diagnosis (assessment tool unclear)	Tobacco>psychosis	W1 and W2 light (vs no) smoking did not predict subsequent schizophrenia (ORs ranged from 1.60-1.62) but W3 did (OR = 1.77, CI = 1.02-3.05); W1 and W3 heavy (vs no) smoking did predict subsequent schizophrenia (ORs ranged from 2.21-2.39), but W2 did not (OR = 1.96, CI = 0.95-4.06)	Family; [illegible]mmunity SES; drug abuse	45.5	Only male youth; psychological disorder assessment method unclear
King et al. [50] (2004) - USA	Youth twins (n = 1364)	11 years of age; 3-year follow-up; 2-waves	Nicotine onset; regular cigarette use; daily nicotine use	DICA-R	Anxiety>tobacco; tobacco>anxiety	Using adjusted analyses, W1 MDD predicted W2 nicotine onset (OR = 1.98, CI = 1.15-3.41), but using unadjusted analyses did not predict regular cigarette use or daily nicotine use (ORs ranged from 0.83-1.94); using unadjusted analyses, W1 separation anxiety disorder and overanxious disorder did not predict any of the outcomes (ORs ranged from 0.84-1.25)	Conduct disorder; oppositional defiant disorder; ADHD; gender	72.7	Only 2-waves; anxiety disorders assessed for females only; variables only measured at one time point each; only some analyses adjusted
MacKie et al. [51] (2011) - UK	Youth (n =409) with elevated hopelessness, anxiety-sensitivity, impulsivity and sensation-seeking	14.5 years of age; 1.5-year follow-up; 4-waves	Cigarette use (yes or no)	DIS	Tobacco>psychosis	W1 cigarette use did not predict persistent psychotic trajectory (OR = 1.3, 0.3-5.1) but did predict increasing psychotic trajectory (OR = 5.4, CI = 1.5-20.1)	Gender; ethnicity; anxiety sensitivity; hopelessness; impulsivity; sensation seeking	54.5	Short follow-up; small sample sizes in sub-groups
Marmorstein et al. [52] (2010) - USA	Male youth (n = 503)	~6.2 years of age; 14-year follow-up; 15-waves	Age at first tobacco use	CBCL; TRF; YSR	Anxiety>tobacco	Both generalised (OR = 0.06, CI = .02-.17) and social anxiety (OR = 0.06, CI = .02-.17) interacted with time to predict earlier onset of tobacco use	Age at first alcohol and substance use; delinquency	63.6	Statistics unclear; only male sample

Marsden et al. [53] (2019) - USA	University students (n = 5236)	21.0 (SD = 2.3) years of age; 3-year follow-up; 6-waves	Past 30-day use and frequency of use of cigarettes, refillable e-cigarettes, disposable e-cigarettes, hookah, cigars (including cigarillos and little cigars), and smokeless tobacco	CESD-10	Tobacco>depression	For past 30-day use, significant predictors of depression were cigarettes, refillable e-cigarettes, and hookah (rate ratios ranged from 1.01-1.03), but disposable e-cigarettes, cigars, and smokeless tobacco were non-significant (rate ratios ranged from 1.00-1.10); for frequency of use, significant predictors of depression were cigarettes, refillable e-cigarettes, and smokeless tobacco (rate ratios ranged from 1.10-1.04), but disposable e-cigarettes, cigars, and hookah were non-significant (rate ratios ranged from 1.01-1.05)	Gender; ethnicity; age; father's education; college duration; survey wave; other tobacco products	54.5	University student sample
Moylan et al. [54] (2013) - Norway	Youth (n = 456)	14-15 years of age; 4-year follow-up; 3-waves	Smoking status (active vs non-active)	GADS	Tobacco>anxiety; anxiety>tobacco	Active smoking in adolescence predicted later anxiety (B = 0.17, p < .05); adolescent anxiety did not predict later smoking (statistics not presented)	Mother's education	72.7	Very small cell sizes; relatively high SES of participants; minimal covariates
Mustonen et al. [55] (2018) - Finland	Youth (n = 6081)	15-16 years of age; 15-year follow-up; number of waves unclear	Cigarette quantity (non-smokers vs moderate [1-9 cigarettes a day] vs heavy [greater than 10 cigarettes a day]); number of daily cigarettes smoked; age of smoking onset	Registry diagnoses based on ICD-10 criteria	Tobacco>psychosis	Heavy smoking (HR = 2.00, CI = 1.13-3.54) and number of daily cigarettes (OR = 1.05, CI = 1.01-1.08) predicted later psychosis; but moderate smoking did not (HR = 0.42, CI = 0.13-1.34); early onset predicted subsequent psychosis compared to late onset (HR = 2.84, CI = 1.12-7.18)	Baseline psychotic experiences; cannabis use; alcohol use; other substance use; parental substance abuse; parental psychosis	72.7	Number of waves unclear; psychosis diagnosis method unclear
Okeke et al. [56] (2013) - USA	Mexican-American youth (N = 1328)	11-13 years of age; 5-year follow-up; 3-waves	Smoking status (never vs puffer [tried but not completed single cigarette] vs experimenter [have consumed one cigarette or more])	STAS	Anxiety>tobacco	Anxiety predicted experimenter status (OR = 1.04, CI = 1.02-1.07) but not puffer status (OR = 1.01, CI = 0.99-1.03)	Gender; age; birth country; parental education; BMI; body image	54.5	Temporal ordering unclear; variables not measured at each time point
Pedersen et al. [57] (2009) - Norway	Youth (n = 1501)	13 years of age; 13-year follow-up; 4-waves	Smoking status (not smoking vs smoking but not dependent vs	(SCL-90)	Tobacco>anxiety; anxiety>tobacco	Nicotine dependent status predicted later anxiety (B = 0.09, p < .01) but non-dependent smoking status did	Gender; age; depression and parasuicide at age 20; and at ages 15 and 20: SES, parental care and monitoring, parental divorce,	54.5	Infrequent assessments

			nicotine dependent)			not (B = 0.05, p > .05); anxiety did not predict later smoking status (OR = 1.06, CI = 0.97-1.17)	education, conduct problems, cannabis		
Purborini et al. [58] (2021) - Indonesia	Youth (n = 1960)	17.0 (SD = 1.4) years of age; 7-year follow-up; 2-waves	Lifetime tobacco status (ever vs never); current tobacco status (never vs current vs former)	CESD-10	Tobacco>depression	All tobacco use statuses predicted depression including ever smoked (B = 0.92, CI = 0.73-1.12), current smoker (B = 0.88, CI = 0.68-1.08), and former smoker (B = 1.52, CI = 0.95-2.08)	Marital status; region; SES	81.8	Only 2-waves; temporal ordering unclear
Raffetti et al. [59] (2019) - Sweden	High school students (n = 3959)	13 years of age; 1-year follow-up; 2-waves	Cigarette smoking; snus use; current; tobacco use; tobacco dependence (all variables yes or no)	CES-DC; SDQ	Tobacco>depression	Cigarette smoking (b = 3.4, p = .006) and tobacco dependence (b = 3.4, p = .008) predicted later depression, but snus (b = -0.1, p = .934) and tobacco (b = 1.9, p = .073) use did not; using depression onset as outcome, only tobacco dependence was a significant predictor (OR = 4.8, CI = 1.7-14.0), but cigarette smoking, tobacco use, and snus use were not (ORs ranged from 0.8-2.0)	Baseline depression; alcohol use; parental education; parental birthplace; gender	72.7	Minimal waves; short follow-up;
Ranjit et al. [60] (2019) - Finland	Youth twins (n = 4152)	14 years of age; 3-year follow-up; 2-waves	Lifetime cigarettes smoked (zero vs 1-50 vs 50+); smoking status (never vs experimenter vs quitter vs regular)	GBI	Tobacco>depression	Lifetime cigarettes smoked and smoking status did not predict later depression (IRRs ranged from 1.05-1.14); depression did not predict later smoking (results not shown)	Gender; school grades; alcohol use to intoxication; health status, pre-existing depressiveness; shared familial and genetic factors between twins	72.7	Minimal waves; variables only measured at one wave
Ranjit et al. [61] (2019b*) - Finland	Youth twins (n = 4236)	17.5 years of age; 5-year follow-up; 2-waves	Smoking status (never vs ever)	GBI	Tobacco>depression; depression>tobacco	Smoking did not predict later depression (OR = 1.02, CI = 0.92-1.14); depression did not predict later smoking (OR = 1.03, CI = 0.91-1.17)	Gender; age; baseline depression; shared familial and genetic factors between twins	54.5	Minimal waves
Savage et al. [62] (2016) - Finland	Youth twins (n = 1906)	12 years of age; 10-year follow-up; 4-waves	Nicotine dependence symptoms	MPNI	Anxiety>tobacco	Peer/teacher/parent-rated social anxiety did not predict future nicotine dependence (Bs ranged from -.15 to -.01)	Nicotine dependence at W2 and W3; gender	45.5	Social anxiety only measured at W1; statistics unclear; low internal reliability of parent-rated social anxiety
Shete et al. [23] (2017) - USA	Mexican-American youth (n = 1328)	11.8 (SD = 0.8) years of age; 5-year follow-up; 2-waves	Smoking escalation (yes or no)	STAS	Anxiety>tobacco	Anxiety predicted smoking escalation (OR = 1.03, CI = 1.02-1.05)	Gender; age; subjective social status; intention to try cigarette; peer smoking; parental smoking	36.4	Minimal waves

Smith et al. [63] (2014) - USA	Sub-sample of young adults (precise N unclear, but approximately 14,000)	18-29 years of age; 1-year follow-up; 2-waves	Smoking cessation (yes or no)	AUDADIS-IV	Depression>tobacco; anxiety>tobacco; bipolar>tobacco	Compared to the longitudinal smoking cessation rate of no-diagnosis (28.7), all longitudinal smoking cessation rates of those with past-year diagnoses were significantly lower (ps < .001): SAD (13.8), agoraphobia (12.0), panic disorder (14.5), specific phobia (20.3), GAD (13.4), mania or hypomania (18.6), MDD (17.6)	Age; gender; education	81.8	Minimal waves; short follow-up; change in psychological diagnosis unclear; symptom severity not measured
Swendsen et al. [64] (2010) - USA	Youth (n = 5001)	15-24 years of age; 10-year follow-up, 2-waves	Daily tobacco use (yes or no); nicotine dependence (yes or no)	CIDI	Depression>tobacco; anxiety>tobacco; bipolar>tobacco	Among W1 non-daily tobacco users, significant predictors of W2 onset of daily use included any mood disorder, panic disorder, SAD, specific phobia, GAD, and any anxiety disorder (ORs ranged from 1.6-3.0), whereas MDD, bipolar, agoraphobia, and separation anxiety were non-significant (ORs ranged from 0.8-1.8); among daily tobacco users, significant predictors of W2 onset of nicotine dependence included bipolar, any mood disorder, agoraphobia, and separation anxiety (ORs ranged from 1.9-3.9), whereas MDD, panic disorder, SAD, GAD, and any anxiety disorder were non-significant (ORs ranged from 0.8-1.4)	Age; gender; ethnicity; education; marital status; number of children; religion; urbanicity; employment status	72.7	Minimal waves
Tomita et al. [65] (2020) - South Africa	Subsample of youth without depression (N = 4207)	15-19 years of age; 7-year follow-up; 4-waves	Smoking cigarette status (yes or no)	CESD-10	Tobacco>depression	Smoking predicted depression for both males (RR = 1.84, CI = 1.18-2.88) and females (RR = 2.47, CI = 1.15-5.29)	Ethnicity; marital status; education; employment status; household income; urban vs rural residence	63.6	None noted
Trotta et al. [66] (2020) - UK	Youth twins (n = 2232)	12 years of age; 6-year follow-up; 2-waves	Tobacco dependence	Structured interview created by authors	Psychosis>tobacco	Psychosis did not predict later tobacco dependence (RR = 1.00, CI = 0.57-1.75)	Shared familial and genetic factors between twins; gender; age-5 IQ; family SES status; age-12 depression, anxiety, self-harm/suicidality, ADHD, conduct disorder, family psychological history; mother's psychotic symptoms	63.6	Only 2-waves;

Ward et al. [67] (2019) - USA and Canada	Youth at clinical high risk of psychosis (N = 587) and healthy controls (N = 274)	18.5 (4.3) years of age for clinical high risk; 19.7 (4.7) years of age for controls; 2-year follow-up; waves unclear but approximately 3-4	Smoking level (none vs light vs heavy); smoking status (never vs ever)	SIPS	Tobacco>psychosis	Light smoking (OR = 0.90, CI = 0.4-2.2), heavy smoking (OR = 0.3, CI = 0.05-2.3), and status as 'ever smoked' (HR = 1.16, CI = 0.82-1.65) did not predict transition to psychosis	Tobacco use; marijuana use; alcohol use; age; ethnicity; academic performance; academic adjustment; depression; anxiety; social anxiety; daily stressors; life events; perceived discrimination	72.7	Some small cell counts; number of waves unclear
Weiser et al. [68] (2004) - Israel	Youth male military recruits (n = 14, 248)	18 years of age; 10.2 (SD = 3.6) year follow-up; number of waves unclear	Smoking status (yes or no); daily smoking quantity (zero vs 1-9 vs 10+)	Registry diagnoses based on ICD-10 criteria	Tobacco>psychosis	Baseline binary smoking (RR = 1.94, CI = 1.05-3.58) and daily smoking 10+ cigarettes (RR = 2.28, CI = 1.19-4.34) predicted later schizophrenia, but daily smoking 1-9 cigarettes (RR = 1.38, CI = 0.48-4.00) did not	Non-psychotic psychological disorders; adolescent social and intellectual functioning; SES	72.7	Inconsistent follow-up periods; number of waves unclear; schizophrenia diagnosis method unclear; smoking only assessed at baseline; only male sample
Wilens et al. [69] (2016) - USA	Youth with bipolar (N = 105) and youth controls without bipolar (N = 98)	13.6 (SD = 2.5) years of age for bipolar, 13.7 (SD = 2.1) years of age for controls; 5-year follow-up; 3-waves (but unclear)	Cigarette smoking (levels unclear)	KSADS-E; SCID	Tobacco>bipolar	Maintenance of smoking predicted bipolar status at final follow-up (HR = 3.2, CI = 1.6-6.7); but smoking did not predict persistence of bipolar (HR = 1.5, CI = 0.7-3.2)	SES; parental history of substance use disorder; probands with bipolar;	63.6	Temporal ordering unclear; small sample size; number of waves unclear; levels of predictor unclear; results unclear
Zammit et al. [70] (2003) - Sweden	Youth military recruits (n = 50,087)	18-20 years of age; 27-year follow-up; number of waves unclear	Smoking quantity (non-smokers vs light smokers vs medium smokers vs heavy smokers)	Registry diagnoses based on ICD-8	Tobacco>psychosis	Smoking quantity negatively predicted schizophrenia by final follow-up (HR = 0.8, CI = 0.7-0.9), but did not predict schizophrenia between 0-5 years from baseline (HR = 0.9, CI = 0.7-1.1)	Diagnosis at conscription; poor social integration; IQ; drug use; disturbed behavior; father's occupation; place of upbringing; family SES; family psychiatric history; alcohol problems	81.8	Psychological disorder diagnosis method unclear; number of waves unclear; smoking only measured at baseline
Zhang et al. [71] (2018) - Germany	Female youth (n = 3065)	21.0 (SD = 1.73) years of age; 1.5-year follow-up; 2-waves	Smoking status (yes or no)	DIMD-RV	Tobacco>depression	Smoking did not predict incremental variance in MDD (OR = 1.55, CI = 0.90-2.66)	BMI; alcohol use; alcohol-related problems; physical activity; good physical health	72.7	Only females; minimal waves; short follow-up; MDD and smoking measured as binary variables

Note: All CIs (confidence intervals) were 95%.

*Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.

BMI = Body Mass Index; CI = 95% confidence interval; Est. = Estimate; GAD = Generalised Anxiety Disorder; IRR = Incidence Rate Ratio; OR = odds ratio; SAD = Social Anxiety Disorder; SES = socioeconomic status; U = Mann Whitney U Test.

AUDADIS-IV = Alcohol Use Disorder and Associated Disabilities Interview Schedule; BCFPI = Brief Child and Family Phone Interview; BDI-II = Beck Depression Inventory-II; BPRS-PS = Brief Psychiatric Rating Scale; CBCL = Child Behavior Checklist; CES-DC = Center for Epidemiologic Studies Depressive symptoms Scale for Children; CESD = Center for Epidemiologic Studies Depression Scale; CGI-S = Clinical Global Impressions – Severity Scale; DAWBA = Development and Wellbeing Assessment; DICA-R = Diagnostic Interview for Children and Adolescents; DIMD-RV = Diagnostic Interview for Mental Disorders—Research Version; DIS = Diagnostic Interview Schedule; DISC = Diagnostic Interview Schedule for Children; DSS = Depressive Symptoms Scale; FTND = Fagerström Test for Nicotine Dependence; GADS = Generalized

Anxiety Disorder Scale; GBI = General Behavior Inventory; KSADS-E = Kiddie Schedule for Affective Disorders-Epidemiologic Version; MCIDI/DIA-X = Munich-Composite International Diagnostic Interview ; MPNI = Multidimensional Peer Nomination Inventory; MSI = Minnesota Smoking Index; PHQ-9 = Patient Health Questionnaire; PLIKSi = Psychosis-Like Symptoms Interview; PLIKSi = Psychosis-like Symptoms interview; RADS = Reynolds Adolescent Depression Scale; RCMAS = Revised Children's Manifest Anxiety Scale; SCID = Scheduled Clinical Interview Diagnosis; SCL-90 = Hopkins Symptom Checklist; SDQ = Strengths and Difficulties Questionnaire; SIPS = Structured Interview for Prodromal Syndromes; SMFQ = Short Mood and Feelings Questionnaire; SOPS = Scale for Assessment of Prodromal Symptoms; SPIKE = Structured Psychopathological Interview and Rating of the Social Consequences of Psychological Disturbances for Epidemiology; STAS = Speilberger's Trait Anxiety Scale; TFR = Teacher Report Form; WMH-CIDI = World Mental Health Composite International Diagnostic Interview; YASR = Young Adult Self-Report; YSR = Youth Self-Report; ZSRAS = Zung Self-Rating Anxiety Scale.

Overview of included cohort studies

As per Table 1, the vast majority of the 49 cohort studies were either from North America (n = 20, with 18 from USA) or Europe (n = 21). Most studies used a non-clinical youth sample (n = 40), with the remaining nine using a clinical sample (youth in receipt of clinical mental health services) or a pseudo-clinical sample (e.g., youth with elevated anxiety sensitivity). Sample sizes ranged widely from 117 to 233,879 (M = 8162.53, Mdn = 14,000, SD = 33738.60). Youth age at baseline ranged from 6.2 to 23.5 (M = 16.09, SD = 3.59). Follow-up periods with youth participants ranged from 1 to 27-years (M = 6.43, SD = 5.15). Of the 46 studies that provided this longitudinal follow-up information, the number of waves ranged from 2 to 15 (M = 3.93, SD = 2.40). In terms of the types of tobacco measures used, numerous studies used a binary measure (n = 25; e.g., cigarette user vs non-user, nicotine user vs non user), while others used a categorical (ordinal) measure (n = 22; e.g., non vs moderate vs heavy smoker), while only five studies used a continuous measure. Nine studies used 'nicotine dependence' as the tobacco-related measure, while five used 'onset' (e.g., age of smoking onset), and four studies also included consumption of tobacco more broadly than cigarettes (e.g., cigarillos, snus, smokeless tobacco). Twelve studies used multiple measures of tobacco use. Only one study examined smoking-cessation as the tobacco-related variable. Most studies (n = 30) used structured interviews with youth (e.g., WHM-CIDI, PLIKSi) to assess the relevant psychological variable (e.g., anxiety), and a moderate number of studies (n = 19) used self-report measures (e.g., PHQ-9, CESD). Only four studies used caregiver-report (teacher or parent) and one study used peer-report. As shown in Table 1, there were zero relevant studies found for BPD. The number of covariates included in analyses ranged from 1 to 19 (M = 6.69, SD = 4.05). Common covariates included gender, age, SES, and other drug use (e.g., cannabis and alcohol). Common limitations of the cohort studies included: only

using two-waves, not controlling for earlier levels of outcome or later levels of predictor, small cell sizes, and unclear temporal ordering.

Overview of included systematic reviews

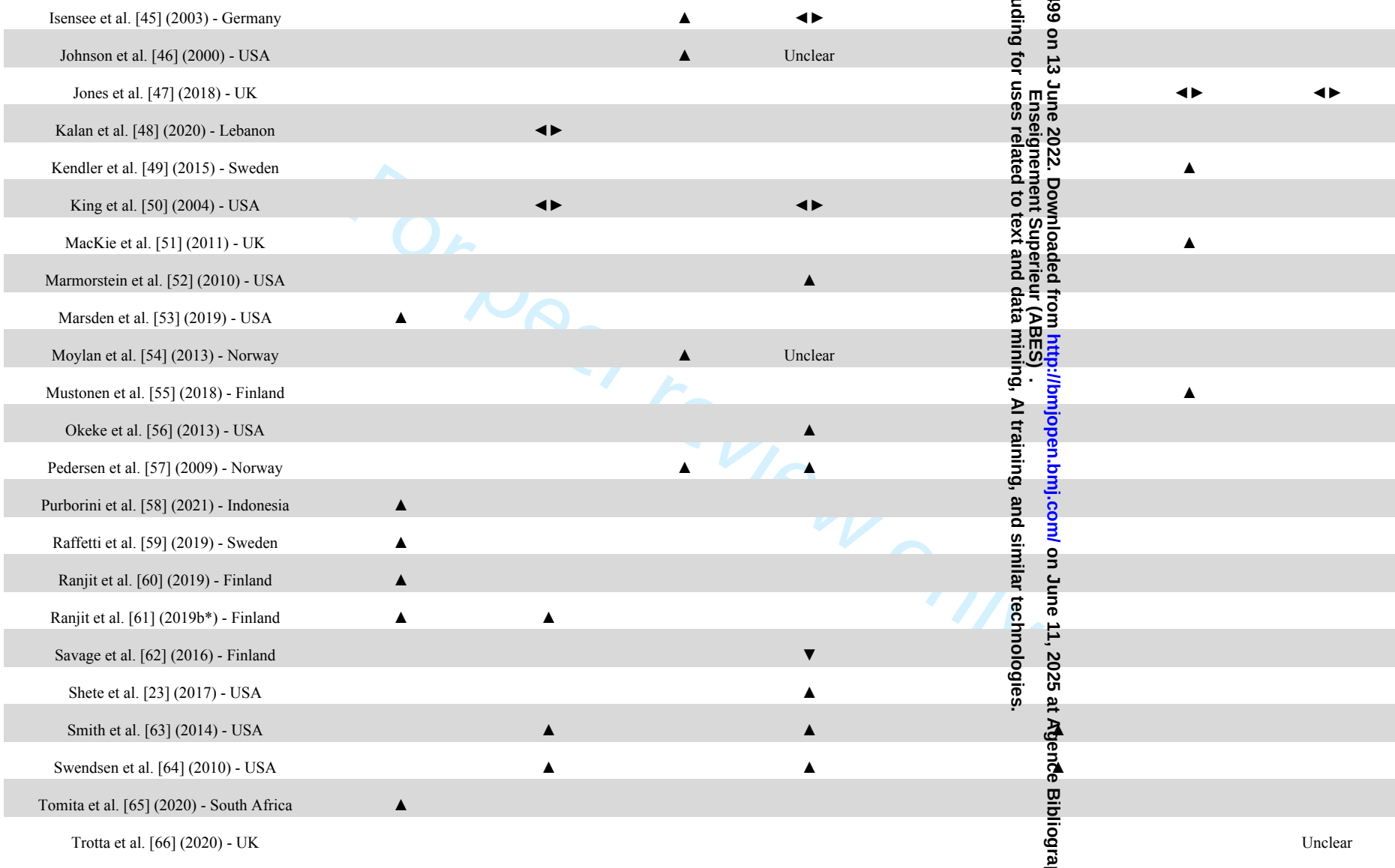
As per Table 3, one of the four systematic reviews only focused on youth from the USA and Canada [11], while the other three did not have geographical constraints. Cairns et al. [9] and Chaiton et al. [10] specified a target population age range, while Esmaeelzadeh et al. [11] and Ahun et al. [20] broadly referred to 'youth'. All reviews examined a variety of tobacco and psychological measures, and all four examined the relationship between tobacco and depression; whereas, only Esmaeelzadeh et al. [11] and Ahun et al. [20] also examined the relationship between tobacco and anxiety. None of the other psychological disorder categories were evaluated. Two of the reviews were limited by small sample sizes for anxiety analyses [11,20].

Tobacco>depression

Fifteen cohort studies examined the effect of tobacco use on the development of depression in youth, including only one with a clinical sample and eight with more than two waves. As shown in Table 2, there was evidence that tobacco had an effect on depression, with 13 of 15 studies (86.7%) showing a positive effect ($p < .001$). Only one of these studies was high quality (quality appraisal score > 75%), and this study found a positive effect. Effect estimates for each cohort study are shown in Table 2. Additionally, three of the four systematic reviews examined the effect of tobacco on depression and found a positive and significant pooled estimate, as shown in Table 3.

Table 2 - Vote counting of the direction of effects for cohort studies

Authors (year) - country	Tobacco>depression	Depression>tobacco	Tobacco>anxiety	Anxiety>tobacco	Tobacco>bipolar	Bipolar>tobacco	Tobacco>psychosis	Psychosis>tobacco
Ajdacic-Gross et al. [24] (2009) - Switzerland					◄►			
Ames et al. [25] (2018) - Canada	▲							
Berk et al. [26] (2010) - Australia							▼	
Bierhoff et al. [27] (2019) - USA		◄►		▲				
Borges et al. [28] (2018) - Mexico	▲	▲		▲				
Buchy et al. [29] (2014) - USA and Canada							▼	
Buchy et al. [30] (2015) - USA and Canada							Unclear	
Bulhões et al. [31] (2020) - Portugal	▲							
Chen et al. [32] (2017) - USA	▲		▲					
Crane et al. [33] (2021) - USA		Unclear						
Davies et al. [34] (2018) - UK		▲						▲
Ferdinand et al. [35] (2004) - Netherlands								▲
Fonseca et al. [36] (2021) - Brazil	▲							
Gage et al. [37] (2014) - UK							▲	
Gårdvik et al. [38] (2020) - Norway	▼		▲					
Goodwin et al. [39] (2004) - New Zealand				▲				
Goodwin et al. [40] (2013) - Germany		◄►		◄►		▲		
Griesler et al. [41] (2008) - USA	◄►	▲	◄►	◄►				
Griesler et al. [42] (2011) - USA	▲	◄►	◄►	▲				
Hu et al. [43] (2012) - USA				▲				
Hui et al. [44] (2013) - China							▲	



Ward et al. [67] (2019) - USA and Canada			◄►
Weiser et al. [68] (2004) - Israel			▲
Wilens et al. [69] (2016) - USA		▲	
Zammit et al. [70] (2003) - Sweden			▼
Zhang et al. [71] (2018) - Germany	▲		

Note. ▲ = positive effect direction; ▼ = negative effect direction; ◄► = conflicting effect directions; unclear = unclear effect direction.
*Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.

Depression>tobacco

Twelve cohort studies examined the effect of depression on development of tobacco use by youth. None of these studies used clinical samples, and seven had more than two waves. There was evidence that depression had an effect on tobacco use, with six of the twelve studies (50.0%) showing a positive effect (p = .016). One of these studies was high quality, and this study showed a positive effect. All of the systematic reviews examined the effect of depression on tobacco and the three reviews that reported a pooled estimate found a significant positive effect. The fourth review reported individual study results and found that 85.7% of the included depression>tobacco studies had a significant positive effect.

Tobacco>anxiety

Eight studies examined the effect of tobacco use on development of anxiety in youth. One of these had a clinical sample, and six had more than two waves. Tobacco appeared to have an effect on anxiety, with six of eight studies (75.0%) showing a positive effect (p = .016). None of these studies were high quality. One systematic review examined the effect of tobacco on anxiety and found a positive and significant effect, but this effect was based on only one study.

Anxiety>tobacco

Eighteen studies examined the effect of anxiety on development tobacco use by youth. None of these used a clinical sample, and 11 had more than two waves. Anxiety appeared to have an effect on tobacco use, with 11 of 18 studies (61.1%) showing a positive effect (p = .003). Two of these studies were high quality, and both showed a positive effect. Two systematic reviews examined the effect of anxiety on tobacco use. One of these found a positive non-significant effect, while the other found a non-significant effect and did not report the effect

direction. However, both reviews only included one anxiety>tobacco study and thus were extremely underpowered.

Tobacco>bipolar

Two studies examined the effect of tobacco use on development of bipolar in youth. Both of these studies used clinical samples and had more than two waves. Tobacco did not appear to have an effect on bipolar, with just one study (50%) showing a positive effect (p = .500). Neither of these studies was high quality. No reviews examined the tobacco-bipolar relationship.

Bipolar>tobacco

Three studies examined the effect of bipolar on development of tobacco use by youth. None of these used a clinical sample, and one had more than two waves. Bipolar did not appear to have an effect on tobacco use, with two studies (66.7%) showing a positive effect (p = .250). One of the three studies was high quality, and this study showed a positive effect. No reviews examined the bipolar-tobacco relationship.

