



What is the prevalence and risk of cannabis use disorders among people who use cannabis? a systematic review and meta-analysis

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HIGHLIGHTS

- There is a global shift towards cannabis legalization and underestimation of harms.
- A systematic review meta-analysed the risk of cannabis use disorders (CUD) from use.
- People who use cannabis have a 1 in 5 risk of developing a CUD.
- Risks increase if cannabis is initiated early and used frequently.
- The public needs to be informed about the risks of developing CUD from cannabis use.

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ABSTRACT

Background and Aims: We aim to quantify the prevalence and risk of having a cannabis use disorder (CUD), cannabis abuse (CA) or cannabis dependence (CD) among people in the general population who have used cannabis.

Method: We conducted a systematic review of epidemiological cross-sectional and longitudinal studies on the prevalence and risks of CUDs among cannabis users. We identified studies published between 2009 and 2019 through PubMed, the Global Burden Disease (GBD) Database, and supplementary searches up to 2020. The outcomes of interest were CUDs based on DSM or ICD criteria. Estimates were synthesized using random-effects meta-analyses, followed by meta-regression of study characteristics on effect sizes.

Results: From 1383 records identified, 21 studies were included. Meta-analyses showed that among people who used cannabis, 22% (18–26%) have CUD, 13% (8–18%) have CA, and 13% (10–15%) have CD. Estimates from cohort studies, showed that the risk of developing CD increased to 33% (22–44%) among young people who engaged in regular (weekly or daily) use of cannabis. There was a lack of data from cohort studies to estimate the risk of CUD or CA among regular cannabis users.

Conclusions: Cannabis users need to be informed about the risks of developing CUDs and the higher risks among those who initiate early and use frequently during adolescence. Future studies are needed to examine how changes in cannabis policies may affect the risks of CUDs in the population.

1. Introduction

"One in 10 cannabis users develop dependence" is the figure widely cited by clinicians, researchers, and policymakers in health and medicine. (Degenhardt and Hall, 2012; Hall and Degenhardt, 2009; Koob and Le Moal, 2001) This estimate comes from the National Comorbidity Survey (NCS), a cross-sectional survey conducted in 1990–1992 in the United States (Anthony et al., 1994), that estimated that the lifetime prevalence of cannabis dependence (CD; using DSM-III-R criteria)

among adults who reported that they had ever used cannabis was 9.1% (7.7%–10.5%). These data were collected almost 30 years ago when cannabis products were less potent than today (Cascini et al., 2012; Chandra et al., 2019) and before major changes in definitions of cannabis use disorders (CUD).

Caulkins has argued out that the Anthony et al. figure probably underestimates the risk of CD from cannabis use, because many "users" had may have only *tried* cannabis once or twice, and so are not at risk of developing dependence. (Caulkins, 2017) Cohort studies (e.g. the

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Colorado Community Twin Study and Longitudinal Twin Study) have also reported that not all individuals who experiment with cannabis will use it again, and not all who do so will develop cannabis use disorders. (Palmer et al., 2009)

An analysis of the Australian National Survey of Mental Health and Well-Being (NSMHWB) conducted in 1997 estimated that 22.2% (19.3%–25.2%) of people who had used cannabis five times or more in the past year met ICD-10 criteria for CD in that year, (Hall et al., 1999) a risk closer to one in five and twice that from the NCS earlier in the same decade. In the 2007 NSMHWB, the prevalence of CD in the overall population had decreased to 0.4% (from 1.9% in 1997). (Hall et al., 1999; Slade et al., 2009) From the 2007 data, Degenhardt et al. estimated a lifetime dependence risk of 9.8% (7.5–12.2) if people had used cannabis five times or in their lives. (Degenhardt et al., 2018) Recent analyses of the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) from the USA reported a prevalence of past-year DSM-IV cannabis dependence of 7–8% (Blanco et al., 2016; Lopez-Quintero and Pérez de los Cobos J, Hasin DS, 2011) and an incidence of 5% (Blanco et al., 2016) among adults who have used cannabis.

