Research Review: Siblings matter

A multi-level meta-analysis on the association between cannabis use among adolescent siblings

Defoe, I.N.; Treffers, S.; Stams, G.J.

DOI
10.1111/jcpp.13836

Publication date
2023

Document Version
Final published version

Published in
Journal of Child Psychology and Psychiatry and Allied Disciplines

Citation for published version (APA):
Defoe, I. N., Treffers, S., & Stams, G. J. (2023). Research Review: Siblings matter: A multi-level meta-analysis on the association between cannabis use among adolescent siblings. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *64*(11), 1532-1544. https://doi.org/10.1111/jcpp.13836

The Journal of Child Psychology and Psychiatry

Journal of Child Psychology and Psychiatry 64:11 (2023), pp 1532–1544 doi:10.1111/jcpp.13836

Research Review: Siblings matter. A multi-level meta-analysis on the association between cannabis use among adolescent siblings

Ivy N. Defoe, Sanne Treffers, and Geert Jan Stams
University of Amsterdam, Amsterdam, The Netherlands

Background: Parents' and peers' cannabis use are well-documented predictors of youth cannabis use, however, relatively little is known about the influence of siblings' cannabis use. Hence, this meta-analysis investigated the association between sibling-youth cannabis use (disorder) and explored moderation by sibling type (monozygotic- vs. dizygotic- vs. non-twins), age, age spacing, birth order, gender, and gender constellations (same- vs. mix- gender pairs). When comparison data of parents' and peers' cannabis use (disorder) were also available in the included studies, separate meta-analyses on associations between parent-youth and peer-youth cannabis use (disorder) were additionally conducted. **Methods:** Studies were selected if they included 11- to 24-year-old participants, and investigated associations between cannabis use (disorder) among those youth and their siblings. These studies were retrieved via a search in seven databases (e.g., PsychINFO). A multi-level meta-analysis using a random effects model was performed on the studies, and heterogeneity analyses and moderator analyses were also conducted. PRISMA guidelines were followed. **Results:** We retrieved 20 studies (most of which originated from Western cultures) with 127 effect sizes for the main sibling-youth meta-analysis and found a large overall effect-size (r = .423), implying that youth had higher cannabis use rates when their sibling used cannabis, and this association was stronger for monozygotic twins and for same-gender sibling pairs. Finally, a medium effect size existed for the associations between parent-youth cannabis use (r = .300) and a large effect size for peer-youth cannabis use (r = .451). **Conclusions:** Youth are more likely to use cannabis when their siblings use cannabis. This sibling-youth cannabis use association existed for all sibling constellations, was larger than the association between parent-youth cannabis use, and was similar in magnitude compared to the association between peer-youth cannabis use—suggesting both genetic and environmental influences (e.g., social-learning) between siblings. Hence, it is important not to neglect sibling influences when treating youth cannabis use (disorder). **Keywords:** Youth; siblings; cannabis use; cannabis use disorder; social influences; meta-analysis.

Introduction

Cannabis—the most illicit used drug among youth—is increasingly being legalized in many parts of the world. However, studies have identified that cannabis use particularly during the *youth* period is linked to neurocognitive disfunctions, breathing problems, hallucinations, paranoia, and cannabis dependency later in life (National Institute on Drug Abuse, 2019; Trimbos-instituut & Wetenschappelijk Onderzoeken Documentatiecentrum, 2020). In fact, cannabis is already the substance for which youth most often seek treatment in numerous countries (e.g., Gov.UK, 2022; Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2015). Hence, as access to cannabis continues to increase, meta-analyses on possible predictors of youth cannabis use are urgently needed for prevention and intervention purposes.

Cannabis use during the youth period is typically a social phenomenon (Defoe, Khurana, Betancourt, Hurt, & Romer, 2019). In fact, one of the prominent predictors of youth cannabis use is their social circle (see, e.g., Defoe et al., 2019). For example, parents' and peers' cannabis use predicts higher rates of youth cannabis use (Johnson et al., 2019; Madras et al., 2019). However, compared to such parent and peer influences, less is known about the association between cannabis use among siblings. This is surprising since the vast majority of youth have at least one sibling (Centraal Bureau voor de Statistiek, 2021; United States Census Bureau, 2020), and youth spend more with their siblings compared to time spent with their parents or peers/friends (Dunifon, Fomby, & Musick, 2017). Moreover, siblings can also be considered as peers, since they are for example typically similar in age. Hence, siblings are obviously unique and influential companions in the lives of youth, and thus when the aim is to impact youth cannabis use, *sibling* cannabis use is an obvious starting point. Still, the research on sibling influences on youth cannabis use has lagged behind the research on parent and peer influences (cf Defoe et al., 2013). Moreover, the existing research on the association between sibling and youth cannabis use consists of studies with different outcomes on the strength of this association, and mixed results have been found for putative moderators such as age and gender. Therefore, the current meta-analysis is the first that aims to establish

Conflict of interest statement: No conflicts declared.

whether (a) cannabis use (disorder) among siblings shows a significant association during the youth period, and if so, (b) what the magnitude of this association is, and (c) whether this association is moderated by sibling type (monozygotic twins vs. dizygotic twins vs. non-twins), age and gender.

The main focus of our meta-analysis was to investigate the association between sibling cannabis use and youth cannabis use (disorder). However, when the included studies also investigated such an association for parent cannabis use and peer cannabis use on the one hand, and youth cannabis on the other hand; we additionally conducted meta-analyses for these parent-youth and peer-youth cannabis use associations as well. As such, we were able to compare the association between sibling-youth cannabis use to parent-youth and peer-youth cannabis use.

Sibling influences

The sibling relationship is one of the most constant relationships in an individual's life-time (Jenkins & Dunn, 2009). Moreover, being both family and peers implies that a sibling's influence might be different or perhaps larger than being either one. Despite this unique relationship among siblings, surprisingly, there is relatively little research that investigates to what extent siblings model each other's behaviors, whether this might be for positive 'prosocial' behaviors or for negative 'risky' behaviors (cf. Buist, Deković, & Prinzie, 2013). Nevertheless, with regard to risk behaviors, over a decade ago, a meta-analysis was conducted on primarily adult twins to establish the contribution of genetics, shared environment, and unshared environment on cannabis use (Verweij et al., 2010). It was revealed that twins are similar in their cannabis use initiation and problematic cannabis use, due to genetics as well as due to their (un) shared environment (Verweij et al., 2010). However, up until now, no meta-analysis exists that has: (a) quantified the *magnitude* of the association between cannabis use among non-twin siblings during the youth period, (b) compared that association between sibling-youth cannabis use to the associations between parent-youth cannabis use and peer-youth cannabis use, or (c) investigated moderation by sibling gender, sibling age, gender constellation, or age constellation within the sibling dyad for that association. The current meta-analysis is designed to fill these gaps.

Why would sibling cannabis use be a risk factor for youth cannabis use?

It can be extrapolated from *Social learning theory* (Bandura, 1977) that siblings would model each other's behaviors because they spend a substantial amount of time together (e.g., they typically share the same home). The same can be expected for the influence of parent and peer cannabis use on youth cannabis use. Following such social learning principles, it can further be extrapolated from the Developmental Neuro-Ecological Risk-taking Model (DNERM; Defoe, 2021) that *observing* a significant other using cannabis makes this behavior appear normative, which could increase attraction to—and engagement in—that behavior (i.e., the 'social cue reactivity' hypothesis). This process is particularly prevalent during the youth period, when individuals are still exploring their identity (Defoe, 2021). Additionally, just the awareness that a significant other (e.g., a sibling) uses cannabis could make youth curious about cannabis, which could also result in their own use of cannabis (Defoe, 2021). Finally, of note is that especially within the sibling dyad, the potential moderation effect of age and gender on sibling similarity is worthy of investigation.