Tobacco>psychosis

Twelve studies examined the effect of tobacco use on development of psychosis in youth. Seven of these used a clinical or pseudo-clinical sample, and seven had more than two waves. Tobacco use did not appear to have an effect on psychosis, with only six studies (50%) showing a positive effect (p = .254). Only one of the twelve studies was high quality, and this study showed a negative effect. No reviews examined the tobacco-psychosis relationship.

Table 3 – Descriptive information about systematic reviews (n = 4)

Authors (year)	Target population and study designs (n)	Tobacco measure/s	Psychological measure/s	Relationship/s examined (n)	Result	Quality score %	Limitations
Ahun et al. [20] (2020)	Youth (n = 43)	Cigarette smoking	Unclear	Depression>tobacco (N = 7); anxiety>tobacco (N = 1)	Six of the depression studies had a significant association with cigarette smoking, while the one anxiety study did not		No statistics reported, only significance of association; only one anxiety study examined;
Cairns et al. [9] (2014)	Youth aged 12-18 (n = 17)	Any form	Unclear	Tobacco/depression	Tobacco associated with increased depression with small effect size (r = .09, CI = 0.06-0.12)		Directionality unclear
Chaiton et al. [10] (2009)	Non-clinical youth aged 13-19 (n = 15)	Mostly 'smoking onset' operationalised as ever having had a 'puff' or 'one cigarette'	Various but mostly CES-D	Tobacco>depression (n = 6); depression>tobacco (n = 12)	Smoking predicted depression (PE = 1.73, CI = 1.32-2.40); depression predicted smoking (PE = 1.41, CI = 1.21-1.63)		Low number of tobacco>depression studies
Esmaeelzadeh et al. [11] (2018)	Youth from USA and Canada (N = 17)	Various (e.g., ever smoked; current smoker; regular smoker)	Various for depression but mostly CES-D; various for anxiety (e.g., SIAS, DISC-IV)	Depression>tobacco (n = 7); tobacco>depression (n = 4); anxiety>tobacco (n = 1); tobacco>anxiety (n = 1)	Depression predicted tobacco use (OR = 1.22, CI = 1.09-1.37); tobacco use predicted depression (OR = 1.87, CI = 1.23-2.85); anxiety did not predict tobacco use (OR = 1.38, CI = 0.83-2.29); tobacco use predicted anxiety (OR = 1.88, CI = 1.47-2.41)	81%	Low number of studies especially for anxiety; only USA and Canada; different types of anxiety pooled together

Note: CES-D = Center for Epidemiology Depression Scale; CI = Confidence interval; DISC-IV = Diagnostic interview schedule for children, version IV; OR = Odds ratio; SIAS = Social interaction anxiety scale.

Psychosis>tobacco

Four studies examined the effect of psychosis on development of tobacco use by youth. None of these used a clinical sample, and three had more than two waves. Psychosis did not appear to have an effect on tobacco use, with two studies (50.0%) showing a positive effect (p = .250). None of these studies were high quality, and no reviews examined the psychosis-tobacco relationship.

DISCUSSION

The purpose of the current study was to review the reciprocal temporal relationships between youth tobacco consumption and a group of psychological disorder categories including depression, anxiety, bipolar, psychosis, and borderline personality disorder (BPD). This review was justified because existing reviews: 1) are several years old, 2) have biased samples, 3) only examine a narrow range of psychological disorders, and 4) lack a dedicated focus on youth.

Synthesising the cohort and review studies, we found evidence that tobacco consumption predicted the development of depression and anxiety for youth, but not bipolar or psychosis. Tobacco might cause depression through certain biological mechanisms (e.g., decreasing the cortisol response) and also by eliciting withdrawal symptoms of low mood [59]. However, it is also possible that this longitudinal relationship is not causal. For example, the relationship may become non-significant when certain confounders (e.g., familial and genetic factors) are controlled for, as was found by Ranjit et al. [60,61]. Tobacco use might cause anxiety because it elicits physiological symptoms for the young person similar to anxiety (e.g., shortness of breath, increased heart rate and blood pressure), which are then catastrophically

misinterpreted [45]. However, similar to depression, this relationship might be better explained by unmeasured confounders and may not be causal [54].

Our synthesis of findings suggests that tobacco may not predict psychosis, which was notable because numerous studies (n = 12) examined this relationship. Of the six studies that found a positive effect, only one of these was a high-quality study [68], though several other moderate quality studies also found a positive effect. Tobacco use may have failed to predict psychosis because other confounders play a true causal role in the young person's experience of psychosis (e.g., other substance use; Ward et al.) [67]. Alternatively, it has been hypothesised that nicotine could actually decrease negative psychotic symptoms, mediated by an increase in dopamine [70]. Our sign test showed an overall lack of effect of tobacco on bipolar, which contradicts past research that does propose a causal effect [72]. However, only two included studies examined the effect of tobacco on bipolar, indicating that more longitudinal research is needed on this topic.

A similar pattern of results was found when investigating reverse-causation. The presence of both depression and anxiety predicted future tobacco use, potentially because people who experience depression and anxiety may have a greater probability of using tobacco to self-medicate (i.e., to try to reduce adverse symptoms; Swendsen et al. [64]. However, as with the effect of tobacco on depression, these relationships may only exist until familial and genetic confounders are controlled for [60,61]. Presence of psychosis may have failed to predict tobacco use due to certain confounders (e.g., cannabis use) that better explain the variance in tobacco use [47], but the number of studies that examined this relationship was minimal (n = 4). Similarly, according to the sign test, presence of bipolar did not have an overall effect on tobacco use. However, only three studies examined this relationship, and one of these studies

was high quality and did find an effect. Hence, more longitudinal research is needed on this question.

There were several limitations to this review. Firstly, the included studies were very heterogeneous, particularly with regard to sample size, sample nature (i.e., clinical vs non-clinical), number and type of confounders, follow-up period, number of waves, and type of statistics used. Due to this heterogeneity, we were unable to meta-analyse the results. However, despite these constraints, we were still able to synthesise the quantitative data using vote counting based on effect direction, which is current best practice when meta-analysis is not possible, according to recent recommendations by Cochrane [18]. A second limitation was the way in which we classified psychological disorder categories. For example, under the category of 'anxiety', we grouped various disorders including panic, social anxiety, generalised anxiety, and agoraphobia. However, it is possible that young people's experiences of these disorders differ in how they relate to tobacco use. For example, tobacco might have a greater effect on panic compared to social anxiety because tobacco can cause impaired respiration which is more associated with panic symptoms than social anxiety symptoms [46]. As more research accumulates on tobacco and mental health, future reviews should distinguish between sub-types of psychological disorder categories.

Given the gap in the literature, future research should examine the reciprocal longitudinal relationship between tobacco use and BPD. Additionally, more studies should be conducted that investigate the relationship between tobacco, psychosis, and bipolar. Although there are numerous studies on tobacco and both depression and anxiety, future research should continue to examine confounders such as familial and genetic factors in order to strengthen causal inferences.

The mechanisms underlying smoking and mental illnesses are complex and yet to be thoroughly investigated and understood. In the meantime, tobacco use and the financial and health burdens of tobacco use are disproportionately high among people living with mental illness and addressing tobacco use remains a high priority.

CONCLUSION

We found support for reciprocal relationships between tobacco and both depression and anxiety for youth, though questions remain around whether these relationships are causal. In contrast, we did not find overall evidence for a causal relationship between tobacco and psychosis for this population, perhaps because nicotine has conflicting effects on the person's experience of psychosis. For the other relationships examined (tobacco>bipolar; bipolar tobacco; psychosis>tobacco), evidence was weak because of low numbers of studies. Further studies that examine the complexities of interactions between tobacco and mental health for different diagnostic groups are needed to inform prevention, early intervention, treatment and smoking cessation support for youth with comorbid psychological conditions and tobacco use.

Author statement: K-M, C-M and S-L conceived the study and the study design. K-M developed and executed the initial search strategy. L-M provided expert advice to and executed the updated search. J-S, S-L and C-M completed the search strategy and determined the final included studies. J-S prepared the draft of the review, S-L, C-M and L-M edited the draft review. S-L finalised the manuscript. All authors read and approved the final manuscript.

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Patient consent for publication: Not required.

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Provenance and peer review: Not commissioned; externally peer reviewed.

Data availability statement: All data relevant to this review are included in the article or uploaded as supplementary

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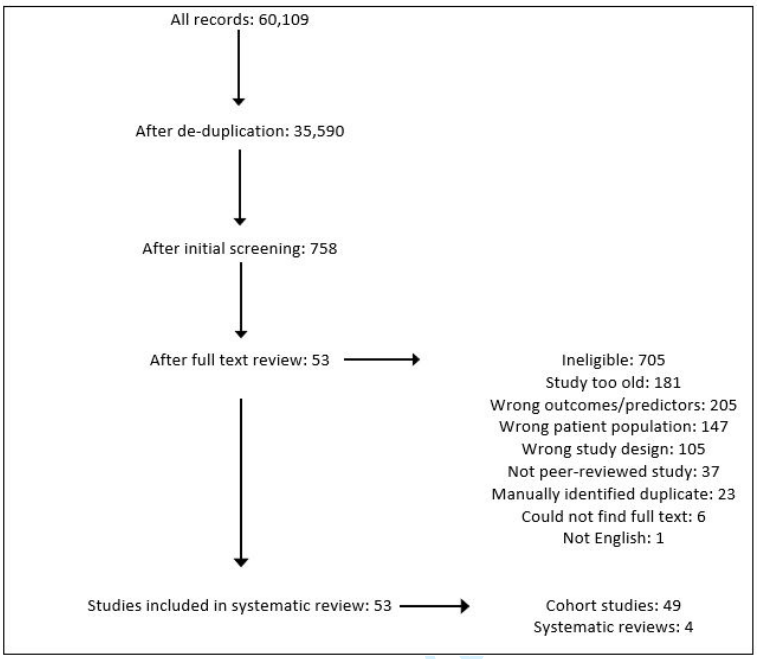

Figure 1: PRISMA flow diagram

Supplementary File: Search strategy for search #1 on 26th September 2019

PubMed:

Smoking	Mental Illness	Study type	Number of results
"tobacco smoking"[mh] OR "smoking"[mh] OR tobacco[tiab] OR cigarette*[tiab] OR smoking[tiab] OR smoker*[tiab]	("Anxiety Disorders"[mh] OR "Bipolar and Related Disorders"[mh] OR "Disruptive, Impulse Control, and Conduct Disorders"[mh] OR "Dissociative Disorders"[mh] OR "Feeding and Eating Disorders"[mh] OR "Mood Disorders"[mh] OR "Personality Disorders"[mh] OR "Schizophrenia Spectrum and Other Psychotic Disorders"[mh] OR "Substance-Related Disorders"[mh] OR "Trauma and Stressor Related Disorders"[mh]) OR (disorder[Title/Abstract] OR mental[Title/Abstract] OR schizophreni*[Title/Abstract] OR catatoni*[Title/Abstract] OR bipolar[Title/Abstract] OR psychosis[Title/Abstract] OR psychotic[Title/Abstract] OR depress*[Title/Abstract] OR Cyclothymi* [Title/Abstract] OR Dysphori*[Title/Abstract] OR "selective mutism"[Title/Abstract] OR Trichotillomania[Title/Abstract] OR dereali*[Title/Abstract] OR mood[Title/Abstract] OR anxi*[Title/Abstract] OR phobia[Title/Abstract] OR dysthymia[Title/Abstract] OR manic[Title/Abstract] OR mania[Title/Abstract] OR dissociat*[Title/Abstract] OR depersonali*[Title/Abstract] OR pica[Title/Abstract] OR anorexia[Title/Abstract] OR bulimia[Title/Abstract] OR binge eating[Title/Abstract] OR substance[Title/Abstract] OR posttraumatic[Title/Abstract] OR post-traumatic[Title/Abstract])	"longitudinal"[tiab] OR "follow up"[tiab] OR "follow-up"[tiab] OR "cohort"[tiab]	9089

Embase:

Smoking	Mental Illness	Study type	filters	Number of results
"tobacco use"/exp OR tobacco:ti,ab OR cigarette*:ti,ab OR smoking:ti,ab OR smoker*:ti,ab	("anxiety disorder"/exp OR "mood disorder"/exp OR "behaviour disorder"/exp OR "dissociative disorder"/exp OR "personality disorder"/exp OR "Psychosis"/exp OR "drug dependence"/exp OR Adjustment disorder/de OR Neurosis/exp (includes dysthymia) OR Psychotrauma/de) OR (disorder:ti,ab OR mental:ti,ab OR schizophreni*:ti,ab OR catatoni*:ti,ab OR bipolar:ti,ab OR psychosis:ti,ab OR psychotic:ti,ab OR depress*:ti,ab OR Cyclothymi* :ti,ab OR Dysphori*:ti,ab OR "selective mutism":ti,ab OR Trichotillomania:ti,ab OR dereali*:ti,ab OR mood:ti,ab OR anxi*:ti,ab OR phobia:ti,ab OR dysthymia:ti,ab OR manic:ti,ab OR mania:ti,ab OR dissociat*:ti,ab OR depersonali*:ti,ab OR pica:ti,ab OR anorexia:ti,ab OR bulimia:ti,ab OR binge eating:ti,ab OR substance:ti,ab OR posttraumatic:ti,ab OR post-traumatic:ti,ab)	"longitudinal":ti,ab OR "follow up":ti,ab OR "cohort":ti,ab	AND [english]/lim AND [embase]/lim	2306

Pubmed mesh term	Emtree term
anxiety disorders	"anxiety disorder"/exp
Bipolar and Related Disorders	"mood disorder"/exp
Disruptive, Impulse Control, and Conduct Disorders	"behaviour disorder"/exp
Dissociative Disorders	"dissociative disorder"/exp
Feeding and Eating Disorders	"behaviour disorder"/exp
Mood Disorders	"mood disorder"/exp
Personality Disorders	"personality disorder"/exp
Schizophrenia Spectrum and Other Psychotic Disorders	"Psychosis"/exp
Substance-Related Disorders	"drug dependence"/exp
Trauma and Stressor Related Disorders	"anxiety disorder"/exp
	Adjustment disorder/de Neurosis/exp (includes dysthymia) Psychotrauma/de

PsycINFO:

Smoking	Mental Illness	Study type	filters	Number of citations
(exp tobacco smoking"OR tobacco.ti,ab OR cigarette$.ti,ab OR smoking.ti,ab OR smoker$.ti,ab)	(exp Anxiety Disorders OR exp Bipolar Disorder OR exp Disruptive Behavior Disorders OR exp Attention Deficit Disorder OR exp Dissociative Disorders OR exp Eating Disorders OR exp Affective Disorders OR exp Personality Disorders OR exp Psychosis OR exp Substance Related and Addictive Disorders OR exp Stress and Trauma Related Disorders) OR (disorder.ti,ab OR mental.ti,ab OR schizophreni$.ti,ab OR catatoni$.ti,ab OR bipolar.ti,ab OR psychosis.ti,ab OR psychotic.ti,ab OR depress$.ti,ab OR Cyclothymi$ .ti,ab OR Dysphori$.ti,ab OR selective mutism.ti,ab OR Trichotillomania.ti,ab OR dereali$.ti,ab OR mood.ti,ab OR anxi$.ti,ab OR phobia.ti,ab OR dysthymia.ti,ab OR manic.ti,ab OR mania.ti,ab OR dissociat$.ti,ab OR depersonali$.ti,ab OR pica.ti,ab OR anorexia.ti,ab OR bulimia.ti,ab OR binge eating.ti,ab OR substance.ti,ab OR posttraumatic.ti,ab OR post-traumatic.ti,ab)	(longitudinal.ti,ab OR Follow up.ti,ab OR cohort.ti,ab)	engs[1]	3648

Thesaurus terms:

Pubmed mesh term	Psyc Info thesaurus term
anxiety disorders	exp Anxiety Disorders
Bipolar and Related Disorders	exp Bipolar Disorder
Disruptive, Impulse Control, and Conduct Disorders	exp Disruptive Behavior Disorders; Attention Deficit Disorder
Dissociative Disorders	exp Dissociative Disorders
Feeding and Eating Disorders	exp Eating Disorders
Mood Disorders	exp Affective Disorders
Personality Disorders	exp Personality Disorders
Schizophrenia Spectrum and Other Psychotic Disorders	exp Psychosis
Substance-Related Disorders	exp Substance Related and Addictive Disorders
Trauma and Stressor Related Disorders	exp Stress and Trauma Related Disorders

Scopus:

Smoking	Mental Illness	Study type	Number of results
tobacco OR cigarette* OR smoking OR smoker* Select 'article title, abstract, keyworks	disorder OR mental OR schizophreni* OR catatoni* OR bipolar OR psychosis OR psychotic OR depress* OR Cyclothymi* OR Dysphori* OR { mutism} OR Trichotillomania OR dereali* OR mood OR anxi* OR phobia OR dysthymia OR manic OR mania OR dissociat* OR depersonali* OR pica OR anorexia OR bulimia OR binge eating OR substance OR posttraumatic OR post-traumatic Select 'article title, abstract, keyworks	longitudinal OR "follow up" OR cohort Select 'article title, abstract, keyworks	17,532

CINAHL:

Smoking	Mental Illness	Study type	Number of results
MH tobacco smoking+ OR TI tobacco OR AB tobacco OR TI cigarette* OR AB cigarette* OR TI smoking OR AB smoking OR TI smoker* OR AB smoker* OR MH smoking+	MH Anxiety Disorders+ OR MH Bipolar Disorder+ OR MH Impulse control disorders+ OR MH Social behaviour disorders+ OR MH Mental Disorders Diagnosed in Childhood+ OR MH Dissociative Disorders+ OR MH Eating Disorders+ OR MH Affective Disorders+ OR MH Personality Disorders+ OR MH Psychotic Disorders+ OR MH Substance Use Disorders+ OR MH Stress Disorders, Post-Traumatic+ OR TI disorder OR AB disorder OR TI mental OR AB mental OR TI schizophreni* OR AB schizophreni* OR TI catatoni* OR AB catatoni* OR TI bipolar OR AB bipolar OR TI psychosis OR AB psychosis OR TI psychotic OR AB psychotic OR TI depress* OR AB depress* OR TI Cyclothymi* OR AB Cyclothymi* OR TI Dysphori* OR AB Dysphori* OR TI selective mutism OR AB selective mutism OR TI Trichotillomania OR AB Trichotillomania OR TI dereali* OR AB dereali* OR TI mood OR AB mood OR TI anxi* OR AB anxi* OR TI phobia OR AB phobia OR TI dysthymia OR AB dysthymia OR TI manic OR AB manic OR TI mania OR AB mania OR TI dissociat* OR AB dissociat* OR TI depersonali* OR AB depersonali* OR TI pica OR AB pica OR TI anorexia OR AB anorexia OR TI bulimia OR AB bulimia OR TI binge eating OR AB binge eating OR TI substance OR AB substance OR TI posttraumatic OR AB posttraumatic OR TI post-traumatic OR AB post-traumatic	TI longitudinal OR AB longitudinal OR TI follow up OR AB follow up OR TI follow-up OR AB follow-up OR TI cohort OR AB cohort	11,037

Pubmed mesh term	Cinahl subject heading
anxiety disorders	Anxiety Disorders+
Bipolar and Related Disorders	Bipolar Disorder+
Disruptive, Impulse Control, and Conduct Disorders	Impulse control disorders+ Social behaviour disorders+ Mental Disorders Diagnosed in Childhood+
Dissociative Disorders	Dissociative Disorders+
Feeding and Eating Disorders	Eating Disorders+
Mood Disorders	Affective Disorders+
Personality Disorders	Personality Disorders+
Schizophrenia Spectrum and Other Psychotic Disorders	Psychotic Disorders+
Substance-Related Disorders	Substance Use Disorders+
Trauma and Stressor Related Disorders	Stress Disorders, Post-Traumatic+

Overview of results for search #2 on 11th May 2021

Database	Result	Date
Pubmed	**1607**	**11/05/2021**
CINAHL	**1555**	**11/05/2021**
Embase	**Not available to Flinders Library but 100% of Embase content is available within Scopus and therefore included in this search**	
SCOPUS	**758**	**11/05/2021**
Psycinfo	**483**	**11/05/2021**
TOTAL	**4403**	
Deduplicate TOTAL	**3132**	

Table S1 – Quality appraisal scores for cohort studies (n = 49)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score %
Ajdacic-Gross et al. (2009)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	U	Y	63.6
Ames et al. (2018)	U	Y	Y	Y	Y	N	Y	Y	Y	U	Y	72.7
Berk et al. (2010)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Bierhoff et al. (2019)	N/A	N/A	Y	N	N	N	Y	Y	N	N	Y	36.4
Borges et al. (2018)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Buchy et al. (2014)	Y	Y	Y	U	U	Y	Y	Y	U	U	Y	63.6
Buchy et al. (2015)	N	Y	Y	Y	U	N	Y	Y	N	U	Y	54.5
Bulhões et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Chen et al. (2017)	N/A	N/A	Y	N	N	N	Y	Y	Y	U	Y	45.5
Crane et al. (2021)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Davies et al. (2018)	Y	Y	Y	Y	Y	N	Y	Y	N	U	Y	72.7
Ferdinand et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Fonseca et al. (2021)	N/A	N/A	Y	Y	N	Y	Y	Y	N	N	Y	54.5
Gage et al. (2014)	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y	72.7
Gårdvik et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Goodwin et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Goodwin et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	N	N	Y	54.5
Griesler et al. (2008)	U	Y	Y	Y	Y	N	Y	Y	Y	N	Y	72.7
Griesler et al. (2011)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Hu et al. (2012)	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	81.8
Hui et al. (2013)	N/A	N/A	Y	U	N	Y	Y	Y	Y	Y	Y	63.6

Isensee et al. (2003)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Johnson et al. (2000)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Jones et al. (2018)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	U	Y	63.6
Kalan et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	N	N	Y	54.5
Kendler et al. (2015)	N/A	N/A	Y	Y	Y	N	U	Y	N	U	Y	45.5
King et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
MacKie et al. (2011)	Y	Y	Y	U	U	N	Y	Y	N	U	Y	54.5
Marmorstein et al. (2010)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	N	Y	63.6
Marsden et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Moylan et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Mustonen et al. (2018)	N	Y	Y	Y	Y	N	U	Y	Y	Y	Y	72.7
Okeke et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Pedersen et al. (2009)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Purborini et al. (2021)	N/A	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	81.8
Raffetti et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Ranjit et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Ranjit et al. (2019b*)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Savageet al. (2016)	N/A	N/A	Y	U	N	N	Y	Y	Y	U	Y	45.5
Shete et al. (2017)	N	Y	U	U	N	N	Y	Y	N	U	Y	36.4
Smith et al. (2014)	U	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	81.8
Swendsen et al. (2010)	N/A	N/A	Y	Y	Y	U	Y	Y	Y	Y	Y	72.7
Tomita et al. (2018)	U	Y	U	Y	Y	Y	Y	Y	N	U	Y	63.6
Trotta et al. (2020)	N/A	N/A	Y	Y	Y	N	U	Y	Y	Y	Y	63.6
Ward et al. (2019)	U	Y	Y	Y	Y	Y	Y	Y	N	U	Y	72.7

Weiser et al. (2004)	N/A	N/A	Y	Y	Y	Y	U	Y	Y	Y	Y	72.7
Wilens et al. (2016)	N	Y	Y	Y	Y	N	Y	Y	N	U	Y	63.6
Zammit et al. (2003)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	Y	81.8
Zhang et al. (2018)	N	Y	Y	Y	Y	N	Y	Y	Y	U	Y	72.7
Total %	8.2	32.7	95.9	85.7	81.6	14.3	89.8	100.0	59.2	44.9	100.0	-

Note: *Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.
Y = Yes; N = No; U = Unclear; N/A = Not applicable. Q1 = Were the two groups similar and recruited from the same population?; Q2 = Were the exposures measured similarly to assign people to both exposed and unexposed groups?; Q3 = Was the exposure measured in a valid and reliable way?; Q4 = Were confounding factors identified?; Q5 = Were strategies to deal with confounding factors stated?; Q6 = Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?; Q7 = Were the outcomes measured in a valid and reliable way?; Q8 = Was the follow up time reported and sufficient to be long enough for outcomes to occur?; Q9 = Was follow up complete, and if not, were the reasons to loss to follow up described and explored?; Q10 = Were strategies to address incomplete follow up utilized?; Q11 = Was appropriate statistical analysis used?

Table S2 – Quality appraisal scores for systematic reviews (n = 4)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score %
Ahun et al. (2020)	Y	Y	Y	Y	Y	U	U	Y	U	Y	Y	72.7
Cairns et al. (2014)	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	90.9
Chaiton et al. (2009)	Y	Y	Y	Y	Y	U	U	Y	Y	Y	Y	81.8
Esmaeelzadeh et al. (2018)	Y	Y	Y	Y	Y	U	U	Y	Y	Y	Y	81.8
Total %	100.0	100.0	100.0	100.0	100.0	0.0	25.0	100.0	75.0	100.0	100.0	-

Y = Yes; N = No; U = Unclear; N/A = Not applicable. Q1 = Is the review question clearly and explicitly stated?; Q2 = Were the inclusion criteria appropriate for the review question?; Q3 = Was the search strategy appropriate?; Q4 = Were the sources and resources used to search for studies adequate?; Q5 = Were the criteria for appraising studies appropriate?; Q6 = Was critical appraisal conducted by two or more reviewers independently?; Q7 = Were there methods to minimize errors in data extraction?; Q8 = Were the methods used to combine studies appropriate?; Q9 = Was the likelihood of publication bias assessed?; Q10 = Were recommendations for policy and/or practice supported by the reported data?; Q11 = Were the specific directives for new research appropriate?

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Investigating the reciprocal temporal relationships between tobacco consumption and psychological disorders for youth: an international review

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Title: Investigating the reciprocal temporal relationships between tobacco consumption and psychological disorders for youth: an international review

Jeremy Stevenson[1], Caroline L Miller[2,3], Kimberley Martin[3], Leila Mohammadi[1], Sharon Lawn[1]

[1]Flinders University, College of Medicine and Public Health, Adelaide, Australia

[2]Health Policy Centre, South Australian Health and Medical Research Institute, Adelaide, Australia

[3]University of Adelaide, School of Public Health, Adelaide, Australia

Corresponding Author: Professor Sharon Lawn, Flinders University, Room 2.11, Health Sciences Building, GPO Box 2100, Adelaide, 5001, South Australia, Australia

Email: sharon.lawn@flinders.edu.au

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Keywords: depression, anxiety, bipolar, psychosis, longitudinal, review, youth.

ABSTRACT

Objective: To investigate reciprocal temporal relationships between tobacco consumption and psychological disorders for youth.

Design: Review

Data sources: Five databases (PubMed, Embase, Scopus, CINAHL, PsycINFO) on 26th September 2019 and updated on 11th May 2021, indexing tobacco, mental illness, and longitudinal.

Study selection: Methods used consensus and multiple reviewers.

Interventions: Cohort studies (n=49) examining tobacco and selected psychological disorders (depression, anxiety, bipolar, psychosis, borderline personality disorder) among youth, and systematic reviews (n=4) of these relationships met inclusion criteria.

Primary and secondary outcome measures: Effect of tobacco on psychological disorders and effect of psychological disorders on tobacco.

Data extraction and synthesis: Independent extraction by the first author and checked by final author. Joanna Briggs Institute Critical Appraisal Tools were used for all studies. Included studies had moderate-to-high appraisal scores. We synthesized findings using vote counting for effect direction and descriptive data.

Results: Fifty-three studies were included in the review. Thirteen of 15 studies showed a positive effect direction of tobacco on depression ($p < .001$). Six of 12 studies showed a positive effect direction of depression on tobacco ($p = .016$). Six of eight studies showed a positive effect direction of tobacco on anxiety ($p = .016$). Eleven of 18 studies showed a positive effect direction of anxiety on tobacco ($p = .003$). No effect between tobacco and bipolar, or tobacco and psychosis was found. No studies examined tobacco and borderline personality disorder.

Conclusions: Reciprocal relationships existed between tobacco and both depression and anxiety for youth, though causality is unconfirmed. No positive effect direction was found between tobacco and psychosis, perhaps because nicotine has conflicting effects on psychosis. For other relationships examined, evidence was weak because of low numbers of studies. More research to inform prevention and early intervention is needed.

PROSPERO Registration Number: CRD42020150457.

ARTICLE SUMMARY

Strengths and limitations of this study

- This review has synthesised, in-depth, 53 studies for evidence of the reciprocal temporal relationships between tobacco consumption and psychological disorders for youth.
- The review has performed an analysis of the quality of the studies and identified knowledge gaps and methodological concerns that require further research.
- The included studies were very heterogeneous, preventing meta-analysis of the results.
- Psychological disorders were classified into broad categories; however, it is possible that young people's experiences of these disorders differ in how they relate to tobacco use.