We reviewed evidence to assess whether the risks of dependence among people who have used cannabis have changed in recent years. We systematically reviewed data on the prevalence and risk of having CUDs, including CD or cannabis abuse (CA) among people who have used cannabis.

2. Method

2.1. Protocol

We followed the PRISMA guidelines (checklist in S1); the a-priori protocol (CRD:42019133166) is registered on PROSPERO, the International Prospective Register of Systematic Reviews.

2.2. Selection criteria

We included observational studies in general population samples, while excluding high-risk or sub-populations such as prisoners or ethnic minorities. Review articles were used to source secondary references. Studies were included if they reported the prevalence of DSM/ICD criteria for CUD, CA, or CD as ascertained by structured interviews for clinical conditions, (e.g. Comprehensive International Diagnostic Interview [CIDI]). This removed studies that used scales that had not been assessed for reliability and validity, or self-reported cannabis problems.

Any version of the DSM was eligible for inclusion. Given the changes in DSM-5 criteria for CUD, (no separate diagnoses for CA and CD anymore; see S1 for differences in criteria) we planned separate analyses for each version of the DSM.

2.3. Search strategy

We conducted our search in Feb 2019 for papers published in the past 10 years (from Jan 2009). We excluded studies published before 2009 because we aimed to summarise evidence from studies published within the past 10 years. We searched PubMed for longitudinal studies using the MeSH Terms “marijuana abuse” AND “cohort studies”, with corresponding titles/abstracts search on their synonyms (see S3a for search terms). We searched the Global Burden Disease (GBD) Data Input Source for CUD for cross-sectional studies. This is the largest comprehensive on-going systematic review that captures all cross-sectional epidemiological studies of the prevalence of cannabis use and CUDs (details are available in S3b). The search was supplemented by a reference list search of relevant articles, key population surveys on substance use, drug monitoring agency publications, references forwarded by experts in the field, the authors' collection, and a search for new publications, conducted in April 2020.

2.4. Study selection

Duplicate records were removed and then titles and abstracts screened to filter out studies that were not on cannabis use or CUDs. Full-texts were retrieved for screening against the exclusion criteria: 1) wrong study design; 2) special samples; 3) not cannabis use; 4) no data on CUD, CA, or CD; 5) no data among people who used cannabis; and 6) duplicate (see S3c for examples).

2.5. Data extraction

Study characteristics extracted included country of data source, year of data collection, study design (cross-sectional or longitudinal), and years of follow-up. Data were extracted on how cannabis use was measured (e.g. ever used, number of times ever used, used in the past year, past month use, used weekly or daily) and how CUD, CA, or CD (criteria and diagnostic tool) were defined. If a study reported data by sex, age, year of data collection across multiple years, or multiple recall periods, they were extracted as separate data-points. This allowed multiple data-points to be extracted from each study.

2.6. Analysis

The key summary measure was the percentage (and standard error or 95% confidence intervals) of those who had used cannabis who had a CUD, CA, or CD. Findings by age and sex were summarised for studies that reported them.

Three sets of random-effects *meta*-analyses were performed on the risk of CUD, CA, and CD separately. Subgroup analyses were performed by type of study design (longitudinal or cross-sectional) and recall period of cannabis use (lifetime, past year or past month, regular [daily or weekly]). We conducted *meta*-regression analyses to examine the effects of the year of data collection, assessment tool used, and country of study on the heterogeneity of effect sizes, while adjusting for age, sex, and recall period.

3. Results

3.1. Study selection

We identified 1383 records and screened 1264 unique titles to obtain 130 full-texts to assess for eligibility (see S1 for flowchart). We excluded 109 full-text articles because: they were not observational general population studies ($n = 9$); they did not provide data on CUD, CA, or CD ($n = 48$; e.g. reported on any substance use disorders combined); the estimates of CUDs were not reported among people who had used cannabis ($n = 31$); or the same data have been captured in another included study ($n = 21$). The final 21 studies allowed extraction of 153 data-points with 255,010, 28,951, and 58,661 observations on risks of CUD, CA, and CD, respectively.