Potential moderators. When examining sibling influences, age and gender differences are important to consider. First, age differences between siblings can reflect at least three things: the age of the siblings (e.g., youth siblings vs. adult siblings), birth order, and age spacing. Birth order is the chronological order (years or months) in which the siblings are born, whereas age spacing is the time (years or months) between the births of the siblings. Of note is that twins are a special type of siblings since the above-described definition of birth order and age spacing do not apply. Second, as for gender differences, the gender composition of the sibling dyad (mix gender vs. same gender dyads) could also have unique influence effects. Additionally, males (male–male dyad) could exert different type of influences compared to females (female–female dyads).

With regard to age differences in sibling effects, as youth grow older, they become better at resisting peer influence (Steinberg, 2008). The same processes may apply for siblings, that is, older youth would be less likely to be influenced by their siblings. As for birth order, the older sibling is likely to serve as a 'role model', and accordingly sibling similarity in cannabis use would be stronger for older-younger sibling dyads than for younger-older sibling dyads (Whiteman & Christiansen, 2008). However, it remains unknown to what extent age moderates the association between cannabis use among siblings since results on birth order and age spacing have been mixed. For example, studies have shown that older siblings also imitate their younger siblings' behavior (Whiteman, Jensen, & McHale, 2017). As such, moderation by birth order and age spacing might be weaker than assumed.

Research findings on the moderating influence of gender on cannabis use are inconclusive as well (e.g., Kothari, Sorenson, Bank, & Snyder, 2014). Notably, social learning theory posits that youth are more likely to imitate models that are similar to them (Bandura, 1977). Thus, it can be inferred that sibling similarity might affect cannabis use, and would be stronger for same-gendered siblings (e.g., Howe, Rosciszewska, & Persram, 2018), however, sibling differentiation has also been documented (Whiteman, McHale, & Crouter, 2007). Besides the potential difference between same and mix gender sibling pairs, there could be a difference between male–male and female–female pairs as well. This could be explained by gender differences in susceptibility to negative peer influences. For example, males have been shown to be more susceptible to peer influences than females when it comes to risk-taking (Defoe et al., 2020; Kothari et al., 2014). We hypothesize that the same processes could apply to sibling pairs.

Current study

The current meta-analysis examines the relation between sibling-youth cannabis use (disorder)—and when comparison data are available—compares this association to associations between parent-youth cannabis use and peer-youth cannabis use via separate meta-analyses. Additionally, we explore the extent to which (a) *sibling type* (i.e., monozygotic twins vs. dizygotic twins vs. non-twins), (b) the *age of youth*, (c) *birth order* (i.e., older-younger, same-aged [twins] or younger-older), (d) *age spacing* (both continuous and categorical with the following categories: 0 years (i.e., twins), 1–2 years and >2 years; Boyle, Sanford, Szatmari, Merikangas, & Offord, 2001; Mikkonen, Savolainen, Aaltonen, & Martikainen, 2020), (e) *gender*, and (f) *gender composition* (same gender [i.e., male & male; female & female] vs. mix gender [i.e., male–female; female–male] vs. all gender compositions combined [i.e., same gender & mix gender]) moderate this association (see Figure 1). Based on DNERM and social learning theory, we hypothesized that sibling cannabis use (disorder) would be associated with youth cannabis use (disorder) (Bandura, 1977; Defoe, 2021), and we explore whether this association is stronger or weaker than associations between parent-youth cannabis use and peer-youth cannabis use. Considering the increasing resistance against peer/social influence during the youth period, we expected the strength of the association between sibling-youth cannabis use would decline with the age of youth (Steinberg, 2008). In line with social learning theory, we expected that the association would be stronger for same gender (vs. mix gender) sibling dyads. We explored moderation effects of sibling type, birth order, and age spacing since findings on such moderation effects are mixed (e.g., Whiteman, Jensen, & Maggs, 2013).

Method

Inclusion and exclusion criteria

In the current paper, youth is considered as young people between the ages of 11–24—a period that is characterized by major developmental growth and transitions in social roles (Sawyer, Azzopardi, Wickremarathne, & Patton, 2018). Studies met the inclusion criteria when they: (a) included participants between ages 11–24, (b) investigated an association between sibling cannabis use (disorder) and youth cannabis use (disorder), (c) were in the Dutch or English language, and (d) reported an effect size which can be converted into a correlation coefficient. Single-case studies were not included. Studies that include monozygotic twins were included. But to prevent the possibility that evidence of significant associations between cannabis use among siblings could be attributed to pure genetic influences (since monozygotic twins share 100% of their genes), we also ran the analyses without monozygotic twins to further confirm whether the results are at least partially due to environmental influences (see Appendices S1 and S2).

Search strategy

We conducted a search via EBSCOhost, ERIC, Google Scholar, Medline, PsychINFO, ScienceDirect, and Web of Science. The following search terms were used: Cannabis OR marijuana OR substance* OR drug* AND Youth OR adolescen* OR teen* AND Sibling* OR brother* OR sister*. We screened the meta-analysis of Verweij and colleagues (Emmelkamp, Asscher, Wissink, & Stams, 2020; Verweij et al., 2010) as well as the literature list of each selected article for potentially relevant studies. The authors were also contacted for unpublished articles or whenever studies had missing data that were needed for our hypotheses. We consulted the databases from February 2, 2021 to March 17, 2021, and updated the search on October 17, 2022. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used (see Figure 2 for the flowchart).

Coding

One researcher coded all of the studies, and a second researcher coded 10% of the studies. The intra-class-coefficient was .798 (95% CI: 0.675–0.878) and Cohen's Kappa was .791, indicating substantial to excellent inter-coder reliability. An overview of all variables (i.e., study and sample characteristics) that were coded is provided in the Supporting Information (see Tables S1 and S2). Of note, we coded the type of cannabis use into two categories: cannabis use and cannabis use disorder. Ethnicity was coded as percentage of whites.