INTRODUCTION

Tobacco consumption is associated with a myriad of economic, social, and health problems for young people [1]. One of the health problems associated with tobacco consumption is psychological disorders, and their co-occurrence can dramatically worsen the overall clinical course, physical health and psychosocial outcomes for the person [2-4]. Nicotine dependence per se is a psychological disorder with comorbid conditions being common. Tobacco contributes substantially to the reduced life expectancy observed among people who experience mental health disorders. Furthermore, people living with mental illness have shorter life expectancy than those without, and this is largely attributable to smoking-related illnesses [5, 6]. Youth (10-24 years of age) with psychological disorders are overrepresented among those who consume tobacco [7]. However, it is unclear if the relationship between tobacco and psychological disorders is causal or merely associational. If the relationship is indeed causal, the direction of this relationship is poorly understood [8]. Furthermore, it is unclear whether the 'tobacco-psychopathology' relationship is different depending on the specific type of psychological disorder experienced by the young person (e.g., perhaps tobacco use causes depression but not anxiety).

Several reviews have attempted to evaluate the relationship between tobacco and psychopathology [9-12], but these have several limitations including: 1) a lack of focus on youth; 2) the sample is mostly or entirely from North America, 3) only a small number of psychological disorders are examined; and 4) the existing studies and reviews are now quite dated. Given these limitations, we sought to produce an updated review that focuses specifically on youth and samples from a broader international population. Furthermore, we included more psychological disorders to facilitate comparison: anxiety, depression, bipolar disorder, psychosis, and borderline personality disorder. We chose these psychological

disorder categories because they affect a substantial percentage of youth [13]. The broad objective of our review was to examine the reciprocal temporal relationship between tobacco consumption and the selected psychological disorders for youth.

METHODS

Eligibility criteria

The inclusion criteria were studies with: 1) a focus on adolescents and youth 10-24 years of age; 2) systematic review of observational longitudinal studies OR observational longitudinal studies conducted since most recent systematic review OR all longitudinal studies if there is no relevant systematic review for the specific disorder; 3) measured tobacco consumption in any form (e.g., smoking, smokeless, snus), 4) measured psychological disorder categories of at least one of anxiety, depression, bipolar, psychosis, or borderline personality disorder; 5) English language; and 6) published in a peer-reviewed journal. Under the anxiety category, we included various types including social anxiety, panic, agoraphobia, and generalised anxiety. Under the bipolar category we included mania as this symptom is mostly associated with bipolar. Under the psychosis category we included schizophrenia and general psychotic symptoms. We included 'nicotine dependence' as a measure of tobacco consumption because these constructs are strongly related [14, 15]. Studies were excluded if the methods used meant that tobacco consumption could not be distinguished from other drug use (e.g., cannabis) and if the population was very specific (e.g., pregnant women). Our search strategy was based on advice from an expert University-based librarian and was also informed by previous systematic reviews identified during the early formulation of the current study [10,11].

Search strategy and study selection

The original search was conducted by KM using PubMed, Embase, Scopus, CINAHL and PsycINFO on 26th September 2019 and updated by LM on 11th May 2021. Initial searches were very broad and focused on keyword categories of tobacco and psychological disorders (for more information see supplementary materials). The screening and review process were managed within COVIDENCE software. After the initial search and de-duplication, JS and SL shared the initial screening and full-text reviews. JS and SL then discussed any conflicts in order to reach consensus about inclusion or exclusion. Where consensus could not be reached or the decision remained uncertain, final eligibility was resolved by CM.

For the updated search SL and JS each screened all new titles/abstracts with CM resolving conflicts, then SL did all full-text reviews, with JS checking 20% of excluded studies – agreement was 100%.

[Figure 1: PRISMA flow diagram]

Quality assessment, data extraction and data synthesis

To assess the quality of the included studies, we used the Joanna Briggs Institute (JBI) Critical Appraisal Tools for cohort studies and systematic reviews [16]. JS appraised all studies while SL appraised a random sample of 20%. Data extraction was conducted by JS and checked by SL in order to produce three tables: 1) Table S1 for descriptive information about the cohort studies, 2) Table 1 for vote counting of the direction of effects for cohort studies, and 3) Table 2 for descriptive information about the systematic reviews. For the 'results' column of Table S1, we extracted the most adjusted results in order to reduce the risk of confounding.[17] We did vote counting for effect direction (Table 1; counting the number of studies with positive vs negative effect direction) based on recent recommendations by Cochrane on conducting synthesis without meta-analysis [18]. To use this approach, we combined similar predictors (e.g., nicotine dependence, cigarette smoking,

and other tobacco use combined into 'tobacco') and outcomes (e.g., social anxiety, panic, and agoraphobia combined into 'anxiety') and classified effect direction as one of the following: 1) a positive/negative effect direction if at least 70% of findings showed consistency in this direction, 2) a conflicting effect if consistency was less than 70%, or 3) an 'unclear' effect if direction was not reported (for a similar method, see Thompson et al. [19]). For data synthesis, we evaluated each relationship individually (e.g., tobacco>depression; depression>tobacco; tobacco>anxiety etc; where the '>' symbol refers to the direction of the relationship). In this synthesis, we attempted to integrate all information from both the cohort and review studies (e.g., descriptive information and vote counting).

RESULTS

Publication dates of included studies

We found four systematic reviews for depression and tobacco in youth [9-11,20]. The most recent of these reviews [20] included studies up to November 1st 2018. So, in order to be comprehensive, we also collected depression cohort studies from 2018 onwards. We found two systematic reviews for anxiety and tobacco in youth; but, given the low sample size of anxiety studies in these reviews [11,20], we included anxiety cohort studies from any period. We did not find any systematic reviews for bipolar, psychosis, or borderline personality and tobacco in youth, so no publication date inclusion constraints were applied to studies involving youth who experience these disorder categories.

Quality appraisal

As per the PRISMA flow diagram (Figure 1) [21], our search identified 49 cohort studies and four systematic reviews, giving a total of 53 included studies. For the quality appraisal of included studies, we converted scores on the JBI into percentages in order to facilitate

interpretation. Higher percentage scores indicated higher quality studies, while a score ≤ 50% reflects low quality. For the cohort studies, there was a relatively low level of agreement between the authors (66.2%), whereas the systematic reviews had comparatively high agreement (84.1%). The main issues contributing to disagreement were different interpretations of the JBI criteria, particularly for cohort questions one, four, five, and six, as well as systematic review question four. These differences were resolved through discussion.

Overall, the included studies had moderate-to-high appraisal scores. The quality appraisal of included cohort studies (n = 49) is displayed in Table S1 and in more detail in Supplementary Table S2. Five of the cohort studies were classified as low quality, with the lowest score being 36.4% [22, 23]. The remaining appraisal scores ranged from 45.5% to 81.8%, with four studies scoring above 75% (i.e., high quality). In terms of common strengths, all studies utilized a sufficient follow-up time (Q8) and appeared to use appropriate statistical analysis (Q11). More than 89% of studies measured the exposures and outcomes in a valid and reliable way (Q3 and Q7). Most studies addressed confounders appropriately (Q4 and Q5). In terms of common weaknesses, only 14.3% of studies had samples that were free of the outcome at first assessment (e.g., below cut-off on a depression scale; Q6). Only a small minority of studies divided the sample into groups based on tobacco or psychological symptoms in order to make baseline comparisons, and thus the studies scored very low on Q1 and Q2. Few studies (44.9%) clearly explained strategies to address incomplete follow-up (Q10). These limitations should be considered when interpreting the review findings.

The quality appraisal of included review studies (n = 4) is displayed in Table 3 and Supplementary Table S2. Three reviews were appraised as high quality with percentage scores above 80%. In terms of strengths, all reviews met eight of the eleven criteria,

including: stating the review question clearly and explicitly (Q1), selecting appropriate inclusion criteria (Q2), utilizing a comprehensive search strategy (Q3 and Q4), using appropriate criteria to appraise studies (Q5), using appropriate methods to combine studies (Q8), and making evidence-based recommendations for policy/practice (Q10) as well as future research directions (Q11). In terms of weaknesses, no reviews clearly stated that critical appraisal was conducted by at least two reviewers independently (Q6), and only one review clearly outlined methods to minimize errors in data extraction (Q7) [9].

Overview of included cohort studies

As per Table S1, the vast majority of the 49 cohort studies were either from North America (n = 20, with 18 from USA) or Europe (n = 21). Most studies used a non-clinical youth sample (n = 40), with the remaining nine using a clinical sample (youth in receipt of clinical mental health services) or a pseudo-clinical sample (e.g., youth with elevated anxiety sensitivity). Sample sizes ranged widely from 117 to 233,879 (M = 8162.53, Mdn = 14,000, SD = 33738.60). Youth age at baseline ranged from 6.2 to 23.5 (M = 16.09, SD = 3.59). Follow-up periods with youth participants ranged from 1 to 27-years (M = 6.43, SD = 5.15). Of the 46 studies that provided this longitudinal follow-up information, the number of waves ranged from 2 to 15 (M = 3.93, SD = 2.40). In terms of the types of tobacco measures used, numerous studies used a binary measure (n = 25; e.g., cigarette user vs non-user, nicotine user vs non user), while others used a categorical (ordinal) measure (n = 22; e.g., non vs moderate vs heavy smoker), while only five studies used a continuous measure. Nine studies used 'nicotine dependence' as the tobacco-related measure, while five used 'onset' (e.g., age of smoking onset), and four studies also included consumption of tobacco more broadly than cigarettes (e.g., cigarillos, snus, smokeless tobacco). Twelve studies used multiple measures of tobacco use. Only one study examined smoking-cessation as the tobacco-related variable. Most studies (n = 30) used structured interviews with youth (e.g., WHM-CIDI, PLIKSi) to assess the relevant psychological variable (e.g., anxiety), and a moderate number of studies (n = 19) used self-report measures (e.g., PHQ-9, CESD). Only four studies used caregiver-report (teacher or parent) and one study used peer-report. As shown in Table S1, there were zero relevant studies found for BPD. The number of covariates included in analyses ranged from 1 to 19 (M = 6.69, SD = 4.05). Common covariates included gender, age, SES, and other drug use (e.g., cannabis and alcohol). Common limitations of the cohort studies included: only

using two-waves, small sample sizes, not controlling for earlier levels of outcome or later levels of predictor, small cell sizes, and unclear temporal ordering.

Overview of included systematic reviews

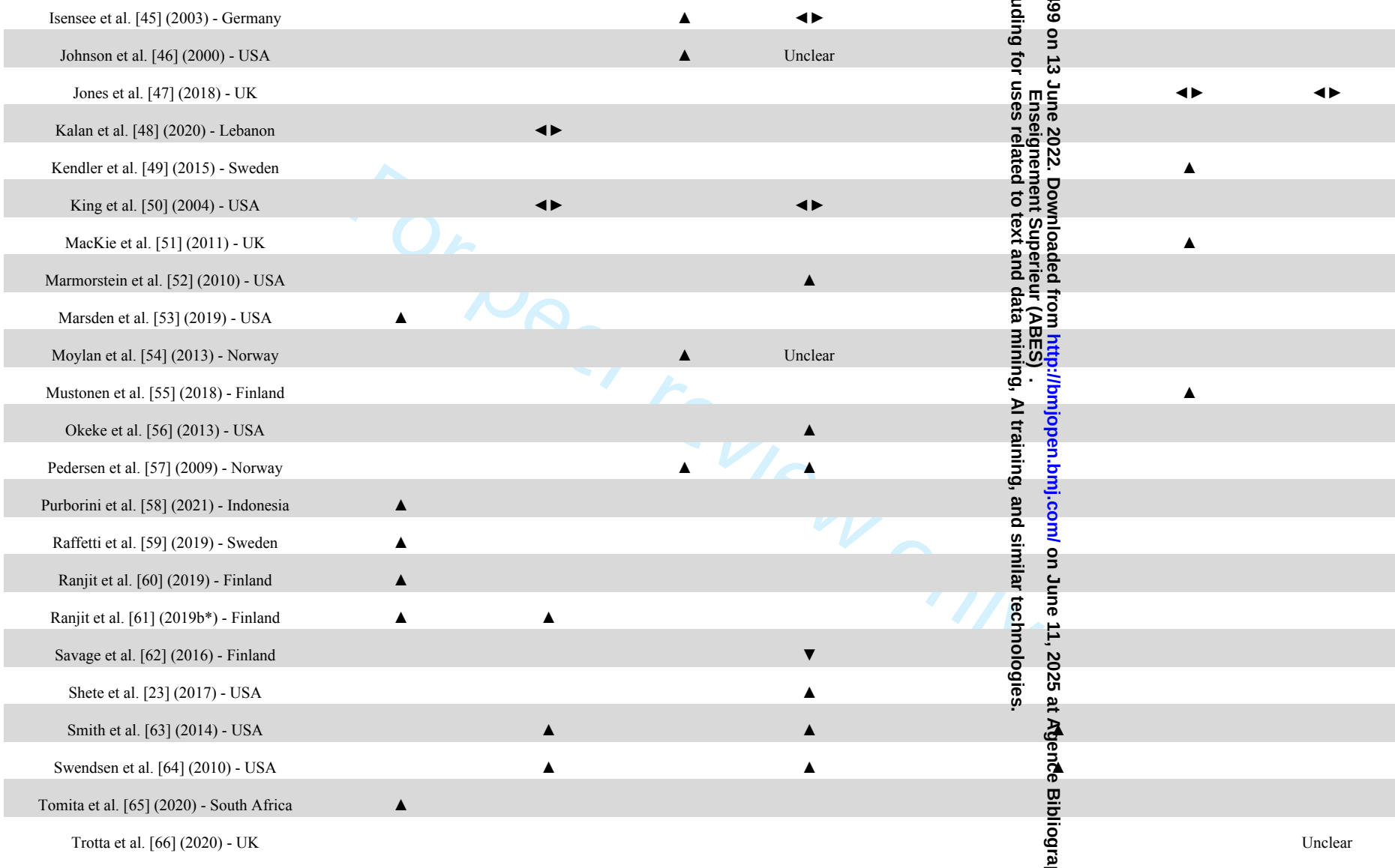
As per Table 3, one of the four systematic reviews only focused on youth from the USA and Canada [11], while the other three did not have geographical constraints. Cairns et al. [9] and Chaiton et al. [10] specified a target population age range, while Esmaeelzadeh et al. [11] and Ahun et al. [20] broadly referred to 'youth'. All reviews examined a variety of tobacco and psychological measures, and all four examined the relationship between tobacco and depression; whereas, only Esmaeelzadeh et al. [11] and Ahun et al. [20] also examined the relationship between tobacco and anxiety. None of the other psychological disorder categories were evaluated. Two of the reviews were limited by small sample sizes for anxiety analyses [11,20].

Tobacco>depression

Fifteen cohort studies examined the effect of tobacco use on the development of depression in youth, including only one with a clinical sample and eight with more than two waves. As shown in Table 2, there was evidence that tobacco had an effect on depression, with 13 of 15 studies (86.7%) showing a positive effect direction ($p < .001$). Only one of these studies was high quality (quality appraisal score > 75%), and this study found a positive effect direction. Effect estimates for each cohort study are shown in Table 2. Additionally, three of the four systematic reviews examined the effect of tobacco on depression and found a positive and significant pooled estimate, as shown in Table 3.

Table 1 - Vote counting of the direction of effects for cohort studies

Authors (year) - country	Tobacco>depression	Depression>tobacco	Tobacco>anxiety	Anxiety>tobacco	Tobacco>bipolar	Bipolar>tobacco	Tobacco>psychosis	Psychosis>tobacco
Ajdacic-Gross et al. [24] (2009) - Switzerland					◄►			
Ames et al. [25] (2018) - Canada	▲							
Berk et al. [26] (2010) - Australia							▼	
Bierhoff et al. [27] (2019) - USA		◄►		▲				
Borges et al. [28] (2018) - Mexico	▲	▲		▲				
Buchy et al. [29] (2014) - USA and Canada							▼	
Buchy et al. [30] (2015) - USA and Canada							Unclear	
Bulhões et al. [31] (2020) - Portugal	▲							
Chen et al. [32] (2017) - USA	▲		▲					
Crane et al. [33] (2021) - USA		Unclear						
Davies et al. [34] (2018) - UK		▲						▲
Ferdinand et al. [35] (2004) - Netherlands								▲
Fonseca et al. [36] (2021) - Brazil	▲							
Gage et al. [37] (2014) - UK							▲	
Gårdvik et al. [38] (2020) - Norway	▼		▲					
Goodwin et al. [39] (2004) - New Zealand				▲				
Goodwin et al. [40] (2013) - Germany		◄►		◄►		▲		
Griesler et al. [41] (2008) - USA	◄►	▲	◄►	◄►				
Griesler et al. [42] (2011) - USA	▲	◄►	◄►	▲				
Hu et al. [43] (2012) - USA				▲				
Hui et al. [44] (2013) - China							▲	



Ward et al. [67] (2019) - USA and Canada			◄►
Weiser et al. [68] (2004) - Israel			▲
Wilens et al. [69] (2016) - USA		▲	
Zammit et al. [70] (2003) - Sweden			▼
Zhang et al. [71] (2018) - Germany	▲		

Note. ▲ = positive effect direction; ▼ = negative effect direction; ◄► = conflicting effect directions; unclear = unclear effect direction.
*Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.

Depression>tobacco

Twelve cohort studies examined the effect of depression on development of tobacco use by youth. None of these studies used clinical samples, and seven had more than two waves. There was evidence that depression had an effect on tobacco use, with six of the twelve studies (50.0%) showing a positive effect direction (p = .016). One of these studies was high quality, and this study showed a positive effect direction. All of the systematic reviews examined the effect of depression on tobacco and the three reviews that reported a pooled estimate found a significant positive effect direction. The fourth review reported individual study results and found that 85.7% of the included depression>tobacco studies had a significant positive effect direction.

Tobacco>anxiety

Eight studies examined the effect of tobacco use on development of anxiety in youth. One of these had a clinical sample, and six had more than two waves. Tobacco appeared to have an effect on anxiety, with six of eight studies (75.0%) showing a positive effect direction (p = .016). None of these studies were high quality. One systematic review examined the effect of tobacco on anxiety and found a positive and significant effect, but this effect was based on only one study.

Anxiety>tobacco

Eighteen studies examined the effect of anxiety on development tobacco use by youth. None of these used a clinical sample, and 11 had more than two waves. Anxiety appeared to have an effect on tobacco use, with 11 of 18 studies (61.1%) showing a positive effect direction (p = .003). Two of these studies were high quality, and both showed a positive effect direction. Two systematic reviews examined the effect of anxiety on tobacco use. One of these found a

positive non-significant effect, while the other found a non-significant effect and did not report the effect direction. However, both reviews only included one anxiety>tobacco study and thus were extremely underpowered.

Tobacco>bipolar

Two studies examined the effect of tobacco use on development of bipolar in youth. Both of these studies used clinical samples and had more than two waves. Tobacco did not appear to have an effect on bipolar, with just one study (50%) showing a positive effect direction (p = .500). Neither of these studies was high quality. No reviews examined the tobacco-bipolar relationship.

Bipolar>tobacco

Three studies examined the effect of bipolar on development of tobacco use by youth. None of these used a clinical sample, and one had more than two waves. Bipolar did not appear to have an effect on tobacco use, with two studies (66.7%) showing a positive effect direction (p = .250). One of the three studies was high quality, and this study showed a positive effect direction. No reviews examined the bipolar-tobacco relationship.

Tobacco>psychosis

Twelve studies examined the effect of tobacco use on development of psychosis in youth. Seven of these used a clinical or pseudo-clinical sample, and seven had more than two waves. Tobacco use did not appear to have an effect on psychosis, with only six studies (50%) showing a positive effect direction (p = .254). Only one of the twelve studies was high quality, and this study showed a negative effect direction. No reviews examined the tobacco-psychosis relationship.

Table 2 – Descriptive information about systematic reviews (n = 4)

Authors (year)	Target population and study designs (n)	Tobacco measure/s	Psychological measure/s	Relationship/s examined (n)	Result	Quality score %	Limitations
Ahun et al. [20] (2020)	Youth (n = 43)	Cigarette smoking	Unclear	Depression>tobacco (N = 7); anxiety>tobacco (N = 1)	Six of the depression studies had a significant association with cigarette smoking, while the one anxiety study did not		No statistics reported, only significance of association; only one anxiety study examined;
Cairns et al. [9] (2014)	Youth aged 12-18 (n = 17)	Any form	Unclear	Tobacco/depression	Tobacco associated with increased depression with small effect size (r = .09, CI = 0.06-0.12)		Directionality unclear
Chaiton et al. [10] (2009)	Non-clinical youth aged 13-19 (n = 15)	Mostly 'smoking onset' operationalised as ever having had a 'puff' or 'one cigarette'	Various but mostly CES-D	Tobacco>depression (n = 6); depression>tobacco (n = 12)	Smoking predicted depression (PE = 1.73, CI = 1.32-2.40); depression predicted smoking (PE = 1.41, CI = 1.21-1.63)		Low number of tobacco>depression studies
Esmaeelzadeh et al. [11] (2018)	Youth from USA and Canada (N = 17)	Various (e.g., ever smoked; current smoker; regular smoker)	Various for depression but mostly CES-D; various for anxiety (e.g., SIAS, DISC-IV)	Depression>tobacco (n = 7); tobacco>depression (n = 4); anxiety>tobacco (n = 1); tobacco>anxiety (n = 1)	Depression predicted tobacco use (OR = 1.22, CI = 1.09-1.37); tobacco use predicted depression (OR = 1.87, CI = 1.23-2.85); anxiety did not predict tobacco use (OR = 1.38, CI = 0.83-2.29); tobacco use predicted anxiety (OR = 1.88, CI = 1.47-2.41)	81%	Low number of studies especially for anxiety; only USA and Canada; different types of anxiety pooled together

Note: CES-D = Center for Epidemiology Depression Scale; CI = Confidence interval; DISC-IV = Diagnostic interview schedule for children, version IV; OR = Odds ratio; SIAS = Social interaction anxiety scale.

Psychosis>tobacco

Four studies examined the effect of psychosis on development of tobacco use by youth. None of these used a clinical sample, and three had more than two waves. Psychosis did not appear to have an effect on tobacco use, with two studies (50.0%) showing a positive effect direction ($p = .250$). None of these studies were high quality, and no reviews examined the psychosis-tobacco relationship.

DISCUSSION

The purpose of the current study was to review the reciprocal temporal relationships between youth tobacco consumption and a group of psychological disorder categories including depression, anxiety, bipolar, psychosis, and borderline personality disorder (BPD). This review was justified because existing reviews: 1) are several years old, 2) have biased samples, 3) only examine a narrow range of psychological disorders, and 4) lack a dedicated focus on youth.

Synthesising the cohort and review studies, we found evidence that tobacco consumption predicted the development of depression and anxiety for youth, but not bipolar or psychosis. Tobacco might cause depression through certain biological mechanisms (e.g., decreasing the cortisol response) and also by eliciting withdrawal symptoms of low mood [59]. However, it is also possible that this longitudinal relationship is not causal. For example, the relationship may become non-significant when certain confounders (e.g., familial and genetic factors) are controlled for, as was found by Ranjit et al. [60,61]. Tobacco use might cause anxiety because it elicits physiological symptoms for the young person similar to anxiety (e.g., shortness of breath, increased heart rate and blood pressure), which are then catastrophically misinterpreted [45]. However, similar to depression, this relationship might be better

explained by unmeasured confounders and may not be causal [54]. Also, it is important to consider is that smoking exerts its adverse effects on a cumulative basis, which means that higher exposure with increasing time will increase the risk of incident mental health events. If specific outcomes do not occur in response to smoking due to restricted timeframe due to younger age, it does not mean that a causal relationship per se can be excluded.

Hahad et al. [72] recently reviewed the evidence for smoking as a potential risk factor for neuropsychiatric disorders such as depression, anxiety and psychosis, with the aim of identifying central pathophysiological mechanisms that may contribute to these relationships. Readers are referred to this review for a more comprehensive understanding of the evidence for neuropsychiatric pathophysiology. Hahad et al. emphasise that oxidative stress or inflammatory mediators associated with cigarette smoke can impair proper endothelial (vascular) function essential for a healthy cardiovascular system, with implications for the function of other bodily systems. They stress that prolonged oxidative stress combined with prolonged exposure noxious chemicals from cigarette smoke can lead to chronic inflammation, and that consequent structural and functional alterations in the central nervous system of individuals who smoke may indeed increase the risk of these disorders and other chronic conditions. Hahad et al. argue, however, that, 'the relationship between smoking, oxidative stress, inflammation, and neuropsychiatric diseases is not always clear. This stems from the fact that neuropsychiatric diseases also increase the chance that a person will start-smoking, making the direction of association difficult to establish' (p.7278). Hahad et al. also remind us that psychiatric disorders, 'have strong link with chronic stress, which represents one of the most prominent risk factors for their onset' (p.7279), and that chronic stress is also featured in several chronic conditions (e.g. cardiac and metabolic conditions) and can therefore intuitively increase the risk of psychiatric disorders.

Our synthesis of findings suggests that tobacco may not predict psychosis, which was notable because numerous studies (n = 12) examined this relationship. Of the six studies that found a positive effect direction, only one of these was a high-quality study [68], though several other moderate quality studies also found a positive effect direction. Tobacco use may have failed to predict psychosis because other confounders play a true causal role in the young person's experience of psychosis (e.g., other substance use; Ward et al.) [67]. Alternatively, it has been hypothesised that nicotine could actually decrease negative psychotic symptoms, mediated by an increase in dopamine [70]. Our sign test showed an overall lack of effect of tobacco on bipolar, which contradicts past research that does propose a causal effect [73]. However, only two included studies examined the effect of tobacco on bipolar, indicating that more longitudinal research is needed on this topic.

A similar pattern of results was found when investigating reverse-causation. The presence of both depression and anxiety predicted future tobacco use, potentially because people who experience depression and anxiety may have a greater probability of using tobacco to self-medicate (i.e., to try to reduce adverse symptoms; Swendsen et al. [64]. However, as with the effect of tobacco on depression, these relationships may only exist until familial and genetic confounders are controlled for [60,61]. Presence of psychosis may have failed to predict tobacco use due to certain confounders (e.g., cannabis use) that better explain the variance in tobacco use [47], but the number of studies that examined this relationship was minimal (n = 4). Similarly, according to the sign test, presence of bipolar did not have an overall effect on tobacco use. However, only three studies examined this relationship, and one of these studies was high quality and did find an effect. Hence, more longitudinal research is needed on this question.

There were several limitations to this review. Firstly, the included studies were very heterogeneous, particularly with regard to sample size, sample nature (i.e., clinical vs non-clinical), number and type of confounders, follow-up period, number of waves, and type of statistics used. Due to this heterogeneity, we were unable to meta-analyse the results and capture effect sizes. However, despite these constraints, we were still able to synthesise the quantitative data using vote counting based on effect direction, which is current best practice when meta-analysis is not possible, according to recent recommendations by Cochrane [18]. A second limitation is consideration of causation itself. For example, where tobacco use precedes and predicts depression, it is conceivable that tobacco use is having an 'effect' on depression, but it is also plausible that some other common factor/s may be causing both disorders, and the temporal sequence is somewhat arbitrary. Further research is needed, investigating to potential interplay of genetics and environmental factors that may act as confounders. A third limitation was the way in which we classified psychological disorder categories. For example, under the category of 'anxiety', we grouped various disorders including panic, social anxiety, generalised anxiety, and agoraphobia. However, it is possible that young people's experiences of these disorders differ in how they relate to tobacco use. For example, tobacco might have a greater effect on panic compared to social anxiety because tobacco can cause impaired respiration which is more associated with panic symptoms than social anxiety symptoms [46]. Also, we included mania under the bipolar category; however, mania could be unipolar as well without depressive symptoms [74]. As more research accumulates on tobacco and mental health, future reviews should distinguish between sub-types of psychological disorder categories.

Given the gap in the literature, future research should examine the reciprocal longitudinal relationship between tobacco use and BPD. Additionally, more studies should be conducted that investigate the relationship between tobacco, psychosis, and bipolar. Although there are numerous studies on tobacco and both depression and anxiety, future research should continue to examine confounders such as familial and genetic factors in order to strengthen causal inferences.

The mechanisms underlying smoking and mental illnesses are complex and yet to be thoroughly investigated and understood. In the meantime, a number of clinical implications are apparent for addressing the health and socio-economic burdens of tobacco use which are disproportionately high among people living with mental disorders. Addressing the uptake of tobacco use by young people must remain a high priority as part of public health measures targeting prevention and early intervention. This should include promoting greater awareness of the links between smoking and the onset of neuropsychiatric disorders among youth, their families, health and welfare professionals (particularly those working with at risk individuals and families), school systems and the community. More concerted treatment and smoking cessation support for young people must also be developed, made available and accessible, with health messaging that is better matched to their help-seeking behaviours, peer networks, and motivations for addressing smoking behaviours. Coupled with this, and in order to prevent the longer-term harms of smoking, health professionals must be supported to gain more skills and confidence to ask, advise and actively help young people with emerging and existing psychological disorders who smoke to address their smoking.

CONCLUSION

We found support for reciprocal relationships between tobacco and both depression and anxiety for youth, though questions remain around whether these relationships are causal. In contrast, we did not find overall evidence for a causal relationship between tobacco and psychosis for this population, perhaps because nicotine has conflicting effects on the person's experience of psychosis. For the other relationships examined (tobacco>bipolar; bipolar tobacco; psychosis>tobacco), evidence was weak because of low numbers of studies. Further studies that examine the complexities of interactions between tobacco and mental health for different diagnostic groups are needed to inform prevention, early intervention, treatment and smoking cessation support for youth with comorbid psychological conditions and tobacco use.