3.2. Study characteristics and narrative summary

Samples were from the United States, Netherlands, Germany, Australia, New Zealand, Ireland, and France (see Table 1). Fifteen studies provided data on cross-sectional and nine on longitudinal associations. Eleven studies sampled adolescents or young adults, one study was on older adults, and the rest covered a wide age-range (e.g. 12 + or 18 +, see Table 1).

Nine studies reported the risk among people who had ever tried cannabis, (Palmer et al., 2009; Lopez-Quintero and Pérez de los Cobos J, Hasin DS, 2011; Harley et al., 2015; Hayatbakhsh et al., 2009; Kirisci et al., 2013; Le Strat et al., 2009; Prince van Leeuwen et al., 2014; Han et al., 2019; Feingold et al., 2020) only three studies included people who had used cannabis multiple times. (Palmer et al., 2009; Degenhardt et al., 2018; Wittchen et al., 2008) Nine studies examined

Table 1
Summary of studies capturing cannabis use disorders, cannabis abuse and cannabis dependence among people who have used cannabis.

Study	Country	Study name, year of data collection (design of analysis)	Age	CU definition	CUD definition	Diagnostic tool	% CUD among CU	Age & sex differences
Blanco (2016)	United States	NESARC I, 2001–02 (Cross-sectional)	18+	Past year use	Past year DSM-IV CUD	AUDADIS-IV	36.1% (33.4–38.7)	–
					Past year DSM-IV CA	28.4% (25.8–30.9)		
Blazer (2009)	United States	National Survey on Drug Use and Health (NSDUH), 2005–06 (Cross-sectional)	50+	Past year use	Past year DSM-IV CD	DSM-IV criteria based tool	7.7% (6.2–9.1)	–
					Past 3 years DSM-IV CUD	CIDI	21.4% (19.2–23.6)	
					CUD			
					Past 3 years DSM-IV CA		16.7% (14.6–18.8)	
					Past 3 years DSM-IV CD		4.7% (3.5–5.9)	
Coffey (2016)	Australia	Victorian Adolescent Health Cohort Study (VAHCS), 1992–95 to 2001–03 (Longitudinal)	15–17 to 25	Weekly use in the past year	Past year DSM-IV	DSM-IV criteria based tool	25.0% (17.3–32.7)	–
					CUD (incidence)		22.6% (15.2–29.9)	
Compton (2019)	United States	NSDUH, 2002 (Cross-sectional)	18+	Daily use in the past year	Past year DSM-IV CA	DSM-IV criteria based tool	40.9% (29.0–52.8)	–
					Past year DSM-IV CD		14.8% (13.6–16.1)	
					Past year use		33.4% (29.8–37.3)	
					Daily or near daily use in the past year		9.2% (8.3–10.1)	
					Daily or near daily use in the past year		23.2% (20.2–26.5)	
					Past year use		5.6% (4.8–6.7)	
					Daily or near daily use in the past year		10.2% (8.0–13.0)	
					Past year use		9.3% (8.6–10.0)	
					Daily or near daily use in the past year		19.5% (17.6–21.5)	
					Past year use		6.4% (5.8–7.0)	
Degenhardt (2018)	Australia	National Survey of Mental Health and Well-Being (NSMHWB), 2007 (Cross-sectional)	18–85	Lifetime use > = 5 times	Lifetime DSM-IV CD	CIDI	9.8% (7.5–12.2)	M > F, Y < MO
					Lifetime DSM-IV CA		22.2% (19.3–25.0)	M > F, YMO = ns
					Lifetime DSM-5 CUD	AUDADIS-5	27.0% (26.2–27.8)	M > F, Y > M > O
Feingold (2020)	United States	NESARC III, 2012–2013 (Longitudinal)	18+	Past year use	Past year DSM-IV CUD	DSM-IV criteria based tool	19.5% (18.3–20.7)	YY > Y
					Lifetime use		15.7% (14.7–16.8)	
Han (2019)	United States	NSDUH, 2015–17 (Cross-sectional)	12–17	Daily or near daily use in the past year	Past year DSM-IV CA		15.4% (14.7–16.2)	
					Lifetime use		9.8% (9.3–10.3)	
Harley (2015)	Ireland	The Challenging Times Two study, ~2011 (Cross-sectional)	18–25	Past year use	Past year DSM-IV CA	SCID	8.9% (0.9–17.0)	–
					Lifetime use		15.1% (8.4–21.8)	
					Past month use		4.7% (0.0–10.6)	
Hasin (2015)	United States	NESARC III, 2012–2013 (Cross-sectional)	18+	Past year use	Past month DSM-IV CA	AUDADIS-5	30.6% (28.6–32.6)	M > F, Y > M > O
					Lifetime use		41.1% (38.4–43.8)	M > F
Hayatbakhsh (2009)	Australia	Mater University of Queensland Study of Pregnancy (MUSP), 2002–2004 (Cross-sectional)	21	Lifetime use	Past year DSM-IV CUD	CIDI	26.4% (20.9–32.0)	–
					Lifetime DSM-IV CUD			
Kircsi (2013)	United States	Center for Education and Drug Abuse Research (CEDAR) longitudinal boys study, 2000 s to 2010 s (Longitudinal)	10–12 to 22	Lifetime use	Lifetime DSM-III-R CUD	SCID		–
					Lifetime DSM-IV CUD			