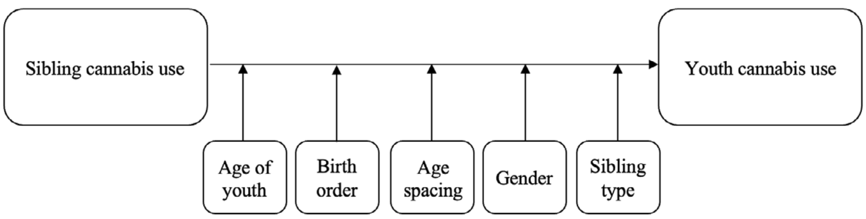

Figure 1 Conceptual model with moderators

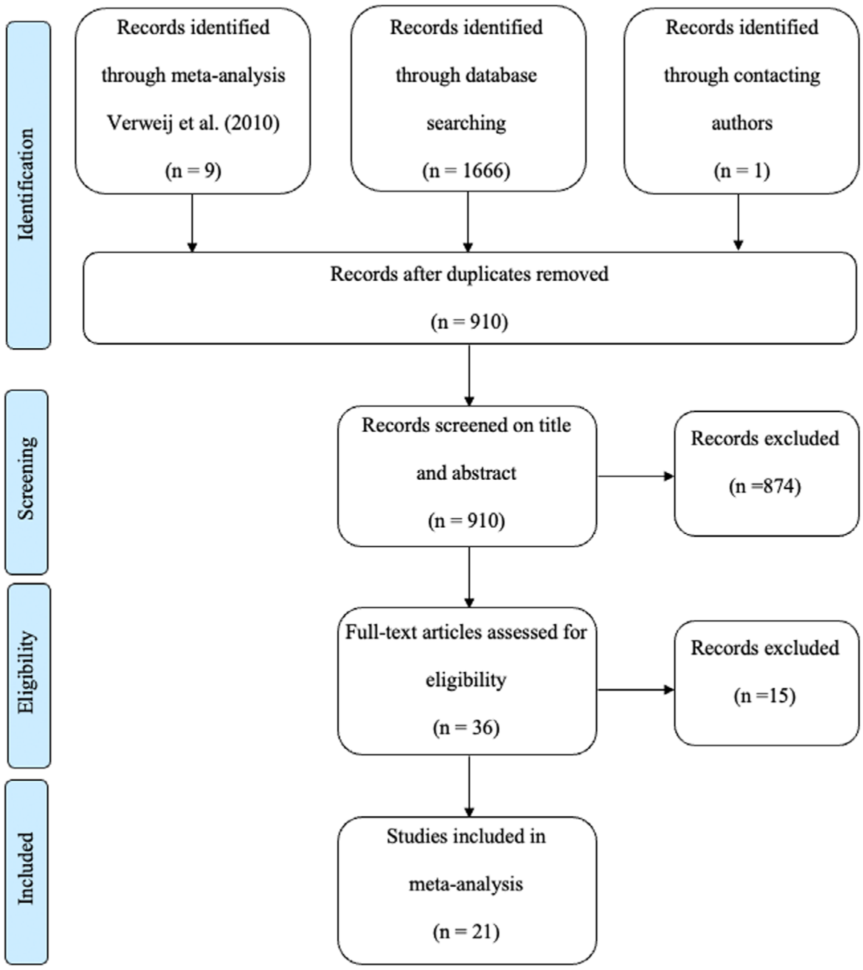

Figure 2 Flowchart. *Note*. Of the final 21 studies, two used the same dataset, so in total, there are 20 independent study IDs

Data analysis

The coding and descriptive analyses were conducted in IBM SPSS, and the main analyses were conducted in the Metafor package of R (Assink & Wibbelink, 2016; Viechtbauer, 2010). Continuous variables were centered around their mean and categorical variables were recoded into dummy variables (Assink & Wibbelink, 2016; Emmelkamp et al., 2020).

Each study reported different outcome measures, such as means and odds ratios. In order to be able to compare studies, we converted all outcome measures into a Pearson's correlation coefficient (cf. Emmelkamp et al., 2020) using the effect size calculator by Wilson (2001). Due to non-normality, the correlations were converted into a Fisher's z for the analysis (van den Noortgate, López-López, Marín-Martínez, & Sánchez-Meca, 2013). After the analysis, the effect sizes were converted back into a Pearson's correlation for interpretation (Emmelkamp et al., 2020). Nearly all studies reported multiple relevant effect sizes. Hence, we used a three-level model, which controls for statistical dependency, thus making it possible to use multiple effect sizes from one study (van den Noortgate et al., 2013). In this model, variances between effect sizes were distributed over three levels: variance between participants or random sampling error (Level 1), variance between effect sizes from the same study (Level 2), and variance between studies (Level 3; van den Noortgate et al., 2013).

We calculated the overall effect size using a random-effects model (Assink & Wibbelink, 2016). A log-likelihood-ratio test was conducted to test for heterogeneity. Moderator analyses were conducted if there was a minimum of six studies for continuous variables and a minimum of four studies per category for categorical variables (Fu et al., 2011). We tested for multicollinearity with all variables that were significant or approached significance (i.e., $p < .100$) in the individual moderator analyses. The test showed substantial multicollinearity between the variables, thus we did not do a multiple moderator analysis. That is, we conducted single moderator analyses. We tested the moderators by calculating the regression coefficient (beta coefficients) and testing if the regression coefficient was significantly different from zero. The study characteristics (e.g., publication year) and the sample characteristics (i.e., our moderation variables; e.g., age) for which we tested moderation effects are reported in Table 1.

Publication bias

We assessed publication bias via a funnel plot based on a trim and fill method (Duval & Tweedie, 2000). An asymmetrical funnel plot, in which the left and right side are dissimilar, could be an indication of publication bias (Duval & Tweedie, 2000).

Results

Study characteristics

A total of 20 independent studies and 127 effect sizes were retrieved (Tables 2 and 3). Five studies with a total of 13 effect sizes were studies with multivariate analyses. The remaining 15 studies and 114 effect

Table 1 Results single moderator analyses

Moderator	K[a]	ES[b]	β_0[c]	r[d]	t_0[e]	p	β_1[f]	t_1[g]	p	F (df1, df2)[h]	p
Year of publication	20	127	.451	.423	10.298	<.001	.003	0.440	.661	F (1, 125) = 0.194	.661
Impact factor	18	124	.444	.417	8.194	<.001	.016	0.660	.510	F (1, 122) = 0.436	.510
Legalization 21+										F (1, 125) = 0.000	.994
Legal for 21+ (RC)	7	22	.450	.422	5.931	<.001					
Illegal for 21+	13	105	.451	.423	8.263	<.001	.001	0.007	.994		
Type of study										F (1, 125) = 0.939	.335
Cross-sectional (RC)	15	120	.473	.441	9.845	<.001					
Longitudinal	5	7	.369	.353	3.882	<.001	−.103	−0.969	.335		
Reporter										F (2, 124) = 0.376	.687
Self-report (RC)	10	100	.471	.439	7.556	<.001					
Self- and sibling report	7	19	.395	.376	4.953	<.001	−.077	−0.758	.450		
Parent report	3	8	.496	.459	4.193	<.001	.025	0.186	.853		
Analysis										F (1, 125) = 0.260	.611
Univariate analyses (RC)	15	114	.463	.433	9.223	<.001					
Multivariate analyses	5	13	.410	.388	4.489	<.001	−.053	−0.510	.611		
Ethnicity (%white)	13	36	.396	.377	7.989	<.001	−.000	−0.231	.818	F (1, 34) = 0.054	.818
Youth age	17	111	.410	.388	11.116	<.001	−.031	−1.715	.089	F (1, 109) = 2.941	.089
Sibling age	10	29	.394	.375	7.276	<.001	−.011	−0.203	.841	F (1, 27) = 0.041	.841
Non-twin vs. twin										F (1, 125) = 4.817	.030
Non-twin (RC)	14	95	.393	.374	8.195	<.001					
Twin	7	32	.549	.500	9.498	<.001	.157	2.195	.030		
Mono vs. dizygotic twins										F (2, 124) = 14.127	<.001
Monozygotic (RC)	7	15	.692	.599	10.673	<.001					
Dizygotic	7	17	.419	.396	6.642	<.001	−.273	−4.847	<.001		
No twins	14	95	.391	.372	8.296	<.001	−.301	−3.938	<.001		
Age spacing continuous	11	41	.507	.468	8.613	<.001	−.067	−1.708	.096	F (1, 39) = 2.916	.096
Age spacing										F (2, 41) = 1.636	.207
0 years (RC)	7	32	.546	.498	8.403	<.001					
1–2 years	1	3	.410	.388	2.213	.033	−.136	−0.694	.492		
>2 years	5	9	.364	.349	3.920	<.001	−.182	−1.758	.086		
Birth order: Sibling is										F (2, 116) = 2.371	.098
Same age (RC)	7	32	.558	.506	8.874	<.001					
Older	6	80	.397	.377	5.459	<.001	−.161	−1.676	.096		
Younger	3	6	.313	.303	2.802	.006	−.246	−1.920	.057		
Gender distribution %male	12	34	.417	.394	8.995	<.001	−.001	−1.126	.269	F (1, 32) = 1.267	.269
Gender composition										F (2, 46) = 8.758	<.001
Same gender (RC)	8	25	.597	.535	9.403	<.001					
Mix gender	3	4	.372	.356	3.337	.002	−.225	−2.206	.032		
All gender compositions combined	9	20	.354	.340	5.679	<.001	−.242	−3.727	<.001		

RC, reference category.
[a]Number of studies.
[b]Number of effect sizes.
[c]Effect size of the respective category in Fisher's *z*.
[d]Effect size of the respective category in Pearson's *r*.
[e]Difference with zero in Fisher's *z*.
[f]Estimated regression coefficients.
[g]Difference with reference category in Fisher's *z*.
[h]Omnibus test.

sizes were studies with univariate analyses. The included studies were published between 1999 and 2022 and most originated from the United States (70.00%). The average age of the target youth was 15.42 years (*SD* = 1.28 years), and the average age of their sibling was 16.91 years (*SD* = 0.95 years). A total of 50.56% of the sample (youth and siblings combined) were male. Seven studies were conducted in countries where cannabis use is legal for people over the age of 21. All studies were correlational, five of which were longitudinal. Two studies consisted mainly of ethnic minorities (i.e., non-whites), one study originated from a non-Western country and one unpublished study was included.