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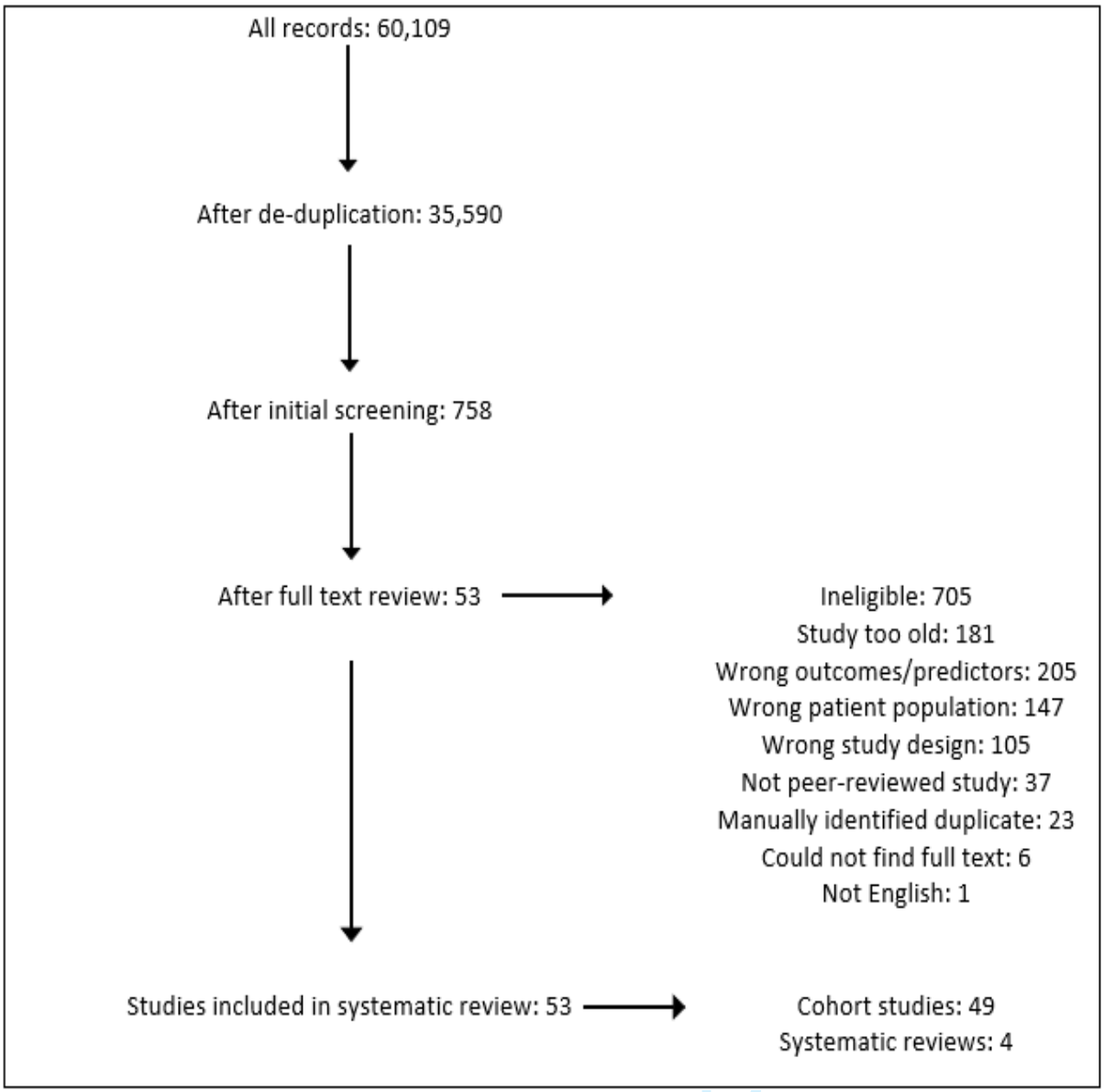

Figure 1: PRISMA flow diagram

Table S1 – Descriptive information about cohort studies (n = 49)

Authors (year) - country	Target population (n)	Structure - Baseline age, cohort years, #waves	Tobacco measure	Psychological measure/s	Relationship/s examined	Result	Covariates	Quality Score %	Limitations
Ajdacic-Gross et al. [24] (2009) - Switzerland	Stratified sample of participants with psychological disorders (N = 591)	21 years of age; 20-year follow-up; 6-waves	Smoking onset (never vs adolescent; never vs adult)	SPIKE	Tobacco>bipolar	For heavy smokers, adolescent onset of smoking predicted later bipolar compared to never smokers (OR = 7.1, CI = 1.9-25.9); but for other smokers this relationship was non-significant (OR = 0.9, CI = 0.3-2.7)	[illegible]ation; gender; [illegible] parents; conduct problems; school problems; family problems; extraversion; neuroticism; masculinity; regular tobacco use	63.6	Adolescent onset of smoking retrospective; temporal sequencing unclear; high attrition; small bipolar sub-group; CIs unavailable
Ames et al. [25] (2018) - Canada	Youth (n = 662)	12-18 years of age; 10-year follow-up; 6-waves	Smoking status (smoker vs non-smoker)	BCFPI	Tobacco>depression	Adolescent smoking predicted membership in persistent high depression trajectory group versus low stable group (Est. = 1.18, SE = 0.55, P < .05, OR = 3.26, CIs unavailable)	Gender; age; SES; earlier levels of smoking and depression; physical health; health-promoting behaviour; heavy drinking; marijuana use; number of sexual partners; BMI	72.7	CIs unavailable
Berk et al. [26] (2010) - Australia	Youth with schizophrenia (n = 193)	21.9 (SD = 3.6) years of age; 7.5-year follow-up; 3-waves	Smoking status (smoker vs non-smoker)	BPRS-PS	Tobacco>psychosis	Baseline smoking did not predict future psychosis (B = 0.20, p = .871)	Gender; problem illicit drug use; problem alcohol use; duration of untreated psychosis	72.7	Change in smoking status not assessed
Bierhoff et al. [27] (2019) - USA	University students (n = 2397)	20.5 (SD = 1.93) years of age; 2-year follow-up; 6-waves	Prior 30-day tobacco quantity (cigarettes, cigarillos)	PHQ-9; ZSRAS	Depression>tobacco; anxiety>tobacco	Depression (OR = 1.05, CI = 1.02-1.09) and anxiety (OR = 1.02, CI = 1.00-1.04) predicted cigarette quantity; depression (OR = 1.05, CI = 1.02-1.09) and anxiety (OR = 1.03, CI = 1.00-1.06) predicted cigarillo quantity; but depression and anxiety did not predict smokeless tobacco use, e-cigarette use, or hookah use (ORs ranged from 0.95-1.06)	Age; gender; sexual orientation; ethnicity; parental education; school type; ADHD;	36.4	Anxiety only measured at W5; only W6 smoking included in analyses; temporal ordering unclear
Borges et al. [28] (2018) - Mexico	Youth (n = 1071)	12-17 years of age; 8-year follow-up; 2-waves	Tobacco use (never vs use before age 15 vs use at age 15 or older); nicotine dependence	WMH-CIDI	Tobacco>depression; tobacco>anxiety; depression>tobacco; anxiety>tobacco	Early tobacco use predicted future mood disorder (RR = 1.42, CIs = 1.02-1.98); other results with tobacco use were non-significant but data not shown; nicotine dependence predicted future mood disorder (RR = 3.30, CI = 1.66-6.55); mood disorder did not predict future nicotine dependence (RR = 1.50, CI* = 0.55-3.90); anxiety did not predict future nicotine dependence (RR = 1.78, CI* =	Alcohol use; drug use; gender; age; living with parents; enrolled in school; parents' education; parents' income; number of childhood adversities	72.7	Individual disorders not examined as outcomes; only 2-waves

					0.95-3.60); data unavailable for nicotine dependence predicting anxiety			
Buchy et al. [29] (2014) - USA and Canada	Youth at high clinical risk of psychosis (n = 170)	19.8 (SD = 4.5) years of age; 4-year follow-up; 2-waves	Tobacco use (abstinent vs any use vs severe dependence)	SIPS	Tobacco>psychosis	Tobacco use did not predict transition to psychosis (U = 1752.5, p = .13)	Alcohol use; cannabis use; other illicit drug use	63.6	Small sub-group sample sizes; smoking only measured at W1; only 2-waves
Buchy et al. [30] (2015) - USA and Canada	Youth at clinical high risk of psychosis (N = 735) and healthy controls (N = 278)	18.5 (SD = 4.2) years of age for clinical high risk; 19.6 (4.7) years of age for controls; 2-year follow-up; 3-waves	Tobacco use (abstinent vs use without impairment vs abuse vs dependence)	SIPS; SOPS	Tobacco>psychosis	Smoking severity (U = 11495.5, p = .24) and frequency (U = 11638.0, p = .35) did not predict transition to psychosis	Alcohol use; cannabis use; other illicit drug use	54.5	Small sub-group sample sizes; all participants were help-seekers which may limit external validity
Bulhões et al. [31] (2020) - Portugal	Youth (n = 2010)	13-years of age; 8-year follow-up; 3-waves	Smoking status (never vs former; never vs current)	BDI-II	Tobacco>depression	Current smoking (vs never) predicted moderate (OR = 1.61, CI = 1.22-2.13) and high (OR = 1.89, CI = 1.18-3.01) depression trajectory groups (vs low). Former smoking (vs never) did not predict moderate (OR = 1.15, CI = 0.87-1.52) or high (OR = 1.08, CI = 0.65-1.78) depression trajectory groups (vs low)	Parents' education	54.5	Minimal covariates; temporal ordering unclear
Chen et al. [32] (2017) - USA	Youth with early-onset schizophrenia (n = 117)	13.9 (SD = 2.34) years of age; 3-year follow-up; 7-waves	Prior 6-month cigarette use (yes or no)	RADS; RCMAS	Tobacco>depression; tobacco>anxiety	Both depression (B = -13.70, SE = 5.03, p < .01) and anxiety (B = -14.41, SE = 5.90, p < .05) interacted with time to predict smoking	Age; gender; race; comorbidity; diagnosis; trauma; ; poverty	45.5	Small sample size; high attrition
Crane et al. [33] (2021) - USA	Youth (n = 1263)	15.6 (SD = 0.6) years of age; 7-year follow-up; 7-waves	Cigarette frequency (#days used in past month)	CESD-20	Depression>tobacco	Depression and time did not interact to predict future cigarette frequency (Est. = 0.00, SE = 0.00, p = .35)	Gender; race; ethnicity	72.7	Minimal covariates
Davies et al. [34] (2018) - UK	Youth (n = 6796)	12 years of age; 8-year follow-up; 4-waves	Smoking frequency (regularly [at least weekly] vs not)	SMFQ; PLIKSi	Psychosis>tobacco; depression>tobacco	Psychosis (OR = 1.11, CI = 0.79-1.56) and depression (OR = 1.23, CI = 0.78-1.95) at age 12 did not predict smoking at age 18	Gender; SES; housing; mother's education; IQ at age 8; SDQ at age 8; baseline levels of psychosis and depression	72.7	Smoking only measured at W3; high attrition
Ferdinand et al. [35] (2004) - Netherlands	Children and youth (n = 2600)	4-16 years of age; 14-year follow-up; 6-waves	Tobacco use (yes or no)	CBCL; YSR; YASR	Psychosis>tobacco	Auditory hallucinations at W2-5 predicted tobacco use at W6 (ORs ranging from 2.0-3.3); visual hallucinations were non-significant predictors (results not shown)	Gender; age; SES	54.5	Tobacco use not measured at W1
Fonseca et al. [36] (2021) - Brazil	University students without depression (n = 1034)	16-25 years of age; 3-year follow-up; 4-waves	Smoking status (yes if smoked at least 1 cigarette in previous 30-days)	PHQ-9	Tobacco>depression	Smoking did not predict depression for males (unadjusted IRR = 1.04, CI = 0.61-1.76) or females (unadjusted IRR = 1.49, CI = 0.97-2.27)	Age; SES; living situation; stress; alcohol use; sedentary behaviour; physical activity; sleep duration	54.5	Temporal ordering unclear; no overall statistics combining genders

Gage et al. [37] (2014) - UK	Youth without psychotic experiences at age 16 (n = 1573)	16 years of age; 2-year follow-up; 2-waves	Cigarette quantity (non-smoker vs experimenter vs weekly smoker vs daily smoker)	PLIKSi	Tobacco>psychosis	W1 cigarette use predicted psychotic symptoms at W2 (OR = 1.77, CI = 1.18-2.66)	Psychotic experience at 18; by categorical frequency of cigarette use at 18; family history of depression; mother's education; borderline personality; IQ at age 8; depression at age 12; conduct disorder; peer problems; bullied; cannabis use; illicit drug use; alcohol use	72.7	Tobacco use not measured at W2; psychosis not measured at W1; only 2-waves
Gårdvik et al. [38] (2020) - Norway	Youth (n = 717)	13-18 years of age; 3-year follow-up; 2-waves	Smoking status (yes or no)	K-SADS; DAWBA	Tobacco>depression; tobacco>anxiety	Smoking did not predict mood disorders (RD% = -0.5, CI = -3.0-2.6) but did predict anxiety disorders (RD% = 4.5, CI = 2.0-9.2)	Chronic pain; any substance disorder; alcohol and drug use; age; SES	72.7	Only 2-waves; temporal ordering unclear
Goodwin et al. [39] (2004) - New Zealand	Youth (n = 1000)	18-years of age; 2-year follow-up; 2-waves	Nicotine dependence (survey constructed based on DSM-IV criteria)	WMH-CIDI	Anxiety>tobacco	Anxiety disorders were not associated with nicotine dependence (OR = 1.46, CI = 0.93-2.29)	Parental change; parental violence; sexual abuse; physical abuse; parental history of criminality, alcohol problems, illicit drug use and depression/anxiety; low self-esteem; neuroticism; quality of parental attachment; family stress; early shyness; early conduct problems; early attention problems; gender; prior substance dependence; concurrent major depression; affiliation with deviant peers	72.7	Only 2-waves; temporal ordering unclear; specific anxiety disorders not specified
Goodwin et al. [40] (2013) - Germany	Youth (n = 3021)	14-24 years of age; 10-year follow-up; 4-waves	Nicotine use (yes or no) and smoking trajectory (non-user vs increasing use vs decreasing use vs persistent use; MCIDI/DIA-X)	MCIDI/DIA-X	Bipolar>tobacco; depression>tobacco; anxiety>tobacco	Any depressive disorder, any fear disorder, GAD, and specific phobia were associated with nicotine use (ORs ranged from 1.1-5.7); any depressive disorder predicted subsequent decreasing smoking trajectory (OR = 1.7, CI = 1.1-2.8); panic disorder negatively predicted increasing smoking trajectory (OR = 0.1; CI = 0.0-0.9); all other results non-significant (ORs ranged from 0.7-2.2)	Gender; age;	54.5	Difficult to interpret results (e.g., depression predicted binary nicotine use but also predicted decreasing trajectory).
Griesler et al. [41] (2008) - USA	Youth (n = 1039)	15.7 (SD = 1.4) years of age; 2-	Nicotine dependence (CIDI); lifetime	DISC	Anxiety>tobacco; tobacco>anxiety;	Anxiety (OR = 1.0, CI = 0.3-3.4) and mood (OR = 1.7, CI = 0.8-3.7) disorder did not predict nicotine dependence;	Age; gender; ethnicity; disruptive disorder; novelty seeking; age of	72.7	Individual disorders not examined as predictors/outcomes;

		year follow-up; 5-waves	cigarettes smoked (0; 1; 2-5; 6-15; 16-25; 26-99; 100+); other lifetime tobacco use		depression>tobacco; tobacco>depression	nicotine dependence did not predict anxiety (OR = 0.8, CI = 0.3-2.0) and mood (OR = 2.4, CI = 0.5-10.7) disorder; lifetime cigarettes smoked did not predict anxiety (OR = 1.0, CI = 0.9-1.0) and mood (OR = 1.0, CI = 0.9-1.0) disorder; other lifetime tobacco use did not predict anxiety (OR = 0.4, CI = 0.2-1.0) and mood (OR = 0.6, CI = 0.1-2.7) disorder	onset of smoking; initial sensitivity to tobacco; number of lifetime cigarettes smoked; other lifetime tobacco use; drug use; peer smoking; sibling smoking; parent smoking; parent depression; parent delinquency; any psychiatric disorder		short follow-up period; variables not measured at all waves
Griesler et al. [42] (2011) - USA	Stratified sample of smoking youth (n = 814)	15.7 (SD = 1.4) years of age; 2-year follow-up; 5-waves	Nicotine dependence (zero dependence criterion vs one dependence criterion vs three criteria; CIDI)	DISC	Tobacco>depression;	No specific psychological disorders predicted one dependence criterion (statistics now shown) and only panic disorder predicted full (i.e., three) dependence criteria (HR = 2.2, CI = 1.2-3.9); nicotine dependence did not predict any specific psychological disorders (statistics not shown); anxiety disorder did not predict first nicotine dependence criterion (HR = 1.10, CI = 0.78-1.55), but did predict full nicotine dependence (HR = 1.68, CI = 1.12-2.52); mood disorder did not predict first nicotine dependence criterion (HR = 1.16, CI = 0.86-1.55) or full nicotine dependence (HR = 0.93, CI = 0.63-1.38); one dependence criterion did not predict anxiety (HR = 1.12, CI = 0.52-2.39) or mood (HR = 1.10, CI = 0.54-2.26) disorder; full dependence criteria did not predict anxiety (HR = 0.76, CI = 0.23-2.49) or mood (HR = 1.82, CI = 0.67-4.96) disorder	Gender; ethnicity; age of onset of tobacco use; initial sensitivity to tobacco; alcohol and other illicit drug use; parent education; parent smoking; parent depression; parent delinquency; ever tobacco dependent	72.7	Individual disorders not examined as predictors/outcomes; short follow-up period; variables not measured at all waves
Hu et al. [43] (2012) - USA	Stratified sample of lifetime youth smokers (n = 877)	14.1 (SD = 1.4) years of age; 7-year follow-up; 6-waves	Nicotine dependence (no dependence criteria vs early onset/chronic course vs early onset/remission vs late onset)	DISC	Anxiety>tobacco	Anxiety disorder predicted chronic course, early remission, and late onset nicotine dependence (compared with none, ORs ranged from 3.65-4.55); anxiety disorder did not predict chronic course vs early remission, chronic course vs late onset, or early remission vs late onset (ORs ranged from 1.04-1.09)	Gender; ethnicity; onset age of smoking; smoked 5+ packs per month; maximum number of drinks per month; marijuana use; onset age of marijuana; pleasant initial sensitivity to tobacco; parental nicotine dependence; disruptive/mood/anxiety disorder by W5	81.8	Anxiety only measured at W3 and W5; temporal ordering unclear

Hui et al. [44] (2013) - China	Youth with psychosis (n = 1400)	21.2 (SD = 3.4) years of age; 3-year follow-up; 3-waves	Smoking status (non-smoker vs current smoker vs ex-smoker)	CGI-S	Tobacco>psychosis	Smoking predicted relapse of psychosis (HR = 1.42, CI = 1.15-1.76)	Age of schizophrenia diagnosis; length of baseline hospitalisation; adherence at clinical stabilisation	63.6	Difficulty defining relapse; confounder of stressful life events not included
Isensee et al. [45] (2003) - Germany	Youth (n = 3021)	14-24 years of age; 3.5-year follow-up; 3-waves	Smoking quantity (never vs occasional vs non-dependent regular vs dependent regular)	MCIDI/DIA-X	Tobacco>anxiety; anxiety>tobacco	Smoking predicted future agoraphobia, SAD, specific phobia, panic attacks without disorder, and unspecified phobia (ORs ranged from 2.4-3.7), but did not predict panic disorder (ORs ranged from 0.1-3.6); no psychological disorders or symptoms predicted smoking (ORs ranged from 0.3-2.6)	Gender; age; PTSD; alcohol and illicit drug disorders; eating disorders	72.7	Small sample sizes for certain disorders
Johnson et al. [46] (2000) - USA	Youth (n = 688)	~16 years of age; 6-year follow-up; 2-waves	Smoking quantity (less than 1-pack per day vs more than 1-pack per day)	DISC	Tobacco>anxiety; anxiety>tobacco	Smoking predicted future agoraphobia, GAD, and panic disorder (ORs ranged from 5.53-15.58) but not SAD (OR = 0.44, CI = 0.04-4.62); anxiety disorders did not predict future smoking (statistics unavailable)	Gender; age; difficult childhood temperament; parental education; parental smoking; parental psychopathology; adolescent alcohol and drug use; adolescent anxiety and depressive disorders	72.7	Only 2-waves; small sample sizes for certain disorders
Jones et al. [47] (2018) - UK	Youth (n = 3328)	13.9 (SD = 2.7) years of age; 5-year follow-up; 6-waves	Cigarette use (yes or no)	PLIKSi	Psychosis>tobacco; tobacco>psychosis	Cigarette use did not predict subsequent psychosis (ORs ranged from 0.73-1.78); psychosis did not predict subsequent cigarette use (ORs ranged from 0.86-1.60)	Gender; mother's education; emotional and behavioural problems at 9 years of age; mother's smoking during pregnancy	63.6	High attrition
Kalan et al. [48] (2020) - Lebanon	Youth waterpipe (N = 228) and cigarette smokers (N = 139)	14.3 (SD = 1.2) years of age; 6-year follow-up; 8-waves	Nicotine dependence initial symptoms; nicotine dependence full diagnosis	DSS	Depression>tobacco	For waterpipe smokers, depression did not predict initial nicotine dependence symptoms (unadjusted HR = 1.03, CI = 0.98-1.09) but did predict full nicotine dependence diagnosis (HR = 1.13, CI = 1.02-1.25). For cigarette smokers, depression did not predict initial dependence symptoms (unadjusted HR = 1.00, CI = 0.94-1.06) or full nicotine dependence diagnosis (unadjusted HR = 0.96, CI = 0.85-1.09)	Gender; BMI; SES; age	54.5	Small sample size
Kendler et al. [49] (2015) - Sweden	Males from conscript registry (n = 233,879)	18.5 (SD = 8.4) years of age; 8-year follow-up; 5-waves	Smoking quantity (none vs light vs heavy)	Registry diagnosis (assessment tool unclear)	Tobacco>psychosis	W1 and W2 light (vs no) smoking did not predict subsequent schizophrenia (ORs ranged from 1.60-1.62) but W3 did (OR = 1.77, CI = 1.02-3.05); W1 and W3 heavy (vs no) smoking did predict subsequent schizophrenia (ORs ranged from 2.21-	Family SES; community SES; drug abuse	45.5	Only male youth; psychological disorder assessment method unclear

						2.39), but W2 did not (OR = 1.96, CI = 0.95-4.06)			
King et al. [50] (2004) - USA	Youth twins (n = 1364)	11 years of age; 3-year follow-up; 2-waves	Nicotine onset; regular cigarette use; daily nicotine use	DICA-R	Anxiety>tobacco; tobacco>anxiety	Using adjusted analyses, W1 MDD predicted W2 nicotine onset (OR = 1.98, CI = 1.15-3.41), but using unadjusted analyses did not predict regular cigarette use or daily nicotine use (ORs ranged from 0.83-1.94); using unadjusted analyses, W1 separation anxiety disorder and overanxious disorder did not predict any of the outcomes (ORs ranged from 0.84-1.25)	Conduct disorder; oppositional defiant disorder; ADHD; gender	72.7	Only 2-waves; anxiety disorders assessed for females only; variables only measured at one time point each; only some analyses adjusted
MacKie et al. [51] (2011) - UK	Youth (n =409) with elevated hopelessness, anxiety-sensitivity, impulsivity and sensation-seeking	14.5 years of age; 1.5-year follow-up; 4-waves	Cigarette use (yes or no)	DIS	Tobacco>psychosis	W1 cigarette use did not predict persistent psychotic trajectory (OR = 1.3, 0.3-5.1) but did predict increasing psychotic trajectory (OR = 5.4, CI = 1.5-20.1)	Gender; ethnicity; anxiety sensitivity; hopelessness; impulsivity; sensation seeking	54.5	Short follow-up; small sample sizes in sub-groups
Marmorstein et al. [52] (2010) - USA	Male youth (n = 503)	~6.2 years of age; 14-year follow-up; 15-waves	Age at first tobacco use	CBCL; TRF; YSR	Anxiety>tobacco	Both generalised (OR = 0.06, CI = .02-.17) and social anxiety (OR = 0.06, CI = .02-.17) interacted with time to predict earlier onset of tobacco use	Age at first alcohol and substance use; delinquency	63.6	Statistics unclear; only male sample
Marsden et al. [53] (2019) - USA	University students (n = 5236)	21.0 (SD = 2.3) years of age; 3-year follow-up; 6-waves	Past 30-day use and frequency of use of cigarettes, refillable e-cigarettes, disposable e-cigarettes, hookah, cigars (including cigarillos and little cigars), and smokeless tobacco	CESD-10	Tobacco>depression	For past 30-day use, significant predictors of depression were cigarettes, refillable e-cigarettes, and hookah (rate ratios ranged from 1.01-1.03), but disposable e-cigarettes, cigars, and smokeless tobacco were non-significant (rate ratios ranged from 1.00-1.10); for frequency of use, significant predictors of depression were cigarettes, refillable e-cigarettes, and smokeless tobacco (rate ratios ranged from 1.10-1.04), but disposable e-cigarettes, cigars, and hookah were non-significant (rate ratios ranged from 1.01-1.05)	Gender; ethnicity; age; father's education; college aspiration; survey wave; other tobacco products	54.5	University student sample
Moylan et al. [54] (2013) - Norway	Youth (n = 456)	14-15 years of age; 4-year follow-up; 3-waves	Smoking status (active vs non-active)	GADS	Tobacco>anxiety; anxiety>tobacco	Active smoking in adolescence predicted later anxiety (B = 0.17, p < .05); adolescent anxiety did not predict later smoking (statistics not presented)	Mother's education	72.7	Very small cell sizes; relatively high SES of participants; minimal covariates
Mustonen et al. [55] (2018) - Finland	Youth (n = 6081)	15-16 years of age; 15-year follow-up;	Cigarette quantity (non-smokers vs moderate [1-9 cigarettes a day] vs	Registry diagnoses based on ICD-10 criteria	Tobacco>psychosis	Heavy smoking (HR = 2.00, CI = 1.13-3.54) and number of daily cigarettes (OR = 1.05, CI = 1.01-1.08) predicted later psychosis; but moderate smoking did not	Baseline psychotic experiences; cannabis use; alcohol use; other substance use; parental	72.7	Number of waves unclear; psychosis diagnosis method unclear

		number of waves unclear	heavy [greater than 10 cigarettes a day]); number of daily cigarettes smoked; age of smoking onset			(HR = 0.42, CI = 0.13-1.34); early onset predicted subsequent psychosis compared to late onset (HR = 2.84, CI = 1.12-7.18)	substance abuse; parental psychosis		
Okeke et al. [56] (2013) - USA	Mexican American youth (N = 1328)	11-13 years of age; 5-year follow-up; 3-waves	Smoking status (never vs puffer [tried but not completed single cigarette] vs experimenter [have consumed one cigarette or more])	STAS	Anxiety>tobacco	Anxiety predicted experimenter status (OR = 1.04, CI = 1.02-1.07) but not puffer status (OR = 1.01, CI = 0.99-1.03)	der; age; birth ntry; parental ion; BMI; body image	54.5	Temporal ordering unclear; variables not measured at each time point
Pedersen et al. [57] (2009) - Norway	Youth (n = 1501)	13 years of age; 13-year follow-up; 4-waves	Smoking status (not smoking vs smoking but not dependent vs nicotine dependent)	(SCL-90)	Tobacco>anxiety; anxiety>tobacco	Nicotine dependent status predicted later anxiety (B = 0.09, p < .01) but non-dependent smoking status did not (B = 0.05, p > .05); anxiety did not predict later smoking status (OR = 1.06, CI = 0.97-1.17)	Gender; age; depression and parasuicide at age 20; at ages 15 and 20: MFQ; parental care and monitoring, parental divorce, education, conduct problems, cannabis	54.5	Infrequent assessments
Purborini et al. [58] (2021) - Indonesia	Youth (n = 1960)	17.0 (SD = 1.4) years of age; 7-year follow-up; 2-waves	Lifetime tobacco status (ever vs never); current tobacco status (never vs current vs former)	CESD-10	Tobacco>depression	All tobacco use statuses predicted depression including ever smoked (B = 0.92, CI = 0.73-1.12), current smoker (B = 0.88, CI = 0.68-1.08), and former smoker (B = 1.52, CI = 0.95-2.08)	Marital status; region; SES	81.8	Only 2-waves; temporal ordering unclear
Raffetti et al. [59] (2019) - Sweden	High school students (n = 3959)	13 years of age; 1-year follow-up; 2-waves	Cigarette smoking; snus use; current; tobacco use; tobacco dependence (all variables yes or no)	CES-DC; SDQ	Tobacco>depression	Cigarette smoking (b = 3.4, p = .006) and tobacco dependence (b = 3.4, p = .008) predicted later depression, but snus (b = -0.1, p = .934) and tobacco (b = 1.9, p = .073) use did not; using depression onset as outcome, only tobacco dependence was a significant predictor (OR = 4.8, CI = 1.7-14.0), but cigarette smoking, tobacco use, and snus use were not (ORs ranged from 0.8-2.0)	Baseline depression; alcohol use; parental education; parental birthplace; gender	72.7	Minimal waves; short follow-up;
Ranjit et al. [60] (2019) - Finland	Youth twins (n = 4152)	14 years of age; 3-year follow-up; 2-waves	Lifetime cigarettes smoked (zero vs 1-50 vs 50+); smoking status (never vs experimenter vs quitter vs regular)	GBI	Tobacco>depression	Lifetime cigarettes smoked and smoking status did not predict later depression (IRRs ranged from 1.05-1.14); depression did not predict later smoking (results not shown)	Gender; school grades; alcohol use to intoxication; health status; pre-existing depressiveness; shared familial and genetic factors between twins	72.7	Minimal waves; variables only measured at one wave