(continued on next page)

Table 1 (continued)

Study	Country	Study name, year of data collection (design of analysis)	Age	CU definition	CUD definition	Diagnostic tool	% CUD among CU	Age & sex differences
Le Strat (2009)	France	Susceptibility Addiction Gene Environment (SAGE), 2007 (Cross-sectional)	18–21	Lifetime use	Lifetime DSM-IV CD	DIGS	17.7% (15.8–19.7)	M > F
Lopez-Quintero (2011)	New Zealand	Christchurch Health and Development Study (CHDS), 1991 to 2002 (Longitudinal)	14–16 to 25–27	Lifetime use	Lifetime DSM-IV CD		28.3% (22.0–34.6)	–
Pabst (2013)	United States	National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) I & II, 2001–02 to 2004–05 (Longitudinal)	18+	Lifetime use	Past year DSM-IV CD	AUDADIS-IV	7.2% (6.6–7.7)	M > F, Y > M > O
Palmer (2009)	Germany	Epidemiological Survey of Substance Abuse (ESA), 2012 (Cross-sectional)	18–64	Past year use	Past year DSM-IV CA	M–CIDI	11.1% (8.1–14.2) n = 48	YMO = ns
Philbin (2019)	United States	Center for Antisocial Drug Dependence (CADD) study, 1998–2015 (Cross-sectional)	17–23	Lifetime use Lifetime use > 6 times	Past year DSM-IV CD	CIDI	11.1% (8.1–14.2) n = 46	YMO = ∩
Prince van Leeuwen (2014)	Netherlands	National Survey on Drug Use and Health (NSDUH), 2004–06 (Cross-sectional)	12+	Lifetime use Lifetime use > 6 times	Lifetime DSM-IV CUD	DSM-IV criteria based tool	8.8% (6.8–10.7) 12.8% (10.0–15.5)	MvF ns MvF ns
Santalla-Tenorio (2019)	United States	National Survey on Drug Use and Health (NSDUH), 2004–06 (Cross-sectional)	12+	Past year use	Past year DSM-IV CUD	DSM-IV criteria based tool	25.8% (22.8–28.8) 37.4% (33.4–41.4)	M > F M > F
van der Pol (2013)	Netherlands	TRacking Adolescents' Individual Lives Survey (TRAILS), 2008–09 to 2011–12 (Longitudinal)	10–11 to 18–19	Lifetime use	Lifetime DSM-IV CUD	CIDI	20.8% (20.3–21.4)	Y > M > O
Wirtchen (2008)	Germany	Early Developmental Stages of Psychopathology study (EDSP), 1995 to 2005 (Longitudinal)	14–24 to 21–34	Daily or near daily use in the past year	Past year DSM-IV CUD	DSM-IV criteria based tool	17.6% (17.1–18.2)	Y > M > O
Wu (2012)	United States	National Survey on Drug Use and Health (NSDUH), 2008 (Cross-sectional)	18+	Past year use	Past year DSM-IV CUD	DSM-IV criteria based tool	23.7% (19.7–27.7)	–
							45.3% (42.8–47.8)	Y > M > O
							32.6% (30.2–34.9)	
							31.4% (29.1–33.7)	
							25.3% (23.4–27.2)	
							21.1% (19.3–22.8)	
							11.9% (10.6–13.2)	
							36.7% (30.0–43.4)	MvF ns
							20.4% (16.8–23.9)	M > F
							6.7% (5.4–8.0)	M > F
							15.0% (14.2–15.8)	–
							5.3% (4.6–6.0)	M > F, Y > O
							9.6% (8.9–10.3)	MvF ns, Y > M > O