Overall effect

The overall effect size showed that sibling cannabis use (disorder) was significantly associated with youth cannabis use (disorder) (r = .423, p < .001, 95% CI: 0.366–0.537; Table 4). This is a 'large' effect (Cohen, 1988). The funnel plot showed that effect sizes larger than the mean effect size were missing (see right side of Figure 3). Adding these missing effect sizes yielded an overall effect size of r = .456 (p < .0001, 95% CI: 0.383–0.523). The log-likelihood-ratio test (Table 4) showed heterogeneity, indicating there were differences in outcomes that can be attributed to population differences within a

Table 2 Overview of included studies

No.	Author	Country	N_{Pairs}	M_{age} youth	M_{age} sibling	%Male
1.	Agrawal, Neale, Prescott, and Kendler (2004)	VA, USA	2,172	18.00	18.00	55.29
2.	Boisvert, Boutwell, Barnes, and Vaske (2013)	USA	1,951	NA	NA	NA
3.	Boisvert, Connolly, Vaske, Armstrong, and Boutwell (2019)	USA	536	NA	NA	50.00
4.	Brook, Balka, and Whiteman (1999)[a]	NY, USA	1,182	14.00	NA	NA
5.	Brook, Brook, Rosen, and Rabbitt (2003)[a]	Colombia	2,226	15.20	NA	NA
6.	Distel et al. (2011)	The Netherlands	1,691	NA	NA	NA
7.	Heerde, Bailey, Toumbourou, and Catalano (2019)	Australia & USA	1,945	15.00	NA	NA
8.	Hopfer, Stallings, Hewitt, and Crowley (2003)[b]	CO, USA	781	15.83	17.70	77.41
9.	Kokkevi, Arapaki, et al. (2007), Kokkevi, Richardson, et al. (2007)[a,c]	Bulgaria, Croatia, Greece, Romania, Slovenia & UK	16,445	15.40	NA	NA
10.	Kothari et al. (2014)	OR, USA	102	20.07	17.27	75.00
11.	McAdams, Rowe, Rijsdijk, Maughan, and Eley (2012)	UK	894	16.91	16.91	41.95
12.	Miles, van den Bree, and Pickens (2002)	USA	740	15.63	15.63	50.95
13.	Pejnović Franelić, Kuzman, Pavić Šimetin, and Kern (2011)[a]	Denmark, Estonia, Norway, Croatia, Slovenia, Germany, Switzerland, Bulgaria, Czech Republic, Russia & Ukraine	34,193	15.78	NA	NA
14.	Schuler, Tucker, Pedersen, and D'Amico (2019)[a]	CA, USA	8,053	14.21	NA	NA
15.	Shelton et al. (2007)	UK	1,088	16.10	16.10	44.39
16.	Thomas, Micalizzi, Meisel, Price, and Spirito (2022)	USA	99	15.95	15.03	55.05
17.	Wallace (2015)	USA	753	16.10	16.50	49.54
18.	Whiteman et al. (2013)	USA	326	14.52	17.17	41.85
19.	Whiteman, Cassinat, and Maiya (unpublished data)	USA	682	13.14	15.67	50.50
20.	Windle, Haardörfer, Lloyd, Foster, and Berg (2017)[d]	GA, USA	3,418	20.55	NA	35.60
	Average		3,964	15.42	16.91	50.56

[a]Included in peer-youth analysis.
[b]Included in parent-youth analysis.
[c]These two studies used the same dataset. In total we used 16 studies, but 15 independent studies.
[d]Included in parent-youth and peer-youth analysis.

study and study characteristics differences between studies. Hence, below we followed up with moderation analyses. But first, as for the meta-analyses on the associations between parent-youth and peer-youth cannabis use (disorder): we found that youth cannabis use was associated with parent cannabis use ($r = .300$, $p < .001$, 95% CI: 0.261–0.357) to a medium extent, and with peer cannabis use ($r = .451$, $p < .001$, 95% CI: 0.327–0.644) to a large extent (Table 4). For the peer-youth cannbis use association, the funnel plot showed missing effect sizes on the right side (Figure 4). After adding these missing effect sizes, the overall effect size increased to $r = .533$ ($p < .001$, 95% CI: 0.418–0.632). Please note, considering there were only four effect sizes for the parent-youth meta-analysis, we deemed it not reliable to conduct publication bias analyses for that meta-analysis. Figures S1–S3 display the forest-plots per meta-analysis (see the Supporting Information).

Moderator analyses

The results of the moderator analyses are presented in Table 1. We started the moderator analysis off with calculating the moderating effect of univariate versus multivariate analyses. The result showed that type of analysis (univariate vs. multivariate) did not have a significant moderating effect on the relation between sibling cannabis use and youth cannabis use (F (1, 125) = 0.260, $p = .611$). Because of this result, we continued the rest of the moderator analyses on the combined sample.

None of the *study level* characteristics were significant moderators. However, some of the *person level* characteristics moderators (thus our *hypothesized* moderators), were significant. First, the association between sibling and youth cannabis use was stronger for monozygotic twins than for dizygotic and non-twins (F (2, 124) = 14.127, β (dizygotic twins) = −.273, $p < .001$ 95% CI: −0.385; −0.162, β (non-twins) = −.301, $p < .001$, 95% CI: −0.452; −0.150), but the effect size for dizygotic twins was not significantly different than the effect-size for non-twins (Dizygotic twins as RC: $\beta = -.028$, $t_1 = -0.371$, $p = .711$, 95% CI: −0.176; 0.120).

Second, the association between cannabis use among siblings was stronger for studies that only used same-gender pairs (vs. mixed gender pairs) (F (2, 46) = 8.758, $p < .001$, β (mixed pairs) = −.215, $p = .032$, 95% CI: −0.430; −0.020, β (same and