Ranjit et al. [61] (2019b*) - Finland	Youth twins (n = 4236)	17.5 years of age; 5-year follow-up; 2-waves	Smoking status (never vs ever)	GBI	Tobacco>depression; depression>tobacco	Smoking did not predict later depression (OR = 1.02, CI = 0.92-1.14); depression did not predict later smoking (OR = 1.03, CI = 0.91-1.17)	Gender; age; baseline depression; shared familial and genetic factors between twins	54.5	Minimal waves
Savage et al. [62] (2016) - Finland	Youth twins (n = 1906)	12 years of age; 10-year follow-up; 4-waves	Nicotine dependence symptoms	MPNI	Anxiety>tobacco	Peer/teacher/parent-rated social anxiety did not predict future nicotine dependence (Bs ranged from -.15 to -.01)	Nicotine dependence at W2 and W3; gender	45.5	Social anxiety only measured at W1; statistics unclear; low internal reliability of parent-rated social anxiety
Shete et al. [23] (2017) - USA	Mexican American youth (n = 1328)	11.8 (SD = 0.8) years of age; 5-year follow-up; 2-waves	Smoking escalation (yes or no)	STAS	Anxiety>tobacco	Anxiety predicted smoking escalation (OR = 1.03, CI = 1.02-1.05)	Gender; age; subjective social status; intention to smoke cigarette; peer smoking; parental smoking	36.4	Minimal waves
Smith et al. [63] (2014) - USA	Sub-sample of young adults (precise N unclear, but approximately 14,000)	18-29 years of age; 1-year follow-up; 2-waves	Smoking cessation (yes or no)	AUDADIS-IV	Depression>tobacco; anxiety>tobacco; bipolar>tobacco	Compared to the longitudinal smoking cessation rate of no-diagnosis (28.7), all longitudinal smoking cessation rates of those with past-year diagnoses were significantly lower (ps < .001): SAD (13.8), agoraphobia (12.0), panic disorder (14.5), specific phobia (20.3), GAD (13.4), mania or hypomania (18.6), MDD (17.6)	Age; gender; education	81.8	Minimal waves; short follow-up; change in psychological diagnosis unclear; symptom severity not measured
Swendsen et al. [64] (2010) - USA	Youth (n = 5001)	15-24 years of age; 10-year follow-up, 2-waves	Daily tobacco use (yes or no); nicotine dependence (yes or no)	CIDI	Depression>tobacco; anxiety>tobacco; bipolar>tobacco	Among W1 non-daily tobacco users, significant predictors of W2 onset of daily use included any mood disorder, panic disorder, SAD, specific phobia, GAD, and any anxiety disorder (ORs ranged from 1.6-3.0), whereas MDD, bipolar, agoraphobia, and separation anxiety were non-significant (ORs ranged from 0.8-1.8); among daily tobacco users, significant predictors of W2 onset of nicotine dependence included bipolar, any mood disorder, agoraphobia, and separation anxiety (ORs ranged from 1.9-3.9), whereas MDD, panic disorder, SAD, GAD, and any anxiety disorder were non-significant (ORs ranged from 0.8-1.4)	Age; gender; ethnicity; education; marital status; number of children; region; urbanicity; employment status	72.7	Minimal waves
Tomita et al. [65] (2020) - South Africa	Subsample of youth without depression (N = 4207)	15-19 years of age; 7-year follow-up; 4-waves	Smoking cigarette status (yes or no)	CESD-10	Tobacco>depression	Smoking predicted depression for both males (RR = 1.84, CI = 1.18-2.88) and females (RR = 2.47, CI = 1.15-5.29)	Ethnicity; marital status; education; employment status; household income; urban/rural residence	63.6	None noted

Trotta et al. [66] (2020) - UK	Youth twins (n = 2232)	12 years of age; 6-year follow-up; 2-waves	Tobacco dependence	Structured interview created by authors	Psychosis>tobacco	Psychosis did not predict later tobacco dependence (RR = 1.00, CI = 0.57-1.75)	Shared familial and genetic factors between twins; gender; age-5 IQ; family SES status; age-12 depression, anxiety, self-harm/suicidality, ADHD, conduct disorder, family psychological history; twin's psychotic symptoms	63.6	Only 2-waves;
Ward et al. [67] (2019) - USA and Canada	Youth at clinical high risk of psychosis (N = 587) and healthy controls (N = 274)	18.5 (4.3) years of age for clinical high risk; 19.7 (4.7) years of age for controls; 2-year follow-up; waves unclear but approximately 3-4	Smoking level (none vs light vs heavy); smoking status (never vs ever)	SIPS	Tobacco>psychosis	Light smoking (OR = 0.90, CI = 0.4-2.2), heavy smoking (OR = 0.3, CI = 0.05-2.3), and status as 'ever smoked' (HR = 1.16, CI = 0.82-1.65) did not predict transition to psychosis	Tobacco use; marijuana use; alcohol use; age; ethnicity; academic performance; academic impairment; depression; anxiety; social anxiety; daily stressors; life events; perceived discrimination	72.7	Some small cell counts; number of waves unclear
Weiser et al. [68] (2004) - Israel	Youth male military recruits (n = 14, 248)	18 years of age; 10.2 (SD = 3.6) year follow-up; number of waves unclear	Smoking status (yes or no); daily smoking quantity (zero vs 1-9 vs 10+)	Registry diagnoses based on ICD-10 criteria	Tobacco>psychosis	Baseline binary smoking (RR = 1.94, CI = 1.05-3.58) and daily smoking 10+ cigarettes (RR = 2.28, CI = 1.19-4.34) predicted later schizophrenia, but daily smoking 1-9 cigarettes (RR = 1.38, CI = 0.48-4.00) did not	Non-psychotic psychological disorders; adolescent social and intellectual functioning; SES	72.7	Inconsistent follow-up periods; number of waves unclear; schizophrenia diagnosis method unclear; smoking only assessed at baseline; only male sample
Wilens et al. [69] (2016) - USA	Youth with bipolar (N = 105) and youth controls without bipolar (N = 98)	13.6 (SD = 2.5) years of age for bipolar, 13.7 (SD = 2.1) years of age for controls; 5-year follow-up; 3-waves (but unclear)	Cigarette smoking (levels unclear)	KSADS-E; SCID	Tobacco>bipolar	Maintenance of smoking predicted bipolar status at final follow-up (HR = 3.2, CI = 1.6-6.7); but smoking did not predict persistence of bipolar (HR = 1.5, CI = 0.7-3.2)	SES; parental history of substance use disorder; probands with bipolar;	63.6	Temporal ordering unclear; small sample size; number of waves unclear; levels of predictor unclear; results unclear
Zammit et al. [70] (2003) - Sweden	Youth military recruits (n = 50,087)	18-20 years of age; 27-year follow-up; number of waves unclear	Smoking quantity (non-smokers vs light smokers vs medium smokers vs heavy smokers)	Registry diagnoses based on ICD-8	Tobacco>psychosis	Smoking quantity negatively predicted schizophrenia by final follow-up (HR = 0.8, CI = 0.7-0.9), but did not predict schizophrenia between 0-5 years from baseline (HR = 0.9, CI = 0.7-1.1)	Diagnosis at conscription; poor social integration; IQ; drug use; disturbed behaviour; father's occupation; place of upbringing; family SES; family psychiatric history; alcohol problems	81.8	Psychological disorder diagnosis method unclear; number of waves unclear; smoking only measured at baseline

Zhang et al. [71] (2018) - Germany	Female youth (n = 3065)	21.0 (SD = 1.73) years of age; 1.5-year follow-up; 2-waves	Smoking status (yes or no)	DIMD-RV	Tobacco>depression	Smoking did not predict incremental variance in MDD (OR = 1.55, CI = 0.90-2.66)	BMI; alcohol use; alcohol-related problems; physical activity; good physical health	72.7	Only females; minimal waves; short follow-up; MDD and smoking measured as binary variables

Note: All CIs (confidence intervals) were 95%.

*Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.

BMI = Body Mass Index; CI = 95% confidence interval; Est. = Estimate; GAD = Generalised Anxiety Disorder; IRR = Incidence Rate Ratio; OR = odds ratio; SAD = Social Anxiety Disorder; SES = socioeconomic status; U = Mann Whitney U Test.

AUDADIS-IV = Alcohol Use Disorder and Associated Disabilities Interview Schedule; BCFPI = Brief Child and Family Phone Interview; BDI-II = Beck Depression Inventory-II; BPRS-PS = Brief Psychiatric Rating Scale; CBCL = Child Behavior Checklist; CES-DC = Center for Epidemiologic Studies Depressive symptoms Scale for Children; CESD = Center for Epidemiologic Studies Depression Scale; CGI-S = Clinical Global Impressions – Severity Scale; DAWBA = Development and Wellbeing Assessment; DICA-R = Diagnostic Interview for Children and Adolescents; DIMD-RV = Diagnostic Interview for Mental Disorders—Research Version; DIS = Diagnostic Interview Schedule; DISC = Diagnostic Interview Schedule for Children; DSS = Depressive Symptoms Scale; FTND = Fagerström Test for Nicotine Dependence; GADS = Generalized Anxiety Disorder Scale; GBI = General Behavior Inventory; KSADS-E = Kiddie Schedule for Affective Disorders-Epidemiologic Version; MCIDI/DIA-X = Munich-Composite International Diagnostic Interview ; MPNI = Multidimensional Peer Nomination Inventory; MSI = Minnesota Smoking Index; PHQ-9 = Patient Health Questionnaire; PLIKSi = Psychosis-Like Symptoms Interview; PLIKSi = Psychosis-like Symptoms interview; RADS = Reynolds Adolescent Depression Scale; RCMAS = Revised Children's Manifest Anxiety Scale; SCID = Scheduled Clinical Interview Diagnosis; SCL-90 = Hopkins Symptom Checklist; SDQ = Strengths and Difficulties Questionnaire; SIPS = Structured Interview for Prodromal Syndromes; SMFQ = Short Mood and Feelings Questionnaire; SOPS = Scale for Assessment of Prodromal Symptoms; SPIKE = Structured Psychopathological Interview and Rating of the Social Consequences of Psychological Disturbances for Epidemiology; STAS = Speilberger's Trait Anxiety Scale; TFR = Teacher Report Form; WMH-CIDI = World Mental Health Composite International Diagnostic Interview; YASR = Young Adult Self-Report; YSR = Youth Self-Report; ZSRAS = Zung Self-Rating Anxiety Scale.

Supplementary File: Search strategy for search #1 on 26th September 2019

PubMed:

Smoking	Mental Illness	Study type	Number of results
"tobacco smoking"[mh] OR "smoking"[mh] OR tobacco[tiab] OR cigarette*[tiab] OR smoking[tiab] OR smoker*[tiab]	("Anxiety Disorders"[mh] OR "Bipolar and Related Disorders"[mh] OR "Disruptive, Impulse Control, and Conduct Disorders"[mh] OR "Dissociative Disorders"[mh] OR "Feeding and Eating Disorders"[mh] OR "Mood Disorders"[mh] OR "Personality Disorders"[mh] OR "Schizophrenia Spectrum and Other Psychotic Disorders"[mh] OR "Substance-Related Disorders"[mh] OR "Trauma and Stressor Related Disorders"[mh]) OR (disorder[Title/Abstract] OR mental[Title/Abstract] OR schizophreni*[Title/Abstract] OR catatoni*[Title/Abstract] OR bipolar[Title/Abstract] OR psychosis[Title/Abstract] OR psychotic[Title/Abstract] OR depress*[Title/Abstract] OR Cyclothymi* [Title/Abstract] OR Dysphori*[Title/Abstract] OR "selective mutism"[Title/Abstract] OR Trichotillomania[Title/Abstract] OR dereali*[Title/Abstract] OR mood[Title/Abstract] OR anxi*[Title/Abstract] OR phobia[Title/Abstract] OR dysthymia[Title/Abstract] OR manic[Title/Abstract] OR mania[Title/Abstract] OR dissociat*[Title/Abstract] OR depersonali*[Title/Abstract] OR pica[Title/Abstract] OR anorexia[Title/Abstract] OR bulimia[Title/Abstract] OR binge eating[Title/Abstract] OR substance[Title/Abstract] OR posttraumatic[Title/Abstract] OR post-traumatic[Title/Abstract])	"longitudinal"[tiab] OR "follow up"[tiab] OR "follow-up"[tiab] OR "cohort"[tiab]	9089

Embase:

Smoking	Mental Illness	Study type	filters	Number of results
"tobacco use"/exp OR tobacco:ti,ab OR cigarette*:ti,ab OR smoking:ti,ab OR smoker*:ti,ab	("anxiety disorder"/exp OR "mood disorder"/exp OR "behaviour disorder"/exp OR "dissociative disorder"/exp OR "personality disorder"/exp OR "Psychosis"/exp OR "drug dependence"/exp OR Adjustment disorder/de OR Neurosis/exp (includes dysthymia) OR Psychotrauma/de) OR (disorder:ti,ab OR mental:ti,ab OR schizophreni*:ti,ab OR catatoni*:ti,ab OR bipolar:ti,ab OR psychosis:ti,ab OR psychotic:ti,ab OR depress*:ti,ab OR Cyclothymi* :ti,ab OR Dysphori*:ti,ab OR "selective mutism":ti,ab OR Trichotillomania:ti,ab OR dereali*:ti,ab OR mood:ti,ab OR anxi*:ti,ab OR phobia:ti,ab OR dysthymia:ti,ab OR manic:ti,ab OR mania:ti,ab OR dissociat*:ti,ab OR depersonali*:ti,ab OR pica:ti,ab OR anorexia:ti,ab OR bulimia:ti,ab OR binge eating:ti,ab OR substance:ti,ab OR posttraumatic:ti,ab OR post-traumatic:ti,ab)	"longitudinal":ti,ab OR "follow up":ti,ab OR "cohort":ti,ab	AND [english]/lim AND [embase]/lim	2306

Pubmed mesh term	Emtree term
anxiety disorders	"anxiety disorder"/exp
Bipolar and Related Disorders	"mood disorder"/exp
Disruptive, Impulse Control, and Conduct Disorders	"behaviour disorder"/exp
Dissociative Disorders	"dissociative disorder"/exp
Feeding and Eating Disorders	"behaviour disorder"/exp
Mood Disorders	"mood disorder"/exp
Personality Disorders	"personality disorder"/exp
Schizophrenia Spectrum and Other Psychotic Disorders	"Psychosis"/exp
Substance-Related Disorders	"drug dependence"/exp
Trauma and Stressor Related Disorders	"anxiety disorder"/exp
	Adjustment disorder/de Neurosis/exp (includes dysthymia) Psychotrauma/de

PsycINFO:

Smoking	Mental Illness	Study type	filters	Number of citations
(exp tobacco smoking"OR tobacco.ti,ab OR cigarette$.ti,ab OR smoking.ti,ab OR smoker$.ti,ab)	(exp Anxiety Disorders OR exp Bipolar Disorder OR exp Disruptive Behavior Disorders OR exp Attention Deficit Disorder OR exp Dissociative Disorders OR exp Eating Disorders OR exp Affective Disorders OR exp Personality Disorders OR exp Psychosis OR exp Substance Related and Addictive Disorders OR exp Stress and Trauma Related Disorders) OR (disorder.ti,ab OR mental.ti,ab OR schizophreni$.ti,ab OR catatoni$.ti,ab OR bipolar.ti,ab OR psychosis.ti,ab OR psychotic.ti,ab OR depress$.ti,ab OR Cyclothymi$ .ti,ab OR Dysphori$.ti,ab OR selective mutism.ti,ab OR Trichotillomania.ti,ab OR dereali$.ti,ab OR mood.ti,ab OR anxi$.ti,ab OR phobia.ti,ab OR dysthymia.ti,ab OR manic.ti,ab OR mania.ti,ab OR dissociat$.ti,ab OR depersonali$.ti,ab OR pica.ti,ab OR anorexia.ti,ab OR bulimia.ti,ab OR binge eating.ti,ab OR substance.ti,ab OR posttraumatic.ti,ab OR post-traumatic.ti,ab)	(longitudinal.ti,ab OR Follow up.ti,ab OR cohort.ti,ab)	engs[la]	3648

Thesaurus terms:

Pubmed mesh term	**Psyc Info thesaurus term**
anxiety disorders	exp Anxiety Disorders
Bipolar and Related Disorders	exp Bipolar Disorder
Disruptive, Impulse Control, and Conduct Disorders	exp Disruptive Behavior Disorders; Attention Deficit Disorder
Dissociative Disorders	exp Dissociative Disorders
Feeding and Eating Disorders	exp Eating Disorders
Mood Disorders	exp Affective Disorders
Personality Disorders	exp Personality Disorders
Schizophrenia Spectrum and Other Psychotic Disorders	exp Psychosis
Substance-Related Disorders	exp Substance Related and Addictive Disorders
Trauma and Stressor Related Disorders	exp Stress and Trauma Related Disorders

Scopus:

Smoking	**Mental Illness**	**Study type**	**Number of results**
tobacco OR cigarette* OR smoking OR smoker* Select ‘article title, abstract, keyworks	disorder OR mental OR schizophreni* OR catatoni* OR bipolar OR psychosis OR psychotic OR depress* OR Cyclothymi* OR Dysphori* OR { mutism} OR Trichotillomania OR dereali* OR mood OR anxi* OR phobia OR dysthymia OR manic OR mania OR dissociat* OR depersonali* OR pica OR anorexia OR bulimia OR binge eating OR substance OR posttraumatic OR post-traumatic Select ‘article title, abstract, keyworks	longitudinal OR "follow up" OR cohort Select ‘article title, abstract, keyworks	17,532

CINAHL:

Smoking	Mental Illness	Study type	Number of results
MH tobacco smoking+ OR TI tobacco OR AB tobacco OR TI cigarette* OR AB cigarette* OR TI smoking OR AB smoking OR TI smoker* OR AB smoker* OR MH smoking+	MH Anxiety Disorders+ OR MH Bipolar Disorder+ OR MH Impulse control disorders+ OR MH Social behaviour disorders+ OR MH Mental Disorders Diagnosed in Childhood+ OR MH Dissociative Disorders+ OR MH Eating Disorders+ OR MH Affective Disorders+ OR MH Personality Disorders+ OR MH Psychotic Disorders+ OR MH Substance Use Disorders+ OR MH Stress Disorders, Post-Traumatic+ OR TI disorder OR AB disorder OR TI mental OR AB mental OR TI schizophreni* OR AB schizophreni* OR TI catatoni* OR AB catatoni* OR TI bipolar OR AB bipolar OR TI psychosis OR AB psychosis OR TI psychotic OR AB psychotic OR TI depress* OR AB depress* OR TI Cyclothymi* OR AB Cyclothymi* OR TI Dysphori* OR AB Dysphori* OR TI selective mutism OR AB selective mutism OR TI Trichotillomania OR AB Trichotillomania OR TI dereali* OR AB dereali* OR TI mood OR AB mood OR TI anxi* OR AB anxi* OR TI phobia OR AB phobia OR TI dysthymia OR AB dysthymia OR TI manic OR AB manic OR TI mania OR AB mania OR TI dissociat* OR AB dissociat* OR TI depersonali* OR AB depersonali* OR TI pica OR AB pica OR TI anorexia OR AB anorexia OR TI bulimia OR AB bulimia OR TI binge eating OR AB binge eating OR TI substance OR AB substance OR TI posttraumatic OR AB posttraumatic OR TI post-traumatic OR AB post-traumatic	TI longitudinal OR AB longitudinal OR TI follow up OR AB follow up OR TI follow-up OR AB follow-up OR TI cohort OR AB cohort	11,037

Pubmed mesh term	Cinahl subject heading
anxiety disorders	Anxiety Disorders+
Bipolar and Related Disorders	Bipolar Disorder+
Disruptive, Impulse Control, and Conduct Disorders	Impulse control disorders+ Social behaviour disorders+ Mental Disorders Diagnosed in Childhood+
Dissociative Disorders	Dissociative Disorders+
Feeding and Eating Disorders	Eating Disorders+
Mood Disorders	Affective Disorders+
Personality Disorders	Personality Disorders+
Schizophrenia Spectrum and Other Psychotic Disorders	Psychotic Disorders+
Substance-Related Disorders	Substance Use Disorders+
Trauma and Stressor Related Disorders	Stress Disorders, Post-Traumatic+

Overview of results for search #2 on 11th May 2021

Database	Result	Date
Pubmed	**1607**	**11/05/2021**
CINAHL	**1555**	**11/05/2021**
Embase	**Not available to Flinders Library but 100% of Embase content is available within Scopus and therefore included in this search**	
SCOPUS	**758**	**11/05/2021**
Psycinfo	**483**	**11/05/2021**
TOTAL	**4403**	
Deduplicate TOTAL	**3132**	

Table S2 – Quality appraisal scores for cohort studies (n = 49)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score %
Ajdacic-Gross et al. (2009)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	U	Y	63.6
Ames et al. (2018)	U	Y	Y	Y	Y	N	Y	Y	Y	U	Y	72.7
Berk et al. (2010)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Bierhoff et al. (2019)	N/A	N/A	Y	N	N	N	Y	Y	N	N	Y	36.4
Borges et al. (2018)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Buchy et al. (2014)	Y	Y	Y	U	U	Y	Y	Y	U	U	Y	63.6
Buchy et al. (2015)	N	Y	Y	Y	U	N	Y	Y	N	U	Y	54.5
Bulhões et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Chen et al. (2017)	N/A	N/A	Y	N	N	N	Y	Y	Y	U	Y	45.5
Crane et al. (2021)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Davies et al. (2018)	Y	Y	Y	Y	Y	N	Y	Y	N	U	Y	72.7
Ferdinand et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Fonseca et al. (2021)	N/A	N/A	Y	Y	N	Y	Y	Y	N	N	Y	54.5
Gage et al. (2014)	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y	72.7
Gårdvik et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Goodwin et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Goodwin et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	N	N	Y	54.5
Griesler et al. (2008)	U	Y	Y	Y	Y	N	Y	Y	Y	N	Y	72.7
Griesler et al. (2011)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Hu et al. (2012)	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	81.8
Hui et al. (2013)	N/A	N/A	Y	U	N	Y	Y	Y	Y	Y	Y	63.6

Isensee et al. (2003)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Johnson et al. (2000)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Jones et al. (2018)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	U	Y	63.6
Kalan et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	N	N	Y	54.5
Kendler et al. (2015)	N/A	N/A	Y	Y	Y	N	U	Y	N	U	Y	45.5
King et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
MacKie et al. (2011)	Y	Y	Y	U	U	N	Y	Y	N	U	Y	54.5
Marmorstein et al. (2010)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	N	Y	63.6
Marsden et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Moylan et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Mustonen et al. (2018)	N	Y	Y	Y	Y	N	U	Y	Y	Y	Y	72.7
Okeke et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Pedersen et al. (2009)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Purborini et al. (2021)	N/A	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	81.8
Raffetti et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Ranjit et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Ranjit et al. (2019b*)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Savageet al. (2016)	N/A	N/A	Y	U	N	N	Y	Y	Y	U	Y	45.5
Shete et al. (2017)	N	Y	U	U	N	N	Y	Y	N	U	Y	36.4
Smith et al. (2014)	U	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	81.8
Swendsen et al. (2010)	N/A	N/A	Y	Y	Y	U	Y	Y	Y	Y	Y	72.7
Tomita et al. (2018)	U	Y	U	Y	Y	Y	Y	Y	N	U	Y	63.6
Trotta et al. (2020)	N/A	N/A	Y	Y	Y	N	U	Y	Y	Y	Y	63.6
Ward et al. (2019)	U	Y	Y	Y	Y	Y	Y	Y	N	U	Y	72.7

Weiser et al. (2004)	N/A	N/A	Y	Y	Y	Y	U	Y	Y	Y	Y	72.7
Wilens et al. (2016)	N	Y	Y	Y	Y	N	Y	Y	N	U	Y	63.6
Zammit et al. (2003)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	Y	81.8
Zhang et al. (2018)	N	Y	Y	Y	Y	N	Y	Y	Y	U	Y	72.7
Total %	8.2	32.7	95.9	85.7	81.6	14.3	89.8	100.0	59.2	44.9	100.0	-

Note: *Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.
Y = Yes; N = No; U = Unclear; N/A = Not applicable. Q1 = Were the two groups similar and recruited from the same population?; Q2 = Were the exposures measured similarly to assign people to both exposed and unexposed groups?; Q3 = Was the exposure measured in a valid and reliable way?; Q4 = Were confounding factors identified?; Q5 = Were strategies to deal with confounding factors stated?; Q6 = Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?; Q7 = Were the outcomes measured in a valid and reliable way?; Q8 = Was the follow up time reported and sufficient to be long enough for outcomes to occur?; Q9 = Was follow up complete, and if not, were the reasons to loss to follow up described and explored?; Q10 = Were strategies to address incomplete follow up utilized?; Q11 = Was appropriate statistical analysis used?

Table S2 – Quality appraisal scores for systematic reviews (n = 4)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score %
Ahun et al. (2020)	Y	Y	Y	Y	Y	U	U	Y	U	Y	Y	72.7
Cairns et al. (2014)	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	90.9
Chaiton et al. (2009)	Y	Y	Y	Y	Y	U	U	Y	Y	Y	Y	81.8
Esmaeelzadeh et al. (2018)	Y	Y	Y	Y	Y	U	U	Y	Y	Y	Y	81.8
Total %	100.0	100.0	100.0	100.0	100.0	0.0	25.0	100.0	75.0	100.0	100.0	-

Y = Yes; N = No; U = Unclear; N/A = Not applicable. Q1 = Is the review question clearly and explicitly stated?; Q2 = Were the inclusion criteria appropriate for the review question?; Q3 = Was the search strategy appropriate?; Q4 = Were the sources and resources used to search for studies adequate?; Q5 = Were the criteria for appraising studies appropriate?; Q6 = Was critical appraisal conducted by two or more reviewers independently?; Q7 = Were there methods to minimize errors in data extraction?; Q8 = Were the methods used to combine studies appropriate?; Q9 = Was the likelihood of publication bias assessed?; Q10 = Were recommendations for policy and/or practice supported by the reported data?; Q11 = Were the specific directives for new research appropriate?

BMJ Open

Investigating the reciprocal temporal relationships between tobacco consumption and psychological disorders for youth: an international review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-055499.R2
Article Type:	Original research
Date Submitted by the Author:	18-Apr-2022
Complete List of Authors:	Stevenson, Jeremy; Flinders University, College of Medicine and Public Health Miller, Caroline; South Australian Health and Medical Research Institute, Population Health; The University of Adelaide Faculty of Health and Medical Sciences, Public Health Martin, Kimberley; The University of Adelaide Faculty of Health and Medical Sciences, Public Health Mohammadi, Leila; Flinders University of South Australia, College of Medicine and Public Health Lawn, Sharon; Flinders University, College of Medicine and Public Health
Primary Subject Heading:	Smoking and tobacco
Secondary Subject Heading:	Mental health, Smoking and tobacco, Respiratory medicine, Public health
Keywords:	Child & adolescent psychiatry < PSYCHIATRY, Depression & mood disorders < PSYCHIATRY, Substance misuse < PSYCHIATRY

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Title: Investigating the reciprocal temporal relationships between tobacco consumption and psychological disorders for youth: an international review

Jeremy Stevenson[1], Caroline L Miller[2,3], Kimberley Martin[3], Leila Mohammadi[1], Sharon Lawn[1]

[1]Flinders University, College of Medicine and Public Health, Adelaide, Australia

[2]Health Policy Centre, South Australian Health and Medical Research Institute, Adelaide, Australia

[3]University of Adelaide, School of Public Health, Adelaide, Australia

Corresponding Author: Professor Sharon Lawn, Flinders University, Room 2.11, Health Sciences Building, GPO Box 2100, Adelaide, 5001, South Australia, Australia

Email: sharon.lawn@flinders.edu.au

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Keywords: depression, anxiety, bipolar, psychosis, longitudinal, review, youth.

ABSTRACT

Objective: To investigate reciprocal temporal relationships between tobacco consumption and psychological disorders for youth.

Design: Review

Data sources: Five databases (PubMed, Embase, Scopus, CINAHL, PsycINFO) on 26th September 2019 and updated on 11th May 2021, indexing tobacco, mental illness, and longitudinal.

Study selection: Methods used consensus and multiple reviewers.

Interventions: Cohort studies (n=49) examining tobacco and selected psychological disorders (depression, anxiety, bipolar, psychosis, borderline personality disorder) among youth, and systematic reviews (n=4) of these relationships met inclusion criteria.