CUD, cannabis use disorder (abuse or dependence); CA, cannabis abuse; CD, cannabis dependence;
 Year of data collection analysed and ages for longitudinal studies were presented from baseline to follow-up;
 CUD definitions are prevalence, unless specified as incidence;
 Diagnostic tools: AUDADISV, Alcohol Use Disorder and Associated Disabilities Interview Schedule; CIDI, Composite International Diagnostic Interview; DIGS, Diagnostic Interview for Genetic Studies; M–CIDI, Munich-Composite International Diagnostic Interview; SCID, Structured Clinical Interview for DSM;
 Age and sex differences: F, female; M, male; Y, young age group; M, mid-age group; O, older age group; ∩, inverted U shape; –, not available; ns, not significant in analysis

people who had used cannabis in the past year. (Blanco et al., 2016; Han et al., 2019; Blazer and Wu, 2009; Coffey and Patton, 2016; Hasin et al., 2015; Pabst et al., 2012. Sucht. 2013.; Philbin et al., 2019; Wu et al., 2012; Compton et al., 2019) Four studies estimated the prevalence or risk among people who used cannabis weekly or daily. (Coffey and Patton, 2016; Compton et al., 2019; van der Pol et al., 2013; Santaella-Tenorio et al., 2019) Three longitudinal studies reported data on incidence at follow-up in a sample of people who used cannabis with no lifetime history of CUD, CA, or CD at baseline. (Blanco et al., 2016; Wittchen et al., 2008; van der Pol et al., 2013)

One study used DSM-5 criteria to diagnose CUD among people who have used cannabis. Lifetime probability of transition to DSM-5 CUD after cannabis use was 27%. (Feingold et al., 2020) One study used DSM-III-R and all others used DSM-IV to define CUD, as the presence of either CA or CD. The study that used DSM-III-R, by Kirisci and colleagues, estimated a 26.4% (20.9–32.0) risk of CUD given lifetime use. (Kirisci et al., 2013) This was similar to the 23.7% (19.7–27.7), estimated by Prince van Leeuwen and colleagues using DSM-IV criteria. Compton and colleagues (Compton et al., 2019) explored approximating DSM-5 diagnosis, by examining the 9 CUD criteria measured by a DSM-IV criteria-based tool that overlapped with DSM-5 criteria. The estimated prevalence of adults who met two or more criteria was 16.8% (15.9–17.7) in past year users, and 36.8% (34.4–39.3%) in daily or near-daily users.