Table 3 Effect size in Pearson's *r* per study

Author	Sibling – Youth	Explanation	Parent – Youth	Peer – Youth
Agrawal et al. (2004)	.27; .15	Monozygotic vs. dizygotic twins	–	–
Boisvert et al. (2013)	.68; .37; .65; .44; .45; .28	Different age groups and monozygotic vs. dizygotic twins	–	–
Boisvert et al. (2019)	.63; .28; .69; .43	Different gender compositions and monozygotic vs. dizygotic twins	–	–
Brook et al. (1999)	.20		–	.34
Brook et al. (2003)	.42; .49	Different gender compositions	–	.42
Distel et al. (2011)	.70; .63; .74; .57; .82; .72	Different ages and gender compositions.	–	–
Heerde et al. (2019)	.59		–	–
Hopfer et al. (2003)	.39; .44; .34	Different kinds of usage: cannabis use, abuse, and dependence	.30; .28; .27	–
Kokkevi, Arapaki, et al. (2007), Kokkevi, Richardson, et al. (2007)	.25; .33; .51; .50	Different genders		.29; .25; .31; .35
Kothari et al. (2014)	.42; .10	Different gender compositions	–	–
McAdams et al. (2012)	.43; .55; .55; .70; .47; .47; .41; .41	Different genders and non-twins vs. monozygotic vs. dizygotic twins		
Miles et al. (2002)	.54; .27; .58; .43; .30	Monozygotic vs. dizygotic twins and different gender compositions		
Pejnović Franelić et al. (2011)	.33; .47; .26; .28; .44; .34; .36; .30; .36; .23; .40; .35; .32; .24; .37; .18; .27; .35; .39; .36; .27; .41; .44; .44; .41; .23; .44; .30; .40; .28; .33; .22; .31; .25; .21; .25; .30; .45; .32; .09; .56; .42; .16; .29; .11; .07; .12; .20; .56; −.20; −.05; .20; .20; .12; .08; .03; .08; −.03; .19; .11; .18; .05; .21; .25; .27; .49	Different countries, genders, and different type of use: lifetime prevalence vs. frequent vs. early use		.52; .62; .54; .39; .71; .57; .22; .36; .23; .39; .32; .38; .24; .27; .36; .31; .33; .30; .31; .49; .28; .48; .62; .77; .57; .55; .66; .39; .35; .42; .50; .55; .52; .48; .53; .49; .37; .35; .51; .53; .46; .38; .38; .59; .25; .48; .44; .22; .74; .39; .29; .11; .21; .18; .25; .26; .25; .06; .24; .13; .27; .32; .44; .07; .18; .21
Schuler et al. (2019)	.62; .53; .51; .51; .52; .49; .39	ES for different ages		.67; .62; .62; .63; .64; .64; .61
Shelton et al. (2007)	.80; .70; .68; .13	Monozygotic vs. dizygotic twins and two types of measures: cannabis initiation vs. cannabis progression		
Thomas et al. (2022)	.19			
Wallace (2015)	.13; .18	ES for different birth orders		
Whiteman et al. (2013)	.46			
Whiteman, Cassinat, and Maiya (unpublished data)	.32			
Windle et al. (2017)	.32		.31	.53

ES, effect size.

mixed pairs) = −.242, $p < .001$, 95% CI: −0.373; −0.111).

There were three variables that were significant at a $p < .100$ level (i.e., "approached significance"), but were not significant at the traditional $p < .05$ level. First, the age of youth approached significance (F (1, 109) = 2.941, $p = .089$). The relation between sibling and youth cannabis use becomes weaker when youth grow older. Second, age spacing approached significance when it was coded as a continuous variable (F (1, 39) = 2.916, $p = .096$). The relation between sibling and youth cannabis use becomes weaker

Table 4 Overall effect for sibling cannabis use and youth cannabis use for the combined sample[a]

	k[b]	ES[c]	N_{pairs}	z[d]	95% CI	r[e]	p	σ^2_{level2}[f]	p	σ^2_{level3}[g]	p	Var_1[h]	Var_2[i]	Var_3[j]
Sibling-youth	20	127	75,099	.451	0.366; 0.537	.423	<.001	.026	<.0001	.025	<.0001	1.11	50.04	48.85
Parent-youth	2	4	4,199	.309	0.261; 0.357	.300	<.001							
Peer-youth	6	80	65,517	.486	0.327; 0.644	.451	<.001							

[a]The sample includes monozygotic twins.
[b]Number of studies.
[c]Number of effect sizes.
[d]Overall effect size in Fisher's *z*.
[e]Overall effect size in Pearson's *r*.
[f]Estimated within-study variance.
[g]Estimated between-study variance.
[h]Percentage of total variance attributed to sampling variance.
[i]Percentage of total variance attributed to within-study variance.
[j]Percentage of total variance attributed to between-study variance.

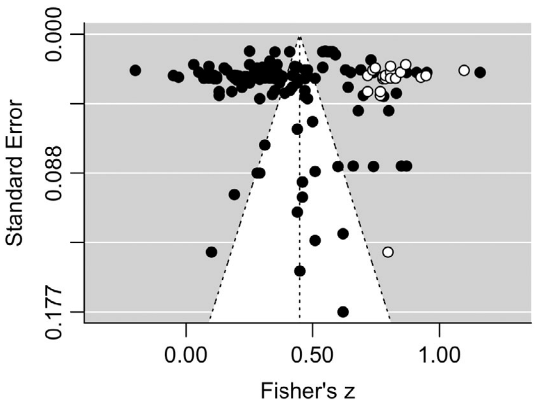

Figure 3 The funnel plot for the youth-sibling meta-analysis including monozygotic twins. *Note*. The black dots are the observed effect sizes. The vertical line is the overall correlation between sibling cannabis use and youth cannabis use. The white dots are missing effect sizes

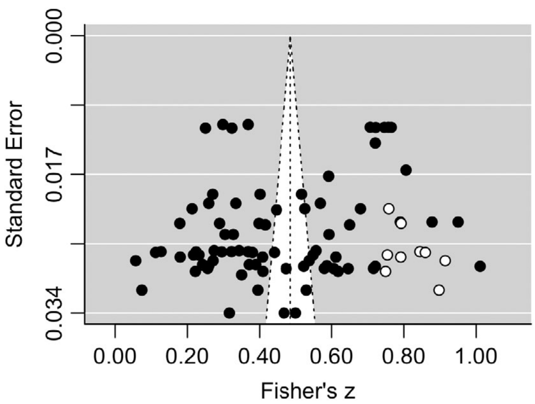

Figure 4 The funnel plot for the youth-peers meta-analysis including monozygotic twins. *Note*. The black dots are the observed effect sizes. The vertical line is the overall correlation between sibling cannabis use and youth cannabis use. The white dots are missing effect sizes

when youth are further apart in age. When we analyzed age spacing as a categorical variable, it did not approach significance (F (2, 41) = 1.636, p = .207). Lastly, birth order approached significance (F (2, 116) = 2.371, p = .098). The relation between youth and sibling cannabis use was stronger for youth that have a sibling of the same age, than for youth that have an older or younger sibling. Overall, the results (especially the overall effect sizes) in the Supporting Information are virtually identical to the results reported here (See Appendices S1 and S2, Tables S3 and S4).

Discussion

This paper presents the first meta-analysis to investigate: the overall magnitude of the association between cannabis use (disorder) among (non-twin) siblings during the youth period and whether this association was moderated by age (i.e., age of the youth, age spacing & birth order), gender (same gender vs. mix gender vs. all gender compositions combined), and by dizygotic twins versus monozygotic twins versus non-twins sibling dyads. When possible, we investigated the associations between parent-youth and peer-youth cannabis use (disorder) in separate meta-analysis as well. Inspired by social learning theory (Bandura, 1977) and DNERM (Defoe, 2021) we hypothesized that higher levels of sibling cannabis use (disorder) (a) would be associated with higher levels of youth cannabis use (disorder) and that (b) the strength of this association would be stronger for same gender siblings and (c) would decline with age. We further hypothesized that higher levels of peer and parent cannabis use (disorder) would also be associated with higher levels of youth cannabis use (disorder). Our multi-level meta-analysis of 20 studies containing 127 effect sizes, showed a large effect for the association between cannabis use (disorder) among siblings. Type of twin and gender composition were significant moderators, and showed that the association between sibling-youth cannabis use was stronger for monozygotic twins than for dizygotic or non-twins, and stronger for same-gender sibling pairs. The moderation effect of age (p = .089) approached significance, implying that the association between sibling-youth cannabis use was somewhat larger for younger youth. Finally, a medium effect size was found for the associations between parent-youth cannabis use ($r = .300$) and a large effect size for peer-youth cannabis use ($r = .451$). Below we discuss these results in detail.