Primary and secondary outcome measures: Effect of tobacco on psychological disorders and effect of psychological disorders on tobacco.

Data extraction and synthesis: Independent extraction by the first author and checked by final author. Joanna Briggs Institute Critical Appraisal Tools were used for all studies. Included studies had moderate-to-high appraisal scores. We synthesized findings using vote counting for effect direction and descriptive data.

Results: Fifty-three studies were included in the review. Thirteen of 15 studies showed a positive effect direction of tobacco on depression ($p < .001$). Six of 12 studies showed a positive effect direction of depression on tobacco ($p = .016$). Six of eight studies showed a positive effect direction of tobacco on anxiety ($p = .016$). Eleven of 18 studies showed a positive effect direction of anxiety on tobacco ($p = .003$). No effect between tobacco and bipolar, or tobacco and psychosis was found. No studies examined tobacco and borderline personality disorder.

Conclusions: Reciprocal relationships existed between tobacco and both depression and anxiety for youth, though causality is unconfirmed. No positive effect direction was found between tobacco and psychosis, perhaps because nicotine has conflicting effects on psychosis. For other relationships examined, evidence was weak because of low numbers of studies. More research to inform prevention and early intervention is needed.

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ARTICLE SUMMARY

Strengths and limitations of this study

- This review has synthesised, in-depth, 53 studies for evidence of the reciprocal temporal relationships between tobacco consumption and psychological disorders for youth.
- The review has performed an analysis of the quality of the studies and identified knowledge gaps and methodological concerns that require further research.
- The included studies were very heterogeneous, preventing meta-analysis of the results.
- Psychological disorders were classified into broad categories; however, it is possible that young people's experiences of these disorders differ in how they relate to tobacco use.

INTRODUCTION

Tobacco consumption is associated with a myriad of economic, social, and health problems for young people [1]. One of the health problems associated with tobacco consumption is psychological disorders, and their co-occurrence can dramatically worsen the overall clinical course, physical health and psychosocial outcomes for the person [2-4]. Nicotine dependence per se is a psychological disorder with comorbid conditions being common. Tobacco contributes substantially to the reduced life expectancy observed among people who experience mental health disorders. Furthermore, people living with mental illness have shorter life expectancy than those without, and this is largely attributable to smoking-related illnesses [5, 6]. Youth (10-24 years of age) with psychological disorders are overrepresented among those who consume tobacco [7]. However, it is unclear if the relationship between tobacco and psychological disorders is causal or merely associational. If the relationship is indeed causal, the direction of this relationship is poorly understood [8]. Furthermore, it is unclear whether the 'tobacco-psychopathology' relationship is different depending on the specific type of psychological disorder experienced by the young person (e.g., perhaps tobacco use causes depression but not anxiety).

Several reviews have attempted to evaluate the relationship between tobacco and psychopathology [9-12], but these have several limitations including: 1) a lack of focus on youth; 2) the sample is mostly or entirely from North America, 3) only a small number of psychological disorders are examined; and 4) the existing studies and reviews are now quite dated. Given these limitations, we sought to produce an updated review that focuses specifically on youth and samples from a broader international population. Furthermore, we included more psychological disorders to facilitate comparison: anxiety, depression, bipolar disorder, psychosis, and borderline personality disorder. We chose these psychological

disorder categories because they affect a substantial percentage of youth [13]. The broad objective of our review was to examine the reciprocal temporal relationship between tobacco consumption and the selected psychological disorders for youth.

METHODS

Eligibility criteria

The inclusion criteria were studies with: 1) a focus on adolescents and youth 10-24 years of age; 2) systematic review of observational longitudinal studies OR observational longitudinal studies conducted since most recent systematic review OR all longitudinal studies if there is no relevant systematic review for the specific disorder; 3) measured tobacco consumption in any form (e.g., smoking, smokeless, snus), 4) measured psychological disorder categories of at least one of anxiety, depression, bipolar, psychosis, or borderline personality disorder; 5) English language; and 6) published in a peer-reviewed journal. Under the anxiety category, we included various types including social anxiety, panic, agoraphobia, and generalised anxiety. Under the bipolar category we included mania as this symptom is mostly associated with bipolar. Under the psychosis category we included schizophrenia and general psychotic symptoms. We included 'nicotine dependence' as a measure of tobacco consumption because these constructs are strongly related [14, 15]. Studies were excluded if the methods used meant that tobacco consumption could not be distinguished from other drug use (e.g., cannabis) and if the population was very specific (e.g., pregnant women). Our search strategy was based on advice from an expert University-based librarian and was also informed by previous systematic reviews identified during the early formulation of the current study [10,11].

Search strategy and study selection

The original search was conducted by KM using PubMed, Embase, Scopus, CINAHL and PsycINFO on 26th September 2019 and updated by LM on 11th May 2021. Initial searches were very broad and focused on keyword categories of tobacco and psychological disorders (for more information see supplementary materials). The screening and review process were managed within COVIDENCE software. After the initial search and de-duplication, JS and SL shared the initial screening and full-text reviews. JS and SL then discussed any conflicts in order to reach consensus about inclusion or exclusion. Where consensus could not be reached or the decision remained uncertain, final eligibility was resolved by CM.

For the updated search SL and JS each screened all new titles/abstracts with CM resolving conflicts, then SL did all full-text reviews, with JS checking 20% of excluded studies – agreement was 100%.

[Figure 1: PRISMA flow diagram]

Quality assessment, data extraction and data synthesis

To assess the quality of the included studies, we used the Joanna Briggs Institute (JBI) Critical Appraisal Tools for cohort studies and systematic reviews [16]. JS appraised all studies while SL appraised a random sample of 20%. Data extraction was conducted by JS and checked by SL in order to produce three tables: 1) Table S1 for descriptive information about the cohort studies, 2) Table 1 for vote counting of the direction of effects for cohort studies, and 3) Table 2 for descriptive information about the systematic reviews. For the 'results' column of Table S1, we extracted the most adjusted results in order to reduce the risk of confounding.[17] We did vote counting for effect direction (Table 1; counting the number of studies with positive vs negative effect direction) based on recent recommendations by Cochrane on conducting synthesis without meta-analysis [18]. To use this approach, we combined similar predictors (e.g., nicotine dependence, cigarette smoking,

and other tobacco use combined into 'tobacco') and outcomes (e.g., social anxiety, panic, and agoraphobia combined into 'anxiety') and classified effect direction as one of the following: 1) a positive/negative effect direction if at least 70% of findings showed consistency in this direction, 2) a conflicting effect if consistency was less than 70%, or 3) an 'unclear' effect if direction was not reported (for a similar method, see Thompson et al. [19]). For data synthesis, we evaluated each relationship individually (e.g., tobacco>depression; depression>tobacco; tobacco>anxiety etc; where the '>' symbol refers to the direction of the relationship). In this synthesis, we attempted to integrate all information from both the cohort and review studies (e.g., descriptive information and vote counting).

RESULTS

Publication dates of included studies

We found four systematic reviews for depression and tobacco in youth [9-11,20]. The most recent of these reviews [20] included studies up to November 1st 2018. So, in order to be comprehensive, we also collected depression cohort studies from 2018 onwards. We found two systematic reviews for anxiety and tobacco in youth; but, given the low sample size of anxiety studies in these reviews [11,20], we included anxiety cohort studies from any period. We did not find any systematic reviews for bipolar, psychosis, or borderline personality and tobacco in youth, so no publication date inclusion constraints were applied to studies involving youth who experience these disorder categories.

Quality appraisal

As per the PRISMA flow diagram (Figure 1) [21], our search identified 49 cohort studies and four systematic reviews, giving a total of 53 included studies. For the quality appraisal of included studies, we converted scores on the JBI into percentages in order to facilitate

interpretation. Higher percentage scores indicated higher quality studies, while a score ≤ 50% reflects low quality. For the cohort studies, there was a relatively low level of agreement between the authors (66.2%), whereas the systematic reviews had comparatively high agreement (84.1%). The main issues contributing to disagreement were different interpretations of the JBI criteria, particularly for cohort questions one, four, five, and six, as well as systematic review question four. These differences were resolved through discussion.

Overall, the included studies had moderate-to-high appraisal scores. The quality appraisal of included cohort studies (n = 49) is displayed in Table S1 and in more detail in Supplementary Table S2. Five of the cohort studies were classified as low quality, with the lowest score being 36.4% [22, 23]. The remaining appraisal scores ranged from 45.5% to 81.8%, with four studies scoring above 75% (i.e., high quality). In terms of common strengths, all studies utilized a sufficient follow-up time (Q8) and appeared to use appropriate statistical analysis (Q11). More than 89% of studies measured the exposures and outcomes in a valid and reliable way (Q3 and Q7). Most studies addressed confounders appropriately (Q4 and Q5). In terms of common weaknesses, only 14.3% of studies had samples that were free of the outcome at first assessment (e.g., below cut-off on a depression scale; Q6). Only a small minority of studies divided the sample into groups based on tobacco or psychological symptoms in order to make baseline comparisons, and thus the studies scored very low on Q1 and Q2. Few studies (44.9%) clearly explained strategies to address incomplete follow-up (Q10). These limitations should be considered when interpreting the review findings.

The quality appraisal of included review studies (n = 4) is displayed in Table 2 and Supplementary Table S2. Three reviews were appraised as high quality with percentage scores above 80%. In terms of strengths, all reviews met eight of the eleven criteria,

including: stating the review question clearly and explicitly (Q1), selecting appropriate inclusion criteria (Q2), utilizing a comprehensive search strategy (Q3 and Q4), using appropriate criteria to appraise studies (Q5), using appropriate methods to combine studies (Q8), and making evidence-based recommendations for policy/practice (Q10) as well as future research directions (Q11). In terms of weaknesses, no reviews clearly stated that critical appraisal was conducted by at least two reviewers independently (Q6), and only one review clearly outlined methods to minimize errors in data extraction (Q7) [9].

Overview of included cohort studies

As per Table S1, the vast majority of the 49 cohort studies were either from North America (n = 20, with 18 from USA) or Europe (n = 21). Most studies used a non-clinical youth sample (n = 40), with the remaining nine using a clinical sample (youth in receipt of clinical mental health services) or a pseudo-clinical sample (e.g., youth with elevated anxiety sensitivity). Sample sizes ranged widely from 117 to 233,879 (M = 8162.53, Mdn = 14,000, SD = 33738.60). Youth age at baseline ranged from 6.2 to 23.5 (M = 16.09, SD = 3.59). Follow-up periods with youth participants ranged from 1 to 27-years (M = 6.43, SD = 5.15). Of the 46 studies that provided this longitudinal follow-up information, the number of waves ranged from 2 to 15 (M = 3.93, SD = 2.40). In terms of the types of tobacco measures used, numerous studies used a binary measure (n = 25; e.g., cigarette user vs non-user, nicotine user vs non-user), while others used a categorical (ordinal) measure (n = 22; e.g., non vs moderate vs heavy smoker), while only five studies used a continuous measure. Nine studies used 'nicotine dependence' as the tobacco-related measure, while five used 'onset' (e.g., age of smoking onset), and four studies also included consumption of tobacco more broadly than cigarettes (e.g., cigarillos, snus, smokeless tobacco). Twelve studies used multiple measures of tobacco use. Only one study examined smoking-cessation as the tobacco-related variable. Most studies (n = 30) used structured interviews with youth (e.g., WHM-CIDI, PLIKSi) to assess the relevant psychological variable (e.g., anxiety), and a moderate number of studies (n = 19) used self-report measures (e.g., PHQ-9, CESD). Only four studies used caregiver-report (teacher or parent) and one study used peer-report. As shown in Table S1, there were zero relevant studies found for BPD. The number of covariates included in analyses ranged from 1 to 19 (M = 6.69, SD = 4.05). Common covariates included gender, age, SES, and other drug use (e.g., cannabis and alcohol). Common limitations of the cohort studies included: only

using two-waves, small sample sizes, not controlling for earlier levels of outcome or later levels of predictor, small cell sizes, and unclear temporal ordering.

Overview of included systematic reviews

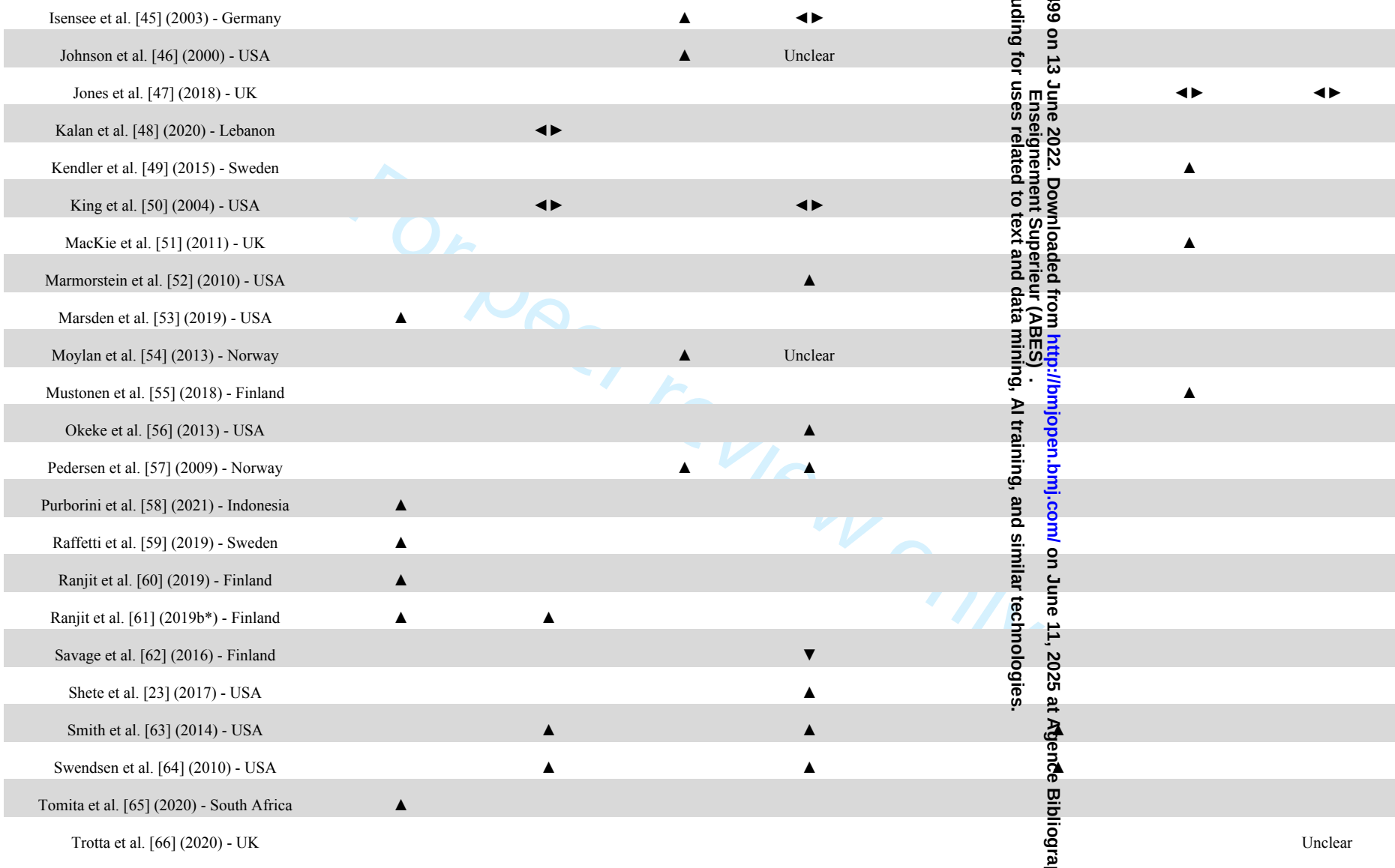
As per Table 2, one of the four systematic reviews only focused on youth from the USA and Canada [11], while the other three did not have geographical constraints. Cairns et al. [9] and Chaiton et al. [10] specified a target population age range, while Esmaeelzadeh et al. [11] and Ahun et al. [20] broadly referred to 'youth'. All reviews examined a variety of tobacco and psychological measures, and all four examined the relationship between tobacco and depression; whereas, only Esmaeelzadeh et al. [11] and Ahun et al. [20] also examined the relationship between tobacco and anxiety. None of the other psychological disorder categories were evaluated. Two of the reviews were limited by small sample sizes for anxiety analyses [11,20].

Tobacco>depression

Fifteen cohort studies examined the effect of tobacco use on the development of depression in youth, including only one with a clinical sample and eight with more than two waves. As shown in Table 1, there was evidence that tobacco had an effect on depression, with 13 of 15 studies (86.7%) showing a positive effect direction ($p < .001$). Only one of these studies was high quality (quality appraisal score > 75%), and this study found a positive effect direction. Effect estimates for each cohort study are shown in Table S1. Additionally, three of the four systematic reviews examined the effect of tobacco on depression and found a positive and significant pooled estimate, as shown in Table 2.

Table 1 - Vote counting of the direction of effects for cohort studies

Authors (year) - country	Tobacco>depression	Depression>tobacco	Tobacco>anxiety	Anxiety>tobacco	Tobacco>bipolar	Bipolar>tobacco	Tobacco>psychosis	Psychosis>tobacco
Ajdacic-Gross et al. [24] (2009) - Switzerland					◄►			
Ames et al. [25] (2018) - Canada	▲							
Berk et al. [26] (2010) - Australia							▼	
Bierhoff et al. [27] (2019) - USA		◄►		▲				
Borges et al. [28] (2018) - Mexico	▲	▲		▲				
Buchy et al. [29] (2014) - USA and Canada							▼	
Buchy et al. [30] (2015) - USA and Canada							Unclear	
Bulhões et al. [31] (2020) - Portugal	▲							
Chen et al. [32] (2017) - USA	▲		▲					
Crane et al. [33] (2021) - USA		Unclear						
Davies et al. [34] (2018) - UK		▲						▲
Ferdinand et al. [35] (2004) - Netherlands								▲
Fonseca et al. [36] (2021) - Brazil	▲							
Gage et al. [37] (2014) - UK							▲	
Gårdvik et al. [38] (2020) - Norway	▼		▲					
Goodwin et al. [39] (2004) - New Zealand				▲				
Goodwin et al. [40] (2013) - Germany		◄►		◄►		▲		
Griesler et al. [41] (2008) - USA	◄►	▲	◄►	◄►				
Griesler et al. [42] (2011) - USA	▲	◄►	◄►	▲				
Hu et al. [43] (2012) - USA				▲				
Hui et al. [44] (2013) - China							▲	



Ward et al. [67] (2019) - USA and Canada			◄►
Weiser et al. [68] (2004) - Israel			▲
Wilens et al. [69] (2016) - USA		▲	
Zammit et al. [70] (2003) - Sweden			▼
Zhang et al. [71] (2018) - Germany	▲		

Note. ▲ = positive effect direction; ▼ = negative effect direction; ◄► = conflicting effect directions; unclear = unclear effect direction.
*Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.

Depression>tobacco

Twelve cohort studies examined the effect of depression on development of tobacco use by youth. None of these studies used clinical samples, and seven had more than two waves. There was evidence that depression had an effect on tobacco use, with six of the twelve studies (50.0%) showing a positive effect direction (p = .016). One of these studies was high quality, and this study showed a positive effect direction. All of the systematic reviews examined the effect of depression on tobacco and the three reviews that reported a pooled estimate found a significant positive effect direction. The fourth review reported individual study results and found that 85.7% of the included depression>tobacco studies had a significant positive effect direction.

Tobacco>anxiety

Eight studies examined the effect of tobacco use on development of anxiety in youth. One of these had a clinical sample, and six had more than two waves. Tobacco appeared to have an effect on anxiety, with six of eight studies (75.0%) showing a positive effect direction (p = .016). None of these studies were high quality. One systematic review examined the effect of tobacco on anxiety and found a positive and significant effect, but this effect was based on only one study.

Anxiety>tobacco

Eighteen studies examined the effect of anxiety on development tobacco use by youth. None of these used a clinical sample, and 11 had more than two waves. Anxiety appeared to have an effect on tobacco use, with 11 of 18 studies (61.1%) showing a positive effect direction (p = .003). Two of these studies were high quality, and both showed a positive effect direction. Two systematic reviews examined the effect of anxiety on tobacco use. One of these found a

positive non-significant effect, while the other found a non-significant effect and did not report the effect direction. However, both reviews only included one anxiety>tobacco study and thus were extremely underpowered.

Tobacco>bipolar

Two studies examined the effect of tobacco use on development of bipolar in youth. Both of these studies used clinical samples and had more than two waves. Tobacco did not appear to have an effect on bipolar, with just one study (50%) showing a positive effect direction (p = .500). Neither of these studies was high quality. No reviews examined the tobacco-bipolar relationship.

Bipolar>tobacco

Three studies examined the effect of bipolar on development of tobacco use by youth. None of these used a clinical sample, and one had more than two waves. Bipolar did not appear to have an effect on tobacco use, with two studies (66.7%) showing a positive effect direction (p = .250). One of the three studies was high quality, and this study showed a positive effect direction. No reviews examined the bipolar-tobacco relationship.

Tobacco>psychosis

Twelve studies examined the effect of tobacco use on development of psychosis in youth. Seven of these used a clinical or pseudo-clinical sample, and seven had more than two waves. Tobacco use did not appear to have an effect on psychosis, with only six studies (50%) showing a positive effect direction (p = .254). Only one of the twelve studies was high quality, and this study showed a negative effect direction. No reviews examined the tobacco-psychosis relationship.

Table 2 – Descriptive information about systematic reviews (n = 4)

Authors (year)	Target population and study designs (n)	Tobacco measure/s	Psychological measure/s	Relationship/s examined (n)	Result	Quality score %	Limitations
Ahun et al. [20] (2020)	Youth (n = 43)	Cigarette smoking	Unclear	Depression>tobacco (N = 7); anxiety>tobacco (N = 1)	Six of the depression studies had a significant association with cigarette smoking, while the one anxiety study did not		No statistics reported, only significance of association; only one anxiety study examined;
Cairns et al. [9] (2014)	Youth aged 12-18 (n = 17)	Any form	Unclear	Tobacco/depression	Tobacco associated with increased depression with small effect size (r = .09, CI = 0.06-0.12)		Directionality unclear
Chaiton et al. [10] (2009)	Non-clinical youth aged 13-19 (n = 15)	Mostly 'smoking onset' operationalised as ever having had a 'puff' or 'one cigarette'	Various but mostly CES-D	Tobacco>depression (n = 6); depression>tobacco (n = 12)	Smoking predicted depression (PE = 1.73, CI = 1.32-2.40); depression predicted smoking (PE = 1.41, CI = 1.21-1.63)		Low number of tobacco>depression studies
Esmaeelzadeh et al. [11] (2018)	Youth from USA and Canada (N = 17)	Various (e.g., ever smoked; current smoker; regular smoker)	Various for depression but mostly CES-D; various for anxiety (e.g., SIAS, DISC-IV)	Depression>tobacco (n = 7); tobacco>depression (n = 4); anxiety>tobacco (n = 1); tobacco>anxiety (n = 1)	Depression predicted tobacco use (OR = 1.22, CI = 1.09-1.37); tobacco use predicted depression (OR = 1.87, CI = 1.23-2.85); anxiety did not predict tobacco use (OR = 1.38, CI = 0.83-2.29); tobacco use predicted anxiety (OR = 1.88, CI = 1.47-2.41)	81%	Low number of studies especially for anxiety; only USA and Canada; different types of anxiety pooled together

Note: CES-D = Center for Epidemiology Depression Scale; CI = Confidence interval; DISC-IV = Diagnostic interview schedule for children, version IV; OR = Odds ratio; SIAS = Social interaction anxiety scale.

Psychosis>tobacco

Four studies examined the effect of psychosis on development of tobacco use by youth. None of these used a clinical sample, and three had more than two waves. Psychosis did not appear to have an effect on tobacco use, with two studies (50.0%) showing a positive effect direction ($p = .250$). None of these studies were high quality, and no reviews examined the psychosis-tobacco relationship.

DISCUSSION

The purpose of the current study was to review the reciprocal temporal relationships between youth tobacco consumption and a group of psychological disorder categories including depression, anxiety, bipolar, psychosis, and borderline personality disorder (BPD). This review was justified because existing reviews: 1) are several years old, 2) have biased samples, 3) only examine a narrow range of psychological disorders, and 4) lack a dedicated focus on youth.

Synthesising the cohort and review studies, we found evidence that tobacco consumption predicted the development of depression and anxiety for youth, but not bipolar or psychosis. Tobacco might cause depression through certain biological mechanisms (e.g., decreasing the cortisol response) and also by eliciting withdrawal symptoms of low mood [59]. However, it is also possible that this longitudinal relationship is not causal. For example, the relationship may become non-significant when certain confounders (e.g., familial and genetic factors) are controlled for, as was found by Ranjit et al. [60,61]. Tobacco use might cause anxiety because it elicits physiological symptoms for the young person similar to anxiety (e.g., shortness of breath, increased heart rate and blood pressure), which are then catastrophically misinterpreted [45]. However, similar to depression, this relationship might be better

explained by unmeasured confounders and may not be causal [54]. Also, it is important to consider is that smoking exerts its adverse effects on a cumulative basis, which means that higher exposure with increasing time will increase the risk of incident mental health events. If specific outcomes do not occur in response to smoking due to restricted timeframe due to younger age, it does not mean that a causal relationship per se can be excluded.

Hahad et al. [72] recently reviewed the evidence for smoking as a potential risk factor for neuropsychiatric disorders such as depression, anxiety and psychosis, with the aim of identifying central pathophysiological mechanisms that may contribute to these relationships. Readers are referred to this review for a more comprehensive understanding of the evidence for neuropsychiatric pathophysiology. Hahad et al. emphasise that oxidative stress or inflammatory mediators associated with cigarette smoke can impair proper endothelial (vascular) function essential for a healthy cardiovascular system, with implications for the function of other bodily systems. They stress that prolonged oxidative stress combined with prolonged exposure noxious chemicals from cigarette smoke can lead to chronic inflammation, and that consequent structural and functional alterations in the central nervous system of individuals who smoke may indeed increase the risk of these disorders and other chronic conditions. Hahad et al. argue, however, that, 'the relationship between smoking, oxidative stress, inflammation, and neuropsychiatric diseases is not always clear. This stems from the fact that neuropsychiatric diseases also increase the chance that a person will start-smoking, making the direction of association difficult to establish' (p.7278). Hahad et al. also remind us that psychiatric disorders, 'have strong link with chronic stress, which represents one of the most prominent risk factors for their onset' (p.7279), and that chronic stress is also featured in several chronic conditions (e.g., cardiac and metabolic conditions) and can therefore intuitively increase the risk of psychiatric disorders.

Our synthesis of findings suggests that tobacco may not predict psychosis, which was notable because numerous studies (n=12) examined this relationship. Of the six studies that found a positive effect direction, only one of these was a high-quality study [68], though several other moderate quality studies also found a positive effect direction. Tobacco use may have failed to predict psychosis because other confounders play a true causal role in the young person's experience of psychosis (e.g., other substance use; Ward et al.) [67]. Alternatively, it has been hypothesised that nicotine could actually decrease negative psychotic symptoms, mediated by an increase in dopamine [70]. Our sign test showed an overall lack of effect of tobacco on bipolar, which contradicts past research that does propose a causal effect [73]. However, only two included studies examined the effect of tobacco on bipolar, indicating that more longitudinal research is needed on this topic.

A similar pattern of results was found when investigating reverse-causation. The presence of both depression and anxiety predicted future tobacco use, potentially because people who experience depression and anxiety may have a greater probability of using tobacco to self-medicate (i.e., to try to reduce adverse symptoms; Swendsen et al. [64]. However, as with the effect of tobacco on depression, these relationships may only exist until familial and genetic confounders are controlled for [60,61]. Presence of psychosis may have failed to predict tobacco use due to certain confounders (e.g., cannabis use) that better explain the variance in tobacco use [47], but the number of studies that examined this relationship was minimal (n = 4). Similarly, according to the sign test, presence of bipolar did not have an overall effect on tobacco use. However, only three studies examined this relationship, and one of these studies was high quality and did find an effect. Hence, more longitudinal research is needed on this question.

There were several limitations to this review. Firstly, the included studies were very heterogeneous, particularly with regard to sample size, sample nature (i.e., clinical vs non-clinical), number and type of confounders, follow-up period, number of waves, and type of statistics used. Due to this heterogeneity, we were unable to meta-analyse the results and capture effect sizes. However, despite these constraints, we were still able to synthesise the quantitative data using vote counting based on effect direction, which is current best practice when meta-analysis is not possible, according to recent recommendations by Cochrane [18]. A second limitation is consideration of causation itself. For example, where tobacco use precedes and predicts depression, it is conceivable that tobacco use is having an 'effect' on depression, but it is also plausible that some other common factor/s may be causing both disorders, and the temporal sequence is somewhat arbitrary. Further research is needed, investigating to potential interplay of genetics and environmental factors that may act as confounders. A third limitation was the way in which we classified psychological disorder categories. For example, under the category of 'anxiety', we grouped various disorders including panic, social anxiety, generalised anxiety, and agoraphobia. However, it is possible that young people's experiences of these disorders differ in how they relate to tobacco use. For example, tobacco might have a greater effect on panic compared to social anxiety because tobacco can cause impaired respiration which is more associated with panic symptoms than social anxiety symptoms [46]. Also, we included mania under the bipolar category; however, mania could be unipolar as well without depressive symptoms [74]. As more research accumulates on tobacco and mental health, future reviews should distinguish between sub-types of psychological disorder categories.