The lowest risk of CUD was 4.5% (1.8–7.3) in older adults aged 50 + in the United States (US) 2005–2006 National Survey on Drug Use and Health (NSDUH). (Blazer and Wu, 2009) The highest risk of CUD was found in the Mater University of Queensland Study of Pregnancy (MUSP) study from Australia. This cohort of 21 year-olds from 2002 to 2004 found that 41.1% (38.4–43.8) of those who reported a history of cannabis use had a lifetime diagnosis of CUD. (Hayatbakhsh et al., 2009)

The lowest risk of CA was also from the NSDUH, which estimated that 2.9% (2.5–3.3), of adults aged 18 +, who had used cannabis in the past year in 2017 had CA. (Compton et al., 2019) This contrasted with observations from National Epidemiologic Survey on Alcohol and Related Conditions (NESARC; 2001–02), which found 28.4% (25.8–30.9) of those who had used cannabis in the past year had CA. Compton and colleagues' analyses of the NSDUH datasets across years reported a decrease in prevalence over time for CA, CUD and CD. (Compton et al., 2019)

The lowest risk for CD was observed in The Challenging Times Two study conducted in Ireland. It estimated that 3.5% (0.1–7.0) of people aged 19–24 years who have tried cannabis had a lifetime CD diagnosis. (Harley et al., 2015) The highest risk was found in an Australian longitudinal study of adolescents, the Victorian Adolescent Health Cohort Study (VAHCS), which followed a sample of 15–17 year-olds who used cannabis from 1992 to 95 to 2001–03 and at age 25. It reported a diagnosis of past year CD in 22.6% (15.2–29.9) of those who used weekly, and 40.9% (29.0–52.8) among those who used daily. (Coffey and Patton, 2016) Recent NSDUH estimates reported that the prevalence of CD was 14.7% (13.0–16.5) among adults who used cannabis daily or near daily in 2017. (Compton et al., 2019)

Ten studies reported sex differences in risks. (Palmer et al., 2009; Degenhardt et al., 2018; Lopez-Quintero and Pérez de los Cobos J, Hasin DS, 2011; Hayatbakhsh et al., 2009; Le Strat et al., 2009; Feingold et al., 2020; Wittchen et al., 2008; Hasin et al., 2015; Wu et al., 2012; van der Pol et al., 2013) Most reported a higher risk in males (see Table 1). Nine studies compared differences by age groups. (Degenhardt et al., 2018; Lopez-Quintero and Pérez de los Cobos J, Hasin DS, 2011; Han et al., 2019; Feingold et al., 2020; Santaella-Tenorio et al., 2019; Hasin et al., 2015; Pabst et al., 2012. Sucht. 2013.; Philbin et al., 2019; Wu et al., 2012) The US studies consistently found that younger age was associated with higher risks. (Lopez-Quintero and Pérez de los Cobos J, Hasin DS, 2011; Han et al., 2019; Feingold et al., 2020; Hasin et al., 2015; Philbin et al., 2019; Wu et al., 2012; Santaella-

Tenorio et al., 2019). A German study reported that the 25–29 age group had the highest risk of CD among adults aged 18–59 who used cannabis in the past year, but no significant age differences for CA. (Pabst et al., 2012. Sucht. 2013) An Australian study found that younger people had significantly lower risks of CD, but reported a trend for higher risk of CA in adults (aged 18–85) who have used cannabis five or more times in their life. (Degenhardt et al., 2018)

Studies that examined age of first cannabis use consistently reported that an earlier onset was associated with higher risks of CUD (Palmer et al., 2009; Feingold et al., 2020; Wu et al., 2012) and CA (Degenhardt et al., 2018). Findings for CD were mixed; two studies found significantly higher risks with earlier use, (Le Strat et al., 2009; Coffey and Patton, 2016) but two did not. (Degenhardt et al., 2018; van der Pol et al., 2013) Average age of first use were around 15 across the samples, but they differed in the cut-offs used to define early onset. Coffey and colleagues reported that first use before 16 years of age was associated with higher odds of CD, OR = 2.7 (1.5, 4.8). (Coffey and Patton, 2016) Le Strat and colleagues reported that age at first cannabis consumption was 15 among students with lifetime CD, compared to 16 among students who were not dependent, $p < 0.001$. (Le Strat et al., 2009) Lopez-Quintero and colleagues reported that