Extrapolating from social learning theory and DNERM, our results could imply that if a sibling uses cannabis this would predict youth cannabis use via modeling (Bandura, 1977; Defoe, 2021) and/or access and/or exposure to cannabis (Defoe, 2021) and that this effect-size is larger or comparable in size to the associations between parent-youth cannabis use and peer-youth cannabis use, respectively. Beyond the results of Verweij et al. (2010) that focused only on twins and pooled youth's and adults' studies together, the current meta-analysis shows that (a) cannabis similarity between siblings is already visible during the youth period (b) non-twin siblings are also similar in their cannabis use, and that (c) the association between sibling-youth cannabis use is larger or similar in magnitude compared to the associations between parent-youth and peer-youth cannabis use, respectively. These results provide compelling evidence for environmental influences (in addition to the genetic influences; Verweij et al., 2010), especially since when we excluded monozygotic twins from the analyses, the association between cannabis use among siblings remained of large magnitude (see Appendices S1 and S2).

Of note is that dizygotic twins and non-twins still share 50% of their genes; thus, the significant effect size for sibling-youth cannabis use could still be due to genetic influences. However, when considering another dyad that shares 50% of their genes, namely offsprings and their parents, we find an association that is weaker than the association between siblings. If the association between sibling-youth cannabis use was purely due to genetic effects, then the association between parent and their youth offspring cannabis use and the association between sibling-youth cannabis use would have been similar. Additionally, if it were a pure genetic effect, the effect size for cannabis use among siblings, would have been substantially larger than the effect-size for peer-youth cannabis use. However, we found that both instances were not the case, which indicates that another mechanism influences the association between sibling-youth cannabis use is present in addition to genetics. We hypothesize that the mechanism could be *social learning*, which is expected to be prevalent between siblings. Social learning also appears in a parent-youth dyads. However, during the youth period, individuals increasingly spend more time with their siblings and other peers than with their parents, which could explain why the social learning effect (and thus the "association") is smaller for parent-youth cannabis use versus sibling-youth cannabis use. Thus, taken together, we conclude that youth may learn behavior from their (social-)environment, including from their siblings. Furthermore, the current meta-analysis uniquely adds to the literature as it investigated various gender and age (composition) moderation effects within the sibling dyad.

Moderation effects of age and gender

A significant association existed between cannabis use among both male and female siblings and among all gender compositions. However, this association was stronger for same-gender sibling dyads. This finding is consistent with social learning theory that posits that youth are more likely to imitate models that are similar to them (Bandura, 1977), and thus siblings of the same gender may have more similarities. Of note is that monozygotic twins are always of the same sex, and the association was stronger for cannabis use among such siblings. This perhaps (partially) presented an artifact in our above-described moderation analyses comparing mixed-gender versus same-gender sibling dyads, especially since when monozygotic twins were excluded from the analyses, the association between cannabis use among sibling was no longer stronger for same-gender sibling dyads (see the Supporting Information). Next, although we also did not find a significant moderation effect for age at the traditional $p < .05$, the moderator 'age of youth' approached significance ($p = .089$). These findings for the moderator 'age of youth' suggest that siblings might show somewhat less similarities in their cannabis use when they get older. This can perhaps be explained by the growing resistance against peer influences (Steinberg, 2008), which could translate to less imitation and thus less similarities between cannabis use among siblings. However, since this moderator did not fully reach significance, future meta-analyses with a larger number of studies are needed to further confirm to what extent age is important for the association between cannabis use among siblings.

Siblings versus parents and peers

As a plethora of studies have shown, we found that both parents' and peers' cannabis use are important for understanding youth cannabis use. The substantially fewer studies on sibling cannabis use suggest that siblings are more or equally relevant for the prediction of youth cannabis use. Namely, both the effect sizes for sibling-youth and peer-youth cannabis use were large, whereas the effect size for parent-youth cannabis use was of medium magnitude. Hence, the association between peer-youth cannabis use appears to be more similar in magnitude to sibling-youth cannabis use (compared to the association of parent-youth cannabis use). Thus, this study demonstrates that unlike parents, siblings (who are typically peers), tend to have similar social influences to peers/friends on youth's behavior (for comparable findings see also: Defoe et al., 2013). Taken together, particularly the consideration of siblings could be of added value in therapies for youth with cannabis use problems, especially since siblings would be more accessible than peers/friends for such therapies. Unfortunately, the vast majority such therapies typically only focus on the parent-child dyad, while neglecting the role of siblings (but see 'Multi-Dimensional Family Therapy' (Liddle, 2002) that aims to take youths' complete social network into account when treating youth's substance abuse problems).

Strengths, limitations, and future directions

There are some limitations that should be noted. First, due to the lack of data on siblings, especially data on siblings during the *youth period*, the included number of studies ($k = 21$) was relatively small. Lots of studies were not suitable for this meta-analysis because they included samples that consisted of adults. However, the minimum amount of studies needed to conduct a meta-analysis is two (Michael, Thornton, Xie, & Tian, 2019; Ryan & Cochrane Consumers and Communication Review Group, 2016), thus our meta-analysis contained a sufficient amount of studies to draw meaningful conclusions. For example, a simulation study showed that the results of a random-effects model are reliable in meta-analyses containing at least two studies (Michael et al., 2019). Still, it needs to be emphasized that since our parent-youth meta-analysis only contained two studies (but 4 effect-sizes), preferably those results should be replicated in a meta-analysis that includes more studies. This lack of parent cannabis use data in the studies included in the current meta-analysis underscores that studies are sorely needed that simultaneously assess sibling effects versus parent effects for youth cannabis use, if we more robustly would like to understand how sibling effects compares to parent effects. Also, although the number of studies in the meta-analysis is sufficient, there might not have been sufficient power for all of our moderation analyses, resulting in the moderation effect of 'age of youth' ($p = .089$) not reaching full statistical significance. A similar issue is that there were little to no data on how many siblings the target youth had, and included studies did not measure potential moderating factors such as sibling relationship quality, and the amount of exposure to sibling cannabis use. Hence, we could not determine whether these important factors served as moderators. Nevertheless, it is fascinating that although sibling *differentiation* is reported by 25% of siblings (Whiteman et al., 2007), we still found a large effect-size for the association between cannabis use among siblings which suggests sibling *modeling*.

Second, only two studies in the current meta-analysis included a substantial amount of ethnic minority participants (non-white) and only one study originated from a non-Western country. Since cannabis use rates and family systems are different across ethnic groups (Areba, Eisenberg, & McMorris, 2018; Tuck, Hamilton, Agic, Ialomiteanu, & Mann, 2017), we thus cannot fully generalize our results to ethnic minorities or non–Western countries. Finally, it is important to note that results of the current meta-analysis are correlational and therefore cannot demonstrate causal influences, since we did not locate any experimental studies. Taken together, the above-mentioned drawbacks are not necessarily limitations of the current meta-analysis but are caused by the nature and quality of the available studies.

Conclusion

Cannabis is currently being legalized globally, but this drug has been shown to be related to multiple negative health outcomes, especially for youth. This multi-level meta-analysis revealed that youth are more likely to use cannabis if their sibling uses cannabis and that this association is strong, and holds true for twins, non-twins, across genders, all ages and for different age spacings, birth orders and gender compositions within the sibling dyad. Additionally, the magnitude of this robust sibling similarity in cannabis use was stronger for monozygotic twins, which suggests a strong genetic component in addition to an environmental component, since we also found a general large effect-size for *non*-twins. Monozygotic twins are always of the same sex, and thus not very surprising that we found that same-gendered sibling dyads also had a larger effect size. Finally, the association between cannabis use among siblings is larger than the association between parent-youth cannabis use, and similar in magnitude to the association between peer-youth cannabis use. Extrapolating from social learning theory and DNERM, this environmental component entails that similar to parents' and peers' cannabis use: if a sibling uses cannabis, this could lead to youth cannabis use via modeling (Bandura, 1977; Defoe, 2021) and/or access and/or exposure to cannabis (Defoe, 2021). Considered together, this meta-analysis revealed that when it comes to youth cannabis use (disorder), all constellations of sibling dyads matter. Thus, if the aim is to manage youth cannabis use, we need not overlook the too often-neglected sibling system.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Appendix S1. Method.