Given the gap in the literature, future research should examine the reciprocal longitudinal relationship between tobacco use and BPD. Additionally, more studies should be conducted that investigate the relationship between tobacco, psychosis, and bipolar. Although there are numerous studies on tobacco and both depression and anxiety, future research should continue to examine confounders such as familial and genetic factors in order to strengthen causal inferences.

The mechanisms underlying smoking and mental illnesses are complex and yet to be thoroughly investigated and understood. In the meantime, a number of clinical implications are apparent for addressing the health and socio-economic burdens of tobacco use which are disproportionately high among people living with mental disorders. Addressing the uptake of tobacco use by young people must remain a high priority as part of public health measures targeting prevention and early intervention. This should include promoting greater awareness of the links between smoking and the onset of neuropsychiatric disorders among youth, their families, health and welfare professionals (particularly those working with at risk individuals and families), school systems and the community. More concerted treatment and smoking cessation support for young people must also be developed, made available and accessible, with health messaging that is better matched to their help-seeking behaviours, peer networks, and motivations for addressing smoking behaviours. Coupled with this, and in order to prevent the longer-term harms of smoking, health professionals must be supported to gain more skills and confidence to ask, advise and actively help young people with emerging and existing psychological disorders who smoke to address their smoking.

CONCLUSION

We found support for reciprocal relationships between tobacco and both depression and anxiety for youth, though questions remain around whether these relationships are causal. In contrast, we did not find overall evidence for a causal relationship between tobacco and psychosis for this population, perhaps because nicotine has conflicting effects on the person's experience of psychosis. For the other relationships examined (tobacco>bipolar; bipolar tobacco; psychosis>tobacco), evidence was weak because of low numbers of studies. Further studies that examine the complexities of interactions between tobacco and mental health for different diagnostic groups are needed to inform prevention, early intervention, treatment and smoking cessation support for youth with comorbid psychological conditions and tobacco use.

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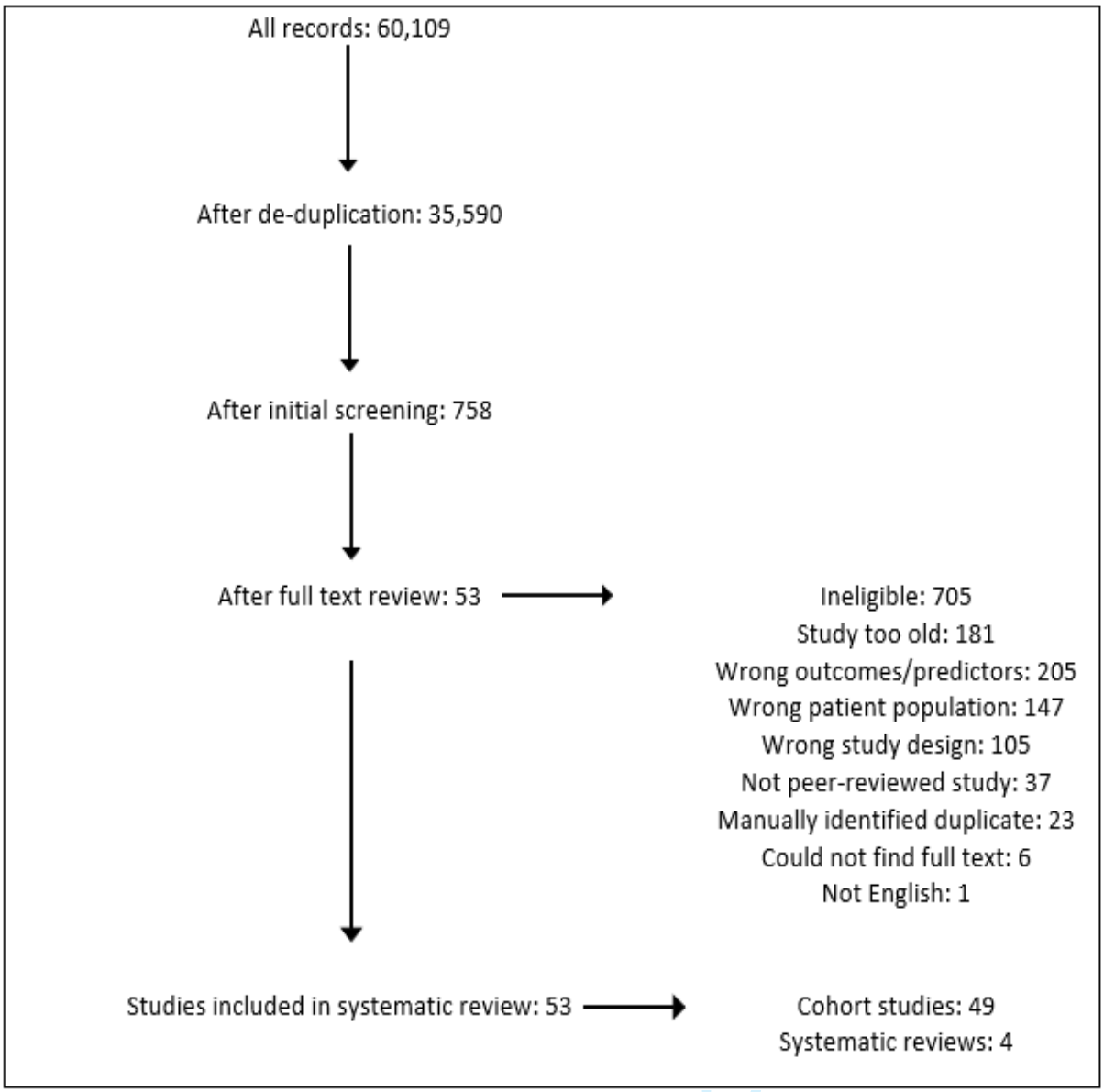

Figure 1: PRISMA flow diagram

Table S1 – Descriptive information about cohort studies (n = 49)

Authors (year) - country	Target population (n)	Structure - Baseline age, cohort years, #waves	Tobacco measure	Psychological measure/s	Relationship/s examined	Result	Covariates	Quality Score %	Limitations
Ajdacic-Gross et al. [24] (2009) - Switzerland	Stratified sample of participants with psychological disorders (N = 591)	21 years of age; 20-year follow-up; 6-waves	Smoking onset (never vs adolescent; never vs adult)	SPIKE	Tobacco>bipolar	For heavy smokers, adolescent onset of smoking predicted later bipolar compared to never smokers (OR = 7.1, CI = 1.9-25.9); but for other smokers this relationship was non-significant (OR = 0.9, CI = 0.3-2.7)	smoking; parents; conduct problems; school problems; family problems; extraversion; neuroticism; masculinity; regular tobacco use	63.6	Adolescent onset of smoking retrospective; temporal sequencing unclear; high attrition; small bipolar sub-group; CIs unavailable
Ames et al. [25] (2018) - Canada	Youth (n = 662)	12-18 years of age; 10-year follow-up; 6-waves	Smoking status (smoker vs non-smoker)	BCFPI	Tobacco>depression	Adolescent smoking predicted membership in persistent high depression trajectory group versus low stable group (Est. = 1.18, SE = 0.55, P < .05, OR = 3.26, CIs unavailable)	Gender; age; SES; earlier levels of smoking and depression; physical health; health-promoting behaviour; heavy drinking; marijuana use; number of sexual partners; BMI	72.7	CIs unavailable
Berk et al. [26] (2010) - Australia	Youth with schizophrenia (n = 193)	21.9 (SD = 3.6) years of age; 7.5-year follow-up; 3-waves	Smoking status (smoker vs non-smoker)	BPRS-PS	Tobacco>psychosis	Baseline smoking did not predict future psychosis (B = 0.20, p = .871)	Gender; problem illicit drug use; problem alcohol use; duration of untreated psychosis	72.7	Change in smoking status not assessed
Bierhoff et al. [27] (2019) - USA	University students (n = 2397)	20.5 (SD = 1.93) years of age; 2-year follow-up; 6-waves	Prior 30-day tobacco quantity (cigarettes, cigarillos)	PHQ-9; ZSRAS	Depression>tobacco; anxiety>tobacco	Depression (OR = 1.05, CI = 1.02-1.09) and anxiety (OR = 1.02, CI = 1.00-1.04) predicted cigarette quantity; depression (OR = 1.05, CI = 1.02-1.09) and anxiety (OR = 1.03, CI = 1.00-1.06) predicted cigarillo quantity; but depression and anxiety did not predict smokeless tobacco use, e-cigarette use, or hookah use (ORs ranged from 0.95-1.06)	Age; gender; sexual orientation; ethnicity; parental education; school type; ADHD;	36.4	Anxiety only measured at W5; only W6 smoking included in analyses; temporal ordering unclear
Borges et al. [28] (2018) - Mexico	Youth (n = 1071)	12-17 years of age; 8-year follow-up; 2-waves	Tobacco use (never vs use before age 15 vs use at age 15 or older); nicotine dependence	WMH-CIDI	Tobacco>depression; tobacco>anxiety; depression>tobacco; anxiety>tobacco	Early tobacco use predicted future mood disorder (RR = 1.42, CIs = 1.02-1.98); other results with tobacco use were non-significant but data not shown; nicotine dependence predicted future mood disorder (RR = 3.30, CI = 1.66-6.55); mood disorder did not predict future nicotine dependence (RR = 1.50, CI* = 0.55-3.90); anxiety did not predict future nicotine dependence (RR = 1.78, CI* =	Alcohol use; drug use; gender; age; living with parents; enrolled in school; parents' education; parents' income; number of childhood adversities	72.7	Individual disorders not examined as outcomes; only 2-waves

					0.95-3.60); data unavailable for nicotine dependence predicting anxiety				
Buchy et al. [29] (2014) - USA and Canada	Youth at high clinical risk of psychosis (n = 170)	19.8 (SD = 4.5) years of age; 4-year follow-up; 2-waves	Tobacco use (abstinent vs any use vs severe dependence)	SIPS	Tobacco>psychosis	Tobacco use did not predict transition to psychosis (U = 1752.5, p = .13)	Alcohol use; cannabis use; other illicit drug use	63.6	Small sub-group sample sizes; smoking only measured at W1; only 2-waves
Buchy et al. [30] (2015) - USA and Canada	Youth at clinical high risk of psychosis (N = 735) and healthy controls (N = 278)	18.5 (SD = 4.2) years of age for clinical high risk; 19.6 (4.7) years of age for controls; 2-year follow-up; 3-waves	Tobacco use (abstinent vs use without impairment vs abuse vs dependence)	SIPS; SOPS	Tobacco>psychosis	Smoking severity (U = 11495.5, p = .24) and frequency (U = 11638.0, p = .35) did not predict transition to psychosis	Alcohol use; cannabis use; other illicit drug use	54.5	Small sub-group sample sizes; all participants were help-seekers which may limit external validity
Bulhões et al. [31] (2020) - Portugal	Youth (n = 2010)	13-years of age; 8-year follow-up; 3-waves	Smoking status (never vs former; never vs current)	BDI-II	Tobacco>depression	Current smoking (vs never) predicted moderate (OR = 1.61, CI = 1.22-2.13) and high (OR = 1.89, CI = 1.18-3.01) depression trajectory groups (vs low). Former smoking (vs never) did not predict moderate (OR = 1.15, CI = 0.87-1.52) or high (OR = 1.08, CI = 0.65-1.78) depression trajectory groups (vs low)	Parents' education	54.5	Minimal covariates; temporal ordering unclear
Chen et al. [32] (2017) - USA	Youth with early-onset schizophrenia (n = 117)	13.9 (SD = 2.34) years of age; 3-year follow-up; 7-waves	Prior 6-month cigarette use (yes or no)	RADS; RCMAS	Tobacco>depression; tobacco>anxiety	Both depression (B = -13.70, SE = 5.03, p < .01) and anxiety (B = -14.41, SE = 5.90, p < .05) interacted with time to predict smoking	Age; gender; race; comorbidity; diagnosis; trauma; ; poverty	45.5	Small sample size; high attrition
Crane et al. [33] (2021) - USA	Youth (n = 1263)	15.6 (SD = 0.6) years of age; 7-year follow-up; 7-waves	Cigarette frequency (#days used in past month)	CESD-20	Depression>tobacco	Depression and time did not interact to predict future cigarette frequency (Est. = 0.00, SE = 0.00, p = .35)	Gender; race; ethnicity	72.7	Minimal covariates
Davies et al. [34] (2018) - UK	Youth (n = 6796)	12 years of age; 8-year follow-up; 4-waves	Smoking frequency (regularly [at least weekly] vs not)	SMFQ; PLIKSi	Psychosis>tobacco; depression>tobacco	Psychosis (OR = 1.11, CI = 0.79-1.56) and depression (OR = 1.23, CI = 0.78-1.95) at age 12 did not predict smoking at age 18	Gender; SES; housing; mother's education; IQ at age 8; SDQ at age 8; baseline levels of psychosis and depression	72.7	Smoking only measured at W3; high attrition
Ferdinand et al. [35] (2004) - Netherlands	Children and youth (n = 2600)	4-16 years of age; 14-year follow-up; 6-waves	Tobacco use (yes or no)	CBCL; YSR; YASR	Psychosis>tobacco	Auditory hallucinations at W2-5 predicted tobacco use at W6 (ORs ranging from 2.0-3.3); visual hallucinations were non-significant predictors (results not shown)	Gender; age; SES	54.5	Tobacco use not measured at W1
Fonseca et al. [36] (2021) - Brazil	University students without depression (n = 1034)	16-25 years of age; 3-year follow-up; 4-waves	Smoking status (yes if smoked at least 1 cigarette in previous 30-days)	PHQ-9	Tobacco>depression	Smoking did not predict depression for males (unadjusted IRR = 1.04, CI = 0.61-1.76) or females (unadjusted IRR = 1.49, CI = 0.97-2.27)	Age; SES; living situation; stress; alcohol use; sedentary behaviour; physical activity; sleep duration	54.5	Temporal ordering unclear; no overall statistics combining genders

Gage et al. [37] (2014) - UK	Youth without psychotic experiences at age 16 (n = 1573)	16 years of age; 2-year follow-up; 2-waves	Cigarette quantity (non-smoker vs experimenter vs weekly smoker vs daily smoker)	PLIKSi	Tobacco>psychosis	W1 cigarette use predicted psychotic symptoms at W2 (OR = 1.77, CI = 1.18-2.66)	psychotic experience at 18; by categorical frequency of cigarette use at 18; family history of depression; mother's education; borderline personality; IQ at age 8; depression at age 12; conduct disorder; peer problems; bullied; cannabis use; illicit drug use; alcohol use	72.7	Tobacco use not measured at W2; psychosis not measured at W1; only 2-waves
Gårdvik et al. [38] (2020) - Norway	Youth (n = 717)	13-18 years of age; 3-year follow-up; 2-waves	Smoking status (yes or no)	K-SADS; DAWBA	Tobacco>depression; tobacco>anxiety	Smoking did not predict mood disorders (RD% = -0.5, CI = -3.0-2.6) but did predict anxiety disorders (RD% = 4.5, CI = 2.0-9.2)	chronic pain; any substance disorder; alcohol and drug use; age; SES	72.7	Only 2-waves; temporal ordering unclear
Goodwin et al. [39] (2004) - New Zealand	Youth (n = 1000)	18-years of age; 2-year follow-up; 2-waves	Nicotine dependence (survey constructed based on DSM-IV criteria)	WMH-CIDI	Anxiety>tobacco	Anxiety disorders were not associated with nicotine dependence (OR = 1.46, CI = 0.93-2.29)	Parental change; parental violence; sexual abuse; physical abuse; parental history of criminality, alcohol problems, illicit drug use and depression/anxiety; low self-esteem; neuroticism; quality of parental attachment; family stress; early shyness; early conduct problems; early attention problems; gender; prior substance dependence; concurrent major depression; affiliation with deviant peers	72.7	Only 2-waves; temporal ordering unclear; specific anxiety disorders not specified
Goodwin et al. [40] (2013) - Germany	Youth (n = 3021)	14-24 years of age; 10-year follow-up; 4-waves	Nicotine use (yes or no) and smoking trajectory (non-user vs increasing use vs decreasing use vs persistent use; MCIDI/DIA-X)	MCIDI/DIA-X	Bipolar>tobacco; depression>tobacco; anxiety>tobacco	Any depressive disorder, any fear disorder, GAD, and specific phobia were associated with nicotine use (ORs ranged from 1.1-5.7); any depressive disorder predicted subsequent decreasing smoking trajectory (OR = 1.7, CI = 1.1-2.8); panic disorder negatively predicted increasing smoking trajectory (OR = 0.1; CI = 0.0-0.9); all other results non-significant (ORs ranged from 0.7-2.2)	Gender; age;	54.5	Difficult to interpret results (e.g., depression predicted binary nicotine use but also predicted decreasing trajectory).
Griesler et al. [41] (2008) - USA	Youth (n = 1039)	15.7 (SD = 1.4) years of age; 2-	Nicotine dependence (CIDI); lifetime	DISC	Anxiety>tobacco; tobacco>anxiety;	Anxiety (OR = 1.0, CI = 0.3-3.4) and mood (OR = 1.7, CI = 0.8-3.7) disorder did not predict nicotine dependence;	Age; gender; ethnicity; disruptive disorder; novelty seeking; age of	72.7	Individual disorders not examined as predictors/outcomes;

		year follow-up; 5-waves	cigarettes smoked (0; 1; 2-5; 6-15; 16-25; 26-99; 100+); other lifetime tobacco use		depression>tobacco; tobacco>depression	nicotine dependence did not predict anxiety (OR = 0.8, CI = 0.3-2.0) and mood (OR = 2.4, CI = 0.5-10.7) disorder; lifetime cigarettes smoked did not predict anxiety (OR = 1.0, CI = 0.9-1.0) and mood (OR = 1.0, CI = 0.9-1.0) disorder; other lifetime tobacco use did not predict anxiety (OR = 0.4, CI = 0.2-1.0) and mood (OR = 0.6, CI = 0.1-2.7) disorder	Onset of smoking; initial sensitivity to tobacco; number of lifetime cigarettes smoked; other lifetime tobacco use; drug use; peer smoking; school smoking; parent smoking; parent depression; parent delinquency; any psychiatric disorder		short follow-up period; variables not measured at all waves
Griesler et al. [42] (2011) - USA	Stratified sample of smoking youth (n = 814)	15.7 (SD = 1.4) years of age; 2-year follow-up; 5-waves	Nicotine dependence (zero dependence criterion vs one dependence criterion vs three criteria; CIDI)	DISC	Tobacco>depression;	No specific psychological disorders predicted one dependence criterion (statistics now shown) and only panic disorder predicted full (i.e., three) dependence criteria (HR = 2.2, CI = 1.2-3.9); nicotine dependence did not predict any specific psychological disorders (statistics not shown); anxiety disorder did not predict first nicotine dependence criterion (HR = 1.10, CI = 0.78-1.55), but did predict full nicotine dependence (HR = 1.68, CI = 1.12-2.52); mood disorder did not predict first nicotine dependence criterion (HR = 1.16, CI = 0.86-1.55) or full nicotine dependence (HR = 0.93, CI = 0.63-1.38); one dependence criterion did not predict anxiety (HR = 1.12, CI = 0.52-2.39) or mood (HR = 1.10, CI = 0.54-2.26) disorder; full dependence criteria did not predict anxiety (HR = 0.76, CI = 0.23-2.49) or mood (HR = 1.82, CI = 0.67-4.96) disorder	Gender; ethnicity; age of onset of tobacco use; initial sensitivity to tobacco; alcohol and other illicit drug use; parent education; parent smoking; parent depression; parent delinquency; ever tobacco dependent	72.7	Individual disorders not examined as predictors/outcomes; short follow-up period; variables not measured at all waves
Hu et al. [43] (2012) - USA	Stratified sample of lifetime youth smokers (n = 877)	14.1 (SD = 1.4) years of age; 7-year follow-up; 6-waves	Nicotine dependence (no dependence criteria vs early onset/chronic course vs early onset/remission vs late onset)	DISC	Anxiety>tobacco	Anxiety disorder predicted chronic course, early remission, and late onset nicotine dependence (compared with none, ORs ranged from 3.65-4.55); anxiety disorder did not predict chronic course vs early remission, chronic course vs late onset, or early remission vs late onset (ORs ranged from 1.04-1.09)	Gender; ethnicity; onset age of smoking; smoked 5+ packs per month; maximum number of drinks per month; marijuana use; onset age of marijuana; pleasant initial sensitivity to tobacco; parental nicotine dependence; disruptive/mood/anxiety disorder by W5	81.8	Anxiety only measured at W3 and W5; temporal ordering unclear

Hui et al. [44] (2013) - China	Youth with psychosis (n = 1400)	21.2 (SD = 3.4) years of age; 3-year follow-up; 3-waves	Smoking status (non-smoker vs current smoker vs ex-smoker)	CGI-S	Tobacco>psychosis	Smoking predicted relapse of psychosis (HR = 1.42, CI = 1.15-1.76)	Age of schizophrenia diagnosis; length of baseline hospitalisation; adherence at clinical stabilisation	63.6	Difficulty defining relapse; confounder of stressful life events not included
Isensee et al. [45] (2003) - Germany	Youth (n = 3021)	14-24 years of age; 3.5-year follow-up; 3-waves	Smoking quantity (never vs occasional vs non-dependent regular vs dependent regular)	MCIDI/DIA-X	Tobacco>anxiety; anxiety>tobacco	Smoking predicted future agoraphobia, SAD, specific phobia, panic attacks without disorder, and unspecified phobia (ORs ranged from 2.4-3.7), but did not predict panic disorder (ORs ranged from 0.1-3.6); no psychological disorders or symptoms predicted smoking (ORs ranged from 0.3-2.6)	Gender; age; PTSD; parental and illicit drug disorders; eating disorders	72.7	Small sample sizes for certain disorders
Johnson et al. [46] (2000) - USA	Youth (n = 688)	~16 years of age; 6-year follow-up; 2-waves	Smoking quantity (less than 1-pack per day vs more than 1-pack per day)	DISC	Tobacco>anxiety; anxiety>tobacco	Smoking predicted future agoraphobia, GAD, and panic disorder (ORs ranged from 5.53-15.58) but not SAD (OR = 0.44, CI = 0.04-4.62); anxiety disorders did not predict future smoking (statistics unavailable)	Gender; age; difficult childhood temperament; parental education; parental smoking; parental psychopathology; adolescent alcohol and drug use; adolescent anxiety and depressive disorders	72.7	Only 2-waves; small sample sizes for certain disorders
Jones et al. [47] (2018) - UK	Youth (n = 3328)	13.9 (SD = 2.7) years of age; 5-year follow-up; 6-waves	Cigarette use (yes or no)	PLIKSi	Psychosis>tobacco; tobacco>psychosis	Cigarette use did not predict subsequent psychosis (ORs ranged from 0.73-1.78); psychosis did not predict subsequent cigarette use (ORs ranged from 0.86-1.60)	Gender; mother's education; emotional and behavioural problems at 9 years of age; mother's smoking during pregnancy	63.6	High attrition
Kalan et al. [48] (2020) - Lebanon	Youth waterpipe (N = 228) and cigarette smokers (N = 139)	14.3 (SD = 1.2) years of age; 6-year follow-up; 8-waves	Nicotine dependence initial symptoms; nicotine dependence full diagnosis	DSS	Depression>tobacco	For waterpipe smokers, depression did not predict initial nicotine dependence symptoms (unadjusted HR = 1.03, CI = 0.98-1.09) but did predict full nicotine dependence diagnosis (HR = 1.13, CI = 1.02-1.25). For cigarette smokers, depression did not predict initial dependence symptoms (unadjusted HR = 1.00, CI = 0.94-1.06) or full nicotine dependence diagnosis (unadjusted HR = 0.96, CI = 0.85-1.09)	Gender; BMI; SES; age	54.5	Small sample size
Kendler et al. [49] (2015) - Sweden	Males from conscript registry (n = 233,879)	18.5 (SD = 8.4) years of age; 8-year follow-up; 5-waves	Smoking quantity (none vs light vs heavy)	Registry diagnosis (assessment tool unclear)	Tobacco>psychosis	W1 and W2 light (vs no) smoking did not predict subsequent schizophrenia (ORs ranged from 1.60-1.62) but W3 did (OR = 1.77, CI = 1.02-3.05); W1 and W3 heavy (vs no) smoking did predict subsequent schizophrenia (ORs ranged from 2.21-	Family SES; community SES; drug abuse	45.5	Only male youth; psychological disorder assessment method unclear

						2.39), but W2 did not (OR = 1.96, CI = 0.95-4.06)			
King et al. [50] (2004) - USA	Youth twins (n = 1364)	11 years of age; 3-year follow-up; 2-waves	Nicotine onset; regular cigarette use; daily nicotine use	DICA-R	Anxiety>tobacco; tobacco>anxiety	Using adjusted analyses, W1 MDD predicted W2 nicotine onset (OR = 1.98, CI = 1.15-3.41), but using unadjusted analyses did not predict regular cigarette use or daily nicotine use (ORs ranged from 0.83-1.94); using unadjusted analyses, W1 separation anxiety disorder and overanxious disorder did not predict any of the outcomes (ORs ranged from 0.84-1.25)	conduct disorder; oppositional defiant disorder; ADHD; gender	72.7	Only 2-waves; anxiety disorders assessed for females only; variables only measured at one time point each; only some analyses adjusted
MacKie et al. [51] (2011) - UK	Youth (n =409) with elevated hopelessness, anxiety-sensitivity, impulsivity and sensation-seeking	14.5 years of age; 1.5-year follow-up; 4-waves	Cigarette use (yes or no)	DIS	Tobacco>psychosis	W1 cigarette use did not predict persistent psychotic trajectory (OR = 1.3, 0.3-5.1) but did predict increasing psychotic trajectory (OR = 5.4, CI = 1.5-20.1)	Gender; ethnicity; anxiety sensitivity; hopelessness; impulsivity; sensation seeking	54.5	Short follow-up; small sample sizes in sub-groups
Marmorstein et al. [52] (2010) - USA	Male youth (n = 503)	~6.2 years of age; 14-year follow-up; 15-waves	Age at first tobacco use	CBCL; TRF; YSR	Anxiety>tobacco	Both generalised (OR = 0.06, CI = .02-.17) and social anxiety (OR = 0.06, CI = .02-.17) interacted with time to predict earlier onset of tobacco use	Age at first alcohol and substance use; delinquency	63.6	Statistics unclear; only male sample
Marsden et al. [53] (2019) - USA	University students (n = 5236)	21.0 (SD = 2.3) years of age; 3-year follow-up; 6-waves	Past 30-day use and frequency of use of cigarettes, refillable e-cigarettes, disposable e-cigarettes, hookah, cigars (including cigarillos and little cigars), and smokeless tobacco	CESD-10	Tobacco>depression	For past 30-day use, significant predictors of depression were cigarettes, refillable e-cigarettes, and hookah (rate ratios ranged from 1.01-1.03), but disposable e-cigarettes, cigars, and smokeless tobacco were non-significant (rate ratios ranged from 1.00-1.10); for frequency of use, significant predictors of depression were cigarettes, refillable e-cigarettes, and smokeless tobacco (rate ratios ranged from 1.10-1.04), but disposable e-cigarettes, cigars, and hookah were non-significant (rate ratios ranged from 1.01-1.05)	Gender; ethnicity; age; father's education; college aspirations; survey wave; other tobacco products	54.5	University student sample
Moylan et al. [54] (2013) - Norway	Youth (n = 456)	14-15 years of age; 4-year follow-up; 3-waves	Smoking status (active vs non-active)	GADS	Tobacco>anxiety; anxiety>tobacco	Active smoking in adolescence predicted later anxiety (B = 0.17, p < .05); adolescent anxiety did not predict later smoking (statistics not presented)	Mother's education	72.7	Very small cell sizes; relatively high SES of participants; minimal covariates
Mustonen et al. [55] (2018) - Finland	Youth (n = 6081)	15-16 years of age; 15-year follow-up;	Cigarette quantity (non-smokers vs moderate [1-9 cigarettes a day] vs	Registry diagnoses based on ICD-10 criteria	Tobacco>psychosis	Heavy smoking (HR = 2.00, CI = 1.13-3.54) and number of daily cigarettes (OR = 1.05, CI = 1.01-1.08) predicted later psychosis; but moderate smoking did not	Baseline psychotic experiences; cannabis use; alcohol use; other substance use; parental	72.7	Number of waves unclear; psychosis diagnosis method unclear

		number of waves unclear	heavy [greater than 10 cigarettes a day]); number of daily cigarettes smoked; age of smoking onset			(HR = 0.42, CI = 0.13-1.34); early onset predicted subsequent psychosis compared to late onset (HR = 2.84, CI = 1.12-7.18)	substance abuse; parental psychosis		
Okeke et al. [56] (2013) - USA	Mexican American youth (N = 1328)	11-13 years of age; 5-year follow-up; 3-waves	Smoking status (never vs puffer [tried but not completed single cigarette] vs experimenter [have consumed one cigarette or more])	STAS	Anxiety>tobacco	Anxiety predicted experimenter status (OR = 1.04, CI = 1.02-1.07) but not puffer status (OR = 1.01, CI = 0.99-1.03)	der; age; birth ntry; parental ation; BMI; body image	54.5	Temporal ordering unclear; variables not measured at each time point
Pedersen et al. [57] (2009) - Norway	Youth (n = 1501)	13 years of age; 13-year follow-up; 4-waves	Smoking status (not smoking vs smoking but not dependent vs nicotine dependent)	(SCL-90)	Tobacco>anxiety; anxiety>tobacco	Nicotine dependent status predicted later anxiety (B = 0.09, p < .01) but non-dependent smoking status did not (B = 0.05, p > .05); anxiety did not predict later smoking status (OR = 1.06, CI = 0.97-1.17)	Gender; age; depression and parasuicide at age 20; at ages 15 and 20: SES, parental care and monitoring, parental divorce, education, conduct problems, cannabis	54.5	Infrequent assessments
Purborini et al. [58] (2021) - Indonesia	Youth (n = 1960)	17.0 (SD = 1.4) years of age; 7-year follow-up; 2-waves	Lifetime tobacco status (ever vs never); current tobacco status (never vs current vs former)	CESD-10	Tobacco>depression	All tobacco use statuses predicted depression including ever smoked (B = 0.92, CI = 0.73-1.12), current smoker (B = 0.88, CI = 0.68-1.08), and former smoker (B = 1.52, CI = 0.95-2.08)	Marital status; region; SES	81.8	Only 2-waves; temporal ordering unclear
Raffetti et al. [59] (2019) - Sweden	High school students (n = 3959)	13 years of age; 1-year follow-up; 2-waves	Cigarette smoking; snus use; current; tobacco use; tobacco dependence (all variables yes or no)	CES-DC; SDQ	Tobacco>depression	Cigarette smoking (b = 3.4, p = .006) and tobacco dependence (b = 3.4, p = .008) predicted later depression, but snus (b = -0.1, p = .934) and tobacco (b = 1.9, p = .073) use did not; using depression onset as outcome, only tobacco dependence was a significant predictor (OR = 4.8, CI = 1.7-14.0), but cigarette smoking, tobacco use, and snus use were not (ORs ranged from 0.8-2.0)	Baseline depression; alcohol use; parental education; parental birthplace; gender	72.7	Minimal waves; short follow-up;
Ranjit et al. [60] (2019) - Finland	Youth twins (n = 4152)	14 years of age; 3-year follow-up; 2-waves	Lifetime cigarettes smoked (zero vs 1-50; zero vs 50+); smoking status (never vs experimenter; never vs quitter; never vs regular)	GBI	Tobacco>depression	Lifetime cigarettes smoked and smoking status predicted later depression (IRR 1.17, 1.19); depression did not predict later smoking (results not shown)	Gender; school grades; alcohol use to intoxication; health status; pre-existing depressiveness; shared familial and genetic factors between twins	72.7	Minimal waves; variables only measured at one wave

Ranjit et al. [61] (2019b*) - Finland	Youth twins (n = 4236)	17.5 years of age; 5-year follow-up; 2-waves	Smoking status (never vs ever; never vs experimenters; never vs quitters or trying to quit; never vs non-daily; never vs daily)	GBI	Tobacco>depression; depression>tobacco	Smoking predicted later depression (IRR 1.17, 95% CI: 1.03-1.33); depression predicted later smoking (RR = 1.05, 95% CI: 1.00–1.10) (based on the individual level findings)	Gender; age; baseline depression; shared familial and genetic factors between twins	54.5	Minimal waves
Savage et al. [62] (2016) - Finland	Youth twins (n = 1906)	12 years of age; 10-year follow-up; 4-waves	Nicotine dependence symptoms	MPNI	Anxiety>tobacco	Peer/teacher/parent-rated social anxiety did not predict future nicotine dependence (Bs ranged from -.15 to -.01)	e dependence at d W3; gender	45.5	Social anxiety only measured at W1; statistics unclear; low internal reliability of parent-rated social anxiety
Shete et al. [23] (2017) - USA	Mexican American youth (n = 1328)	11.8 (SD = 0.8) years of age; 5-year follow-up; 2-waves	Smoking escalation (yes or no)	STAS	Anxiety>tobacco	Anxiety predicted smoking escalation (OR = 1.03, CI = 1.02-1.05)	Gender; age; subjective social status; intention to igarette; peer king; parental smoking	36.4	Minimal waves
Smith et al. [63] (2014) - USA	Sub-sample of young adults (precise N unclear, but approximately 14,000)	18-29 years of age; 1-year follow-up; 2-waves	Smoking cessation (yes or no)	AUDADIS-IV	Depression>tobacco; anxiety>tobacco; bipolar>tobacco	Compared to the longitudinal smoking cessation rate of no-diagnosis (28.7), all longitudinal smoking cessation rates of those with past-year diagnoses were significantly lower (ps < .001): SAD (13.8), agoraphobia (12.0), panic disorder (14.5), specific phobia (20.3), GAD (13.4), mania or hypomania (18.6), MDD (17.6)	Age; gender; education	81.8	Minimal waves; short follow-up; change in psychological diagnosis unclear; symptom severity not measured
Swendsen et al. [64] (2010) - USA	Youth (n = 5001)	15-24 years of age; 10-year follow-up, 2-waves	Daily tobacco use (yes or no); nicotine dependence (yes or no)	CIDI	Depression>tobacco; anxiety>tobacco; bipolar>tobacco	Among W1 non-daily tobacco users, significant predictors of W2 onset of daily use included any mood disorder, panic disorder, SAD, specific phobia, GAD, and any anxiety disorder (ORs ranged from 1.6-3.0), whereas MDD, bipolar, agoraphobia, and separation anxiety were non-significant (ORs ranged from 0.8-1.8); among daily tobacco users, significant predictors of W2 onset of nicotine dependence included bipolar, any mood disorder, agoraphobia, and separation anxiety (ORs ranged from 1.9-3.9), whereas MDD, panic disorder, SAD, GAD, and any anxiety disorder were non-significant (ORs ranged from 0.8-1.4)	Age; gender; ethnicity; education; marital status; number of children; region; urbanicity; employment status	72.7	Minimal waves

Tomita et al. [65] (2020) - South Africa	Subsample of youth without depression (N = 4207)	15-19 years of age; 7-year follow-up; 4-waves	Smoking cigarette status (yes or no)	CESD-10	Tobacco>depression	Smoking predicted depression for both males (RR = 1.84, CI = 1.18-2.88) and females (RR = 2.47, CI = 1.15-5.29)	Ethnicity; marital status; education; employment status; household income; urban vs rural residence	63.6	None noted
Trotta et al. [66] (2020) - UK	Youth twins (n = 2232)	12 years of age; 6-year follow-up; 2-waves	Tobacco dependence	Structured interview created by authors	Psychosis>tobacco	Psychosis did not predict later tobacco dependence (RR = 1.00, CI = 0.57-1.75)	Shared familial and genetic factors between twins; gender; age-5 IQ; family SES status; age-12 depression, anxiety, self-harm, suicidality, ADHD, conduct disorder, family psychological history; caregiver's psychotic symptoms	63.6	Only 2-waves;
Ward et al. [67] (2019) - USA and Canada	Youth at clinical high risk of psychosis (N = 587) and healthy controls (N = 274)	18.5 (4.3) years of age for clinical high risk; 19.7 (4.7) years of age for controls; 2-year follow-up; waves unclear but approximately 3-4	Smoking level (none vs light vs heavy); smoking status (never vs ever)	SIPS	Tobacco>psychosis	Light smoking (OR = 0.90, CI = 0.4-2.2), heavy smoking (OR = 0.3, CI = 0.05-2.3), and status as 'ever smoked' (HR = 1.16, CI = 0.82-1.65) did not predict transition to psychosis	bacco use; marijuana alcohol use; age; ity; academic mance; academic djustment; depression; anxiety; social anxiety; daily stressors; life events; perceived discrimination	72.7	Some small cell counts; number of waves unclear
Weiser et al. [68] (2004) - Israel	Youth male military recruits (n = 14, 248)	18 years of age; 10.2 (SD = 3.6) year follow-up; number of waves unclear	Smoking status (yes or no); daily smoking quantity (zero vs 1-9 vs 10+)	Registry diagnoses based on ICD-10 criteria	Tobacco>psychosis	Baseline binary smoking (RR = 1.94, CI = 1.05-3.58) and daily smoking 10+ cigarettes (RR = 2.28, CI = 1.19-4.34) predicted later schizophrenia, but daily smoking 1-9 cigarettes (RR = 1.38, CI = 0.48-4.00) did not	Non-psychotic psychological disorders; adolescent social and intellectual functioning; SES	72.7	Inconsistent follow-up periods; number of waves unclear; schizophrenia diagnosis method unclear; smoking only assessed at baseline; only male sample
Wilens et al. [69] (2016) - USA	Youth with bipolar (N = 105) and youth controls without bipolar (N = 98)	13.6 (SD = 2.5) years of age for bipolar, 13.7 (SD = 2.1) years of age for controls; 5-year follow-up; 3-waves (but unclear)	Cigarette smoking (levels unclear)	KSADS-E; SCID	Tobacco>bipolar	Maintenance of smoking predicted bipolar status at final follow-up (HR = 3.2, CI = 1.6-6.7); but smoking did not predict persistence of bipolar (HR = 1.5, CI = 0.7-3.2)	SES; parental history of substance use disorder; probands with bipolar;	63.6	Temporal ordering unclear; small sample size; number of waves unclear; levels of predictor unclear; results unclear
Zammit et al. [70] (2003) - Sweden	Youth military recruits (n = 50,087)	18-20 years of age; 27-year follow-up; number of waves unclear	Smoking quantity (non-smokers vs light smokers vs medium smokers vs heavy smokers)	Registry diagnoses based on ICD-8	Tobacco>psychosis	Smoking quantity negatively predicted schizophrenia by final follow-up (HR = 0.8, CI = 0.7-0.9), but did not predict schizophrenia between 0-5 years from baseline (HR = 0.9, CI = 0.7-1.1)	Diagnosis at conscription; poor social integration; IQ; drug use; disturbed behaviour; father's occupation; place of	81.8	Psychological disorder diagnosis method unclear; number of waves unclear;

							upbringing; family SES; family psychiatric history; alcohol problems		smoking only measured at baseline
Zhang et al. [71] (2018) - Germany	Female youth (n = 3065)	21.0 (SD = 1.73) years of age; 1.5-year follow-up; 2-waves	Smoking status (yes or no)	DIMD-RV	Tobacco>depression	Smoking did not predict incremental variance in MDD (OR = 1.55, CI = 0.90-2.66)	BMI; alcohol use; alcohol-related problems; physical activity; good physical health	72.7	Only females; minimal waves; short follow-up; MDD and smoking measured as binary variables

Note: All CIs (confidence intervals) were 95%.

*Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.

BMI = Body Mass Index; CI = 95% confidence interval; Est. = Estimate; GAD = Generalised Anxiety Disorder; IRR = Incidence Rate Ratio; OR = odds ratio; SAD = Social Anxiety Disorder; SES = socioeconomic status; U = Mann Whitney U Test.

AUDADIS-IV = Alcohol Use Disorder and Associated Disabilities Interview Schedule; BCFPI = Brief Child and Family Phone Interview; BDI-II = Beck Depression Inventory-II; BPRS-PS = Brief Psychiatric Rating Scale; CBCL = Child Behavior Checklist; CES-DC = Center for Epidemiologic Studies Depressive symptoms Scale for Children; CESD = Center for Epidemiologic Studies Depression Scale; CGI-S = Clinical Global Impressions – Severity Scale; DAWBA = Development and Wellbeing Assessment; DICA-R = Diagnostic Interview for Children and Adolescents; DIMD-RV = Diagnostic Interview for Mental Disorders—Research Version; DIS = Diagnostic Interview Schedule; DISC = Diagnostic Interview Schedule for Children; DSS = Depressive Symptoms Scale; FTND = Fagerström Test for Nicotine Dependence; GADS = Generalized Anxiety Disorder Scale; GBI = General Behavior Inventory; KSADS-E = Kiddie Schedule for Affective Disorders-Epidemiologic Version; MCIDI/DIA-X = Munich-Composite International Diagnostic Interview ; MPNI = Multidimensional Peer Nomination Inventory; MSI = Minnesota Smoking Index; PHQ-9 = Patient Health Questionnaire; PLIKSi = Psychosis-Like Symptoms Interview; PLIKSi = Psychosis-like Symptoms interview; RADS = Reynolds Adolescent Depression Scale; RCMAS = Revised Children's Manifest Anxiety Scale; SCID = Scheduled Clinical Interview Diagnosis; SCL-90 = Hopkins Symptom Checklist; SDQ = Strengths and Difficulties Questionnaire; SIPS = Structured Interview for Prodromal Syndromes; SMFQ = Short Mood and Feelings Questionnaire; SOPS = Scale of Assessment of Prodromal Symptoms; SPIKE = Structured Psychopathological Interview and Rating of the Social Consequences of Psychological Disturbances for Epidemiology; STAS = Speilberger's Trait Anxiety Scale; TFR = Teacher Report Form; WMH-CIDI = World Mental Health Composite International Diagnostic Interview; YASR = Young Adult Self-Report; YSR = Youth Self-Report; ZSRAS = Zung Self-Rating Anxiety Scale.

Supplementary File: Search strategy for search #1 on 26th September 2019

PubMed:

Smoking	Mental Illness	Study type	Number of results
"tobacco smoking"[mh] OR "smoking"[mh] OR tobacco[tiab] OR cigarette*[tiab] OR smoking[tiab] OR smoker*[tiab]	("Anxiety Disorders"[mh] OR "Bipolar and Related Disorders"[mh] OR "Disruptive, Impulse Control, and Conduct Disorders"[mh] OR "Dissociative Disorders"[mh] OR "Feeding and Eating Disorders"[mh] OR "Mood Disorders"[mh] OR "Personality Disorders"[mh] OR "Schizophrenia Spectrum and Other Psychotic Disorders"[mh] OR "Substance-Related Disorders"[mh] OR "Trauma and Stressor Related Disorders"[mh]) OR (disorder[Title/Abstract] OR mental[Title/Abstract] OR schizophreni*[Title/Abstract] OR catatoni*[Title/Abstract] OR bipolar[Title/Abstract] OR psychosis[Title/Abstract] OR psychotic[Title/Abstract] OR depress*[Title/Abstract] OR Cyclothymi* [Title/Abstract] OR Dysphori*[Title/Abstract] OR "selective mutism"[Title/Abstract] OR Trichotillomania[Title/Abstract] OR dereali*[Title/Abstract] OR mood[Title/Abstract] OR anxi*[Title/Abstract] OR phobia[Title/Abstract] OR dysthymia[Title/Abstract] OR manic[Title/Abstract] OR mania[Title/Abstract] OR dissociat*[Title/Abstract] OR depersonali*[Title/Abstract] OR pica[Title/Abstract] OR anorexia[Title/Abstract] OR bulimia[Title/Abstract] OR binge eating[Title/Abstract] OR substance[Title/Abstract] OR posttraumatic[Title/Abstract] OR post-traumatic[Title/Abstract])	"longitudinal"[tiab] OR "follow up"[tiab] OR "follow-up"[tiab] OR "cohort"[tiab]	9089

Embase:

Smoking	Mental Illness	Study type	filters	Number of results
"tobacco use"/exp OR tobacco:ti,ab OR cigarette*:ti,ab OR smoking:ti,ab OR smoker*:ti,ab	("anxiety disorder"/exp OR "mood disorder"/exp OR "behaviour disorder"/exp OR "dissociative disorder"/exp OR "personality disorder"/exp OR "Psychosis"/exp OR "drug dependence"/exp OR Adjustment disorder/de OR Neurosis/exp (includes dysthymia) OR Psychotrauma/de) OR (disorder:ti,ab OR mental:ti,ab OR schizophreni*:ti,ab OR catatoni*:ti,ab OR bipolar:ti,ab OR psychosis:ti,ab OR psychotic:ti,ab OR depress*:ti,ab OR Cyclothymi* :ti,ab OR Dysphori*:ti,ab OR "selective mutism":ti,ab OR Trichotillomania:ti,ab OR dereali*:ti,ab OR mood:ti,ab OR anxi*:ti,ab OR phobia:ti,ab OR dysthymia:ti,ab OR manic:ti,ab OR mania:ti,ab OR dissociat*:ti,ab OR depersonali*:ti,ab OR pica:ti,ab OR anorexia:ti,ab OR bulimia:ti,ab OR binge eating:ti,ab OR substance:ti,ab OR posttraumatic:ti,ab OR post-traumatic:ti,ab)	"longitudinal":ti,ab OR "follow up":ti,ab OR "cohort":ti,ab	AND [english]/lim AND [embase]/lim	2306

Pubmed mesh term	Emtree term
anxiety disorders	"anxiety disorder"/exp
Bipolar and Related Disorders	"mood disorder"/exp
Disruptive, Impulse Control, and Conduct Disorders	"behaviour disorder"/exp
Dissociative Disorders	"dissociative disorder"/exp
Feeding and Eating Disorders	"behaviour disorder"/exp
Mood Disorders	"mood disorder"/exp
Personality Disorders	"personality disorder"/exp
Schizophrenia Spectrum and Other Psychotic Disorders	"Psychosis"/exp
Substance-Related Disorders	"drug dependence"/exp
Trauma and Stressor Related Disorders	"anxiety disorder"/exp
	Adjustment disorder/de Neurosis/exp (includes dysthymia) Psychotrauma/de

PsycINFO:

Smoking	Mental Illness	Study type	filters	Number of citations
(exp tobacco smoking"OR tobacco.ti,ab OR cigarette$.ti,ab OR smoking.ti,ab OR smoker$.ti,ab)	(exp Anxiety Disorders OR exp Bipolar Disorder OR exp Disruptive Behavior Disorders OR exp Attention Deficit Disorder OR exp Dissociative Disorders OR exp Eating Disorders OR exp Affective Disorders OR exp Personality Disorders OR exp Psychosis OR exp Substance Related and Addictive Disorders OR exp Stress and Trauma Related Disorders) OR (disorder.ti,ab OR mental.ti,ab OR schizophreni$.ti,ab OR catatoni$.ti,ab OR bipolar.ti,ab OR psychosis.ti,ab OR psychotic.ti,ab OR depress$.ti,ab OR Cyclothymi$ .ti,ab OR Dysphori$.ti,ab OR selective mutism.ti,ab OR Trichotillomania.ti,ab OR dereali$.ti,ab OR mood.ti,ab OR anxi$.ti,ab OR phobia.ti,ab OR dysthymia.ti,ab OR manic.ti,ab OR mania.ti,ab OR dissociat$.ti,ab OR depersonali$.ti,ab OR pica.ti,ab OR anorexia.ti,ab OR bulimia.ti,ab OR binge eating.ti,ab OR substance.ti,ab OR posttraumatic.ti,ab OR post-traumatic.ti,ab)	(longitudinal.ti,ab OR Follow up.ti,ab OR cohort.ti,ab)	engs[la]	3648

Thesaurus terms:

Pubmed mesh term	**Psyc Info thesaurus term**
anxiety disorders	exp Anxiety Disorders
Bipolar and Related Disorders	exp Bipolar Disorder
Disruptive, Impulse Control, and Conduct Disorders	exp Disruptive Behavior Disorders; Attention Deficit Disorder
Dissociative Disorders	exp Dissociative Disorders
Feeding and Eating Disorders	exp Eating Disorders
Mood Disorders	exp Affective Disorders
Personality Disorders	exp Personality Disorders
Schizophrenia Spectrum and Other Psychotic Disorders	exp Psychosis
Substance-Related Disorders	exp Substance Related and Addictive Disorders
Trauma and Stressor Related Disorders	exp Stress and Trauma Related Disorders

Scopus:

Smoking	**Mental Illness**	**Study type**	**Number of results**
tobacco OR cigarette* OR smoking OR smoker* Select ‘article title, abstract, keyworks	disorder OR mental OR schizophreni* OR catatoni* OR bipolar OR psychosis OR psychotic OR depress* OR Cyclothymi* OR Dysphori* OR { mutism} OR Trichotillomania OR dereali* OR mood OR anxi* OR phobia OR dysthymia OR manic OR mania OR dissociat* OR depersonali* OR pica OR anorexia OR bulimia OR binge eating OR substance OR posttraumatic OR post-traumatic Select ‘article title, abstract, keyworks	longitudinal OR "follow up" OR cohort Select ‘article title, abstract, keyworks	17,532

CINAHL:

Smoking	Mental Illness	Study type	Number of results
MH tobacco smoking+ OR TI tobacco OR AB tobacco OR TI cigarette* OR AB cigarette* OR TI smoking OR AB smoking OR TI smoker* OR AB smoker* OR MH smoking+	MH Anxiety Disorders+ OR MH Bipolar Disorder+ OR MH Impulse control disorders+ OR MH Social behaviour disorders+ OR MH Mental Disorders Diagnosed in Childhood+ OR MH Dissociative Disorders+ OR MH Eating Disorders+ OR MH Affective Disorders+ OR MH Personality Disorders+ OR MH Psychotic Disorders+ OR MH Substance Use Disorders+ OR MH Stress Disorders, Post-Traumatic+ OR TI disorder OR AB disorder OR TI mental OR AB mental OR TI schizophreni* OR AB schizophreni* OR TI catatoni* OR AB catatoni* OR TI bipolar OR AB bipolar OR TI psychosis OR AB psychosis OR TI psychotic OR AB psychotic OR TI depress* OR AB depress* OR TI Cyclothymi* OR AB Cyclothymi* OR TI Dysphori* OR AB Dysphori* OR TI selective mutism OR AB selective mutism OR TI Trichotillomania OR AB Trichotillomania OR TI dereali* OR AB dereali* OR TI mood OR AB mood OR TI anxi* OR AB anxi* OR TI phobia OR AB phobia OR TI dysthymia OR AB dysthymia OR TI manic OR AB manic OR TI mania OR AB mania OR TI dissociat* OR AB dissociat* OR TI depersonali* OR AB depersonali* OR TI pica OR AB pica OR TI anorexia OR AB anorexia OR TI bulimia OR AB bulimia OR TI binge eating OR AB binge eating OR TI substance OR AB substance OR TI posttraumatic OR AB posttraumatic OR TI post-traumatic OR AB post-traumatic	TI longitudinal OR AB longitudinal OR TI follow up OR AB follow up OR TI follow-up OR AB follow-up OR TI cohort OR AB cohort	11,037

Pubmed mesh term	Cinahl subject heading
anxiety disorders	Anxiety Disorders+
Bipolar and Related Disorders	Bipolar Disorder+
Disruptive, Impulse Control, and Conduct Disorders	Impulse control disorders+ Social behaviour disorders+ Mental Disorders Diagnosed in Childhood+
Dissociative Disorders	Dissociative Disorders+
Feeding and Eating Disorders	Eating Disorders+
Mood Disorders	Affective Disorders+
Personality Disorders	Personality Disorders+
Schizophrenia Spectrum and Other Psychotic Disorders	Psychotic Disorders+
Substance-Related Disorders	Substance Use Disorders+
Trauma and Stressor Related Disorders	Stress Disorders, Post-Traumatic+

Overview of results for search #2 on 11th May 2021

Database	Result	Date
Pubmed	**1607**	**11/05/2021**
CINAHL	**1555**	**11/05/2021**
Embase	**Not available to Flinders Library but 100% of Embase content is available within Scopus and therefore included in this search**	
SCOPUS	**758**	**11/05/2021**
Psycinfo	**483**	**11/05/2021**
TOTAL	**4403**	
Deduplicate TOTAL	**3132**	

Table S2 – Quality appraisal scores for cohort studies (n = 49)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score %
Ajdacic-Gross et al. (2009)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	U	Y	63.6
Ames et al. (2018)	U	Y	Y	Y	Y	N	Y	Y	Y	U	Y	72.7
Berk et al. (2010)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Bierhoff et al. (2019)	N/A	N/A	Y	N	N	N	Y	Y	N	N	Y	36.4
Borges et al. (2018)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Buchy et al. (2014)	Y	Y	Y	U	U	Y	Y	Y	U	U	Y	63.6
Buchy et al. (2015)	N	Y	Y	Y	U	N	Y	Y	N	U	Y	54.5
Bulhões et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Chen et al. (2017)	N/A	N/A	Y	N	N	N	Y	Y	Y	U	Y	45.5
Crane et al. (2021)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Davies et al. (2018)	Y	Y	Y	Y	Y	N	Y	Y	N	U	Y	72.7
Ferdinand et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Fonseca et al. (2021)	N/A	N/A	Y	Y	N	Y	Y	Y	N	N	Y	54.5
Gage et al. (2014)	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y	72.7
Gårdvik et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Goodwin et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Goodwin et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	N	N	Y	54.5
Griesler et al. (2008)	U	Y	Y	Y	Y	N	Y	Y	Y	N	Y	72.7
Griesler et al. (2011)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Hu et al. (2012)	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	81.8
Hui et al. (2013)	N/A	N/A	Y	U	N	Y	Y	Y	Y	Y	Y	63.6

Isensee et al. (2003)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Johnson et al. (2000)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Jones et al. (2018)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	U	Y	63.6
Kalan et al. (2020)	N/A	N/A	Y	Y	Y	N	Y	Y	N	N	Y	54.5
Kendler et al. (2015)	N/A	N/A	Y	Y	Y	N	U	Y	N	U	Y	45.5
King et al. (2004)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
MacKie et al. (2011)	Y	Y	Y	U	U	N	Y	Y	N	U	Y	54.5
Marmorstein et al. (2010)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	N	Y	63.6
Marsden et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Moylan et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Mustonen et al. (2018)	N	Y	Y	Y	Y	N	U	Y	Y	Y	Y	72.7
Okeke et al. (2013)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Pedersen et al. (2009)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Purborini et al. (2021)	N/A	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y	81.8
Raffetti et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Ranjit et al. (2019)	N/A	N/A	Y	Y	Y	N	Y	Y	Y	Y	Y	72.7
Ranjit et al. (2019b*)	N/A	N/A	Y	Y	Y	N	Y	Y	N	U	Y	54.5
Savageet al. (2016)	N/A	N/A	Y	U	N	N	Y	Y	Y	U	Y	45.5
Shete et al. (2017)	N	Y	U	U	N	N	Y	Y	N	U	Y	36.4
Smith et al. (2014)	U	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	81.8
Swendsen et al. (2010)	N/A	N/A	Y	Y	Y	U	Y	Y	Y	Y	Y	72.7
Tomita et al. (2018)	U	Y	U	Y	Y	Y	Y	Y	N	U	Y	63.6
Trotta et al. (2020)	N/A	N/A	Y	Y	Y	N	U	Y	Y	Y	Y	63.6
Ward et al. (2019)	U	Y	Y	Y	Y	Y	Y	Y	N	U	Y	72.7

Weiser et al. (2004)	N/A	N/A	Y	Y	Y	Y	U	Y	Y	Y	Y	72.7
Wilens et al. (2016)	N	Y	Y	Y	Y	N	Y	Y	N	U	Y	63.6
Zammit et al. (2003)	Y	Y	Y	Y	Y	N	U	Y	Y	Y	Y	81.8
Zhang et al. (2018)	N	Y	Y	Y	Y	N	Y	Y	Y	U	Y	72.7
Total %	8.2	32.7	95.9	85.7	81.6	14.3	89.8	100.0	59.2	44.9	100.0	-

Note: *Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study.
Y = Yes; N = No; U = Unclear; N/A = Not applicable. Q1 = Were the two groups similar and recruited from the same population?; Q2 = Were the exposures measured similarly to assign people to both exposed and unexposed groups?; Q3 = Was the exposure measured in a valid and reliable way?; Q4 = Were confounding factors identified?; Q5 = Were strategies to deal with confounding factors stated?; Q6 = Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?; Q7 = Were the outcomes measured in a valid and reliable way?; Q8 = Was the follow up time reported and sufficient to be long enough for outcomes to occur?; Q9 = Was follow up complete, and if not, were the reasons to loss to follow up described and explored?; Q10 = Were strategies to address incomplete follow up utilized?; Q11 = Was appropriate statistical analysis used?

Table S2 – Quality appraisal scores for systematic reviews (n = 4)

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score %
Ahun et al. (2020)	Y	Y	Y	Y	Y	U	U	Y	U	Y	Y	72.7
Cairns et al. (2014)	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	90.9
Chaiton et al. (2009)	Y	Y	Y	Y	Y	U	U	Y	Y	Y	Y	81.8
Esmaeelzadeh et al. (2018)	Y	Y	Y	Y	Y	U	U	Y	Y	Y	Y	81.8
Total %	100.0	100.0	100.0	100.0	100.0	0.0	25.0	100.0	75.0	100.0	100.0	-

Y = Yes; N = No; U = Unclear; N/A = Not applicable. Q1 = Is the review question clearly and explicitly stated?; Q2 = Were the inclusion criteria appropriate for the review question?; Q3 = Was the search strategy appropriate?; Q4 = Were the sources and resources used to search for studies adequate?; Q5 = Were the criteria for appraising studies appropriate?; Q6 = Was critical appraisal conducted by two or more reviewers independently?; Q7 = Were there methods to minimize errors in data extraction?; Q8 = Were the methods used to combine studies appropriate?; Q9 = Was the likelihood of publication bias assessed?; Q10 = Were recommendations for policy and/or practice supported by the reported data?; Q11 = Were the specific directives for new research appropriate?