Appendix S2. Results excluding monozygotic twins.
Table S1. Coding sheet.
Table S2. Overview of included studies.
Table S3. Overall effect for sibling cannabis use and youth cannabis use for the combined sample.
Table S4. Results single moderator analyses excluding monozygotic twins.
Figure S1. The forest plot for the youth-sibling meta-analysis including monozygotic twins.
Figure S2. The forest plot for the youth-parent meta-analysis including monozygotic twins.
Figure S3. The forest plot for the youth-peers meta-analysis including monozygotic twins.

Acknowledgments

The authors have declared that they have no competing or potential conflicts of interest.

The authors thank the researchers who answered their request to provide extra information about their studies, and Dan Romer for his comments on a previous version of this meta-analysis.

Correspondence

Ivy N. Defoe, University of Amsterdam, PO Box 15776, 1001 NG, Amsterdam, The Netherlands; Email: i.n.defoe@uva.nl

Key points

- Parents' and peers' cannabis use are well-documented predictors of youth cannabis use.
- However, the extent to which siblings' cannabis use predicts youth cannabis use is relatively overlooked.
- We conducted the first meta-analysis on the association between sibling-youth cannabis use (disorder), and when comparison data were available, we conducted meta-analyses on the associations between parent-youth cannabis use (disorder) and peer-youth cannabis use (disorder).
- A large effect size existed for the association between sibling-youth cannabis use among all sibling constellations, and this effect size was larger than the parent-youth cannabis use association and comparable to the peer-youth cannabis use association.
- The effectiveness of treatments for youth with cannabis use problems could improve if the overlooked influence of siblings is considered.

References

Agrawal, A., Neale, M.C., Prescott, C.A., & Kendler, K.S. (2004). A twin study of early cannabis use and subsequent use and abuse/dependence of other illicit drugs. *Psychological Medicine*, *34*, 1227–1237.

Areba, E.M., Eisenberg, M.E., & McMorris, B.J. (2018). Relationships between family structure, adolescent health status and substance use: Does ethnicity matter? *Journal of Community Psychology*, *46*, 44–57.

Assink, M., & Wibbelink, C.J.M. (2016). Fitting three-level meta-analytic models in R: A step-by-step tutorial. *The Quantitative Methods for Psychology*, *12*, 154–174.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.

Boisvert, D., Boutwell, B.B., Barnes, J.C., & Vaske, J. (2013). Genetic and environmental influences underlying the relationship between low self-control and substance use. *Journal of Criminal Justice*, *41*, 262–272.

Boisvert, D.L., Connolly, E.J., Vaske, J.C., Armstrong, T.A., & Boutwell, B.B. (2019). Genetic and environmental overlap between substance use and delinquency in adolescence: An analysis by same-sex twins. *Youth Violence and Juvenile Justice*, *17*, 154–173.

Boyle, M.H., Sanford, M., Szatmari, P., Merikangas, K., & Offord, D.R. (2001). Familial influences on substance use by adolescents and young adults. *Canadian Journal of Public Health*, *92*, 206–209.

Brook, J.S., Balka, E.B., & Whiteman, M. (1999). The risks for late adolescence of early adolescent marijuana use. *American Journal of Public Health*, *89*, 1549–1554.

Brook, J.S., Brook, D.W., Rosen, Z., & Rabbitt, C.R. (2003). Earlier marijuana use and later problem behavior in Colombian youths. *Journal of the American Academy of Child and Adolescent Psychiatry*, *42*, 485–492.

Buist, K.L., Deković, M., & Prinzie, P. (2013). Sibling relationship quality and psychopathology of children and adolescents: A meta-analysis. *Clinical Psychology Review*, *33*, 97–106.

Centraal Bureau voor de Statistiek. (2021). Huishoudens nu. Available from: https://www.cbs.nl/nl-nl/visualisaties/dashboard-bevolking/woonsituatie/huishoudens-nu [last accessed 5 June 2023].

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Earlbam Associates.

Defoe, I.N. (2021). Towards a hybrid criminological and psychological model of risk behavior: The developmental neuro-ecological risk-taking model (DNERM). *Developmental Review*, *62*, 100995.

Defoe, I. N., Keijsers, L., Hawk, S. T., Branje, S., Dubas, J. S., Buist, K., … & Meeus, W. (2013). Siblings versus parents and friends: Longitudinal linkages to adolescent externalizing problems. *Journal of Child Psychology and Psychiatry*, *54*(8), 881-889.

Defoe, I.N., Khurana, A., Betancourt, L.M., Hurt, H., & Romer, D. (2019). Disentangling longitudinal relations between youth cannabis use, peer cannabis use, and conduct problems: Developmental cascading links to cannabis use disorder. *Addiction*, *114*, 485–493.

Defoe, I.N., Dubas, J.S., Dalmaijer, E.S., & van Aken, M.A.G. (2020). Is the peer presence effect on heightened adolescent risky decision-making only present in males? *Journal of Youth and Adolescence*, *49*, 693–705.

Distel, M.A., Vink, J.M., Bartels, M., van Beijsterveldt, C.E.M., Neale, M.C., & Boomsma, D.I. (2011). Age moderates non-genetic influences on the initiation of cannabis use: A twin-sibling study in Dutch adolescents and young adults. *Addiction*, *106*, 1658–1666.

Dunifon, R., Fomby, P., & Musick, K. (2017). Siblings and children's time use in the United States. *Demographic Research*, *37*, 1611–1624.

Duval, S., & Tweedie, R. (2000). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*, 455–463.
Emmelkamp, J., Asscher, J.J., Wissink, I.B., & Stams, G.J.J.M. (2020). Risk factors for (violent) radicalization in juveniles: A multilevel meta-analysis. *Aggression and Violent Behavior*, *55*, 101489.
Fu, R., Gartlehner, G., Grant, M., Shamliyan, T., Sedrakyan, A., Wilt, T.J., … & Trikalinos, T.A. (2011). Conducting quantitative synthesis when comparing medical interventions: AHRQ and the effective health care program. *Journal of Clinical Epidemiology*, *64*, 1187–1197.
Gov.UK. (2022). Young people's substance misuse treatment statistics 2020 to 2021: Report - GOV.UK. Available from: www.gov.UK/government/statistics/substance-misuse-treatment-for-young-people-statistics-2020-to-2021/young-peoples-substance-misuse-treatment-statistics-2020-to-2021-report [last accessed 5 June 2023].
Heerde, J.A., Bailey, J.A., Toumbourou, J.W., & Catalano, R.F. (2019). Longitudinal associations between the adolescent family environment and young adult substance use in Australia and the United States. *Frontiers in Psychiatry*, *10*. https://doi.org/10.3389/fpsyt.2019.00821
Hopfer, C.J., Stallings, M.C., Hewitt, J.K., & Crowley, T.J. (2003). Family transmission of marijuana use, abuse, and dependence. *Journal of the American Academy of Child and Adolescent Psychiatry*, *42*, 834–841.
Howe, N., Rosciszewska, J., & Persram, R. J. (2018). "I'm an ogre so I'm very hungry!" "I'm assistant ogre": The social function of sibling imitation in early childhood. *Infant and Child Development*, *27*(1), e2040. https://doi.org/10.1002/icd.2040
Jenkins, J., & Dunn, J. (2009). Siblings within families: Levels of analysis and patterns of influence. *New Directions for Child and Adolescent Development*, *2009*, 79–93.
Johnson, E.C., Tillman, R., Aliev, F., Meyers, J.L., Salvatore, J.E., Anokhin, A.P., … & Agrawal, A. (2019). Exploring the relationship between polygenic risk for cannabis use, peer cannabis use and the longitudinal course of cannabis involvement. *Addiction*, *114*, 687–697.
Johnston, L., O'Malley, P., Miech, R., Bachman, J., & Schulenberg, J. (2015). Marijuana: Facts parents need to know. https://nida.nih.gov/sites/default/files/parents_mj_brochure_2016.pdf [last accessed 8 June 2023].
Kokkevi, A., Richardson, C., Florescu, S., Kuzman, M., & Stergar, E. (2007). Psychosocial correlates of substance use in adolescence: A cross-national study in six European countries. *Drug and Alcohol Dependence*, *86*, 67–74.
Kokkevi, A.E., Arapaki, A.A., Richardson, C., Florescu, S., Kuzman, M., & Stergar, E. (2007). Further investigation of psychological and environmental correlates of substance use in adolescence in six European countries. *Drug and Alcohol Dependence*, *88*, 308–312.
Kothari, B.H., Sorenson, P., Bank, L., & Snyder, J. (2014). Alcohol and substance use in adolescence and young adulthood: The role of siblings. *Journal of Family Social Work*, *17*, 324–343.
Liddle, H.A. (2002). *Multidimensional family therapy for adolescent cannabis users. Cannabis youth treatment (CYT) series* (Vol. *5*). Rockville, MD: Center for Substance Abuse Treatment, Substance Abuse and Mental Health Services Administration.
Madras, B.K., Han, B., Compton, W.M., Jones, C.M., Lopez, E.I., & McCance-Katz, E.F. (2019). Associations of parental marijuana use with offspring marijuana, tobacco, and alcohol use and opioid misuse. *JAMA Network Open*, *2*, e1916015.
McAdams, T., Rowe, R., Rijsdijk, F., Maughan, B., & Eley, T.C. (2012). The variation of antisocial behavior and substance use in adolescence: A behavioral genetic perspective. *Journal of Research on Adolescence*, *22*, 100–112.
Michael, H., Thornton, S., Xie, M., & Tian, L. (2019). Exact inference on the random-effects model for meta-analyses with few studies. *Biometrics*, *75*(2), 485-493.
Mikkonen, J., Savolainen, J., Aaltonen, M., & Martikainen, P. (2020). Using age difference and sex similarity to detect evidence of sibling influence on criminal offending. *Psychological Medicine*, *52*, 1892–1900.
Miles, D.R., van den Bree, M.B.M., & Pickens, R.W. (2002). Sex differences in shared genetic and environmental influences between conduct disorder symptoms and marijuana use in adolescents. *American Journal of Medical Genetics*, *114*, 159–168.
National Institute on Drug Abuse. (2019). Marijuana drugfacts. Available from: https://www.drugabuse.gov/publications/drugfacts/marijuana [last accessed 5 June 2023].
Pejnović Franelić, I., Kuzman, M., Pavić Šimetin, I., & Kern, J. (2011). Impact of environmental factors on marijuana use in 11 European countries. *Croatian Medical Journal*, *52*, 446–457.
Ryan, R., & Cochrane Consumers and Communication Review Group. (2016). Cochrane consumers and communicationgroup: Meta-analysis. Available from: http://cccrg.cochrane.org [last accessed 5 June 2023].
Sawyer, S.M., Azzopardi, P.S., Wickremarathne, D., & Patton, G.C. (2018). The age of adolescence. *The Lancet Child & Adolescent Health*, *2*, 223–228.
Schuler, M.S., Tucker, J.S., Pedersen, E.R., & D'Amico, E.J. (2019). Relative influence of perceived peer and family substance use on adolescent alcohol, cigarette, and marijuana use across middle and high school. *Addictive Behaviors*, *88*, 99–105.
Shelton, K., Lifford, K., Fowler, T., Rice, F., Neale, M., Harold, G., … & van den Bree, M. (2007). The association between conduct problems and the initiation and progression of marijuana use during adolescence: A genetic analysis across time. *Behavior Genetics*, *37*, 314–325.
Steinberg, L. (2008). A social neuroscience perspective on adolescent risk-taking. *Developmental Review*, *28*, 78–106.
Thomas, S.A., Micalizzi, L., Meisel, S.N., Price, D., & Spirito, A. (2022). Adolescent sibling associations among alcohol, cannabis, and sexual risk behavior: A test of interdependence. *Substance Use & Misuse*, *57*, 1572–1580.
Trimbos-instituut, & Wetenschappelijk Onderzoek- en Documentatiecentrum. (2020). *Nationale drug monitor: jaarbericht 2019*.
Tuck, A., Hamilton, H.A., Agic, B., Ialomiteanu, A.R., & Mann, R.E. (2017). Past year cannabis use and problematic cannabis use among adults by ethnicity in Ontario. *Drug and Alcohol Dependence*, *179*, 93–99.
United States Census Bureau. (2020). America's families and living arrangements: 2020. Available from: https://www2.census.gov/programs-surveys/demo/tables/families/2020/cps-2020/tabc3-all.xls [last accessed 5 June 2023].
van den Noortgate, W., López-López, J.A., Marín-Martínez, F., & Sánchez-Meca, J. (2013). Three-level meta-analysis of dependent effect sizes. *Behavior Research Methods*, *45*, 576–594.
Verweij, K.J.H., Zietsch, B.P., Lynskey, M.T., Medland, S.E., Neale, M.C., Martin, N.G., … & Vink, J.M. (2010). Genetic and environmental influences on cannabis use initiation and problematic use: A meta-analysis of twin studies. *Addiction*, *105*, 417–430.
Viechtbauer, W. (2010). Conducting meta-analyses in R with the meta for package. *Journal of Statistical Software*, *36*(3), 1–48. https://doi.org/10.18637/jss.v036.i03
Wallace, L.N. (2015). Sibling popularity: A moderator of sibling influence for adolescent substance use. *Addiction Research and Theory*, *23*, 481–489.
Whiteman, S.D., & Christiansen, A. (2008). Processes of sibling influence in adolescence: Individual and family correlates. *Family Relations*, *57*, 24–34.

Whiteman, S.D., McHale, S.M., & Crouter, A.C. (2007). Competing processes of sibling influence: Observational learning and sibling deidentification. *Social Development*, *16*, 642–661.
Whiteman, S.D., Jensen, A.C., & Maggs, J.L. (2013). Similarities in adolescent siblings' substance use: Testing competing pathways of influence. *Journal of Studies on Alcohol and Drugs*, *74*, 104–113.
Whiteman, S.D., Jensen, A.C., & McHale, S.M. (2017). Sibling influences on risky behaviors from adolescence to young adulthood: Vertical socialization or bidirectional effects? *New Directions for Child and Adolescent Development*, *2017*, 67–85.
Wilson, D.B. (2001). Practical meta-analysis effect size calculator. Available from: https://www.campbellcollaboration.org/escalc/html/EffectSizeCalculator-Home.php [last accessed 5 June 2023].
Windle, M., Haardörfer, R., Lloyd, S.A., Foster, B., & Berg, C.J. (2017). Social influences on college student use of tobacco products, alcohol, and marijuana. *Substance Use and Misuse*, *52*, 1111–1119.

Accepted for publication: 23 March 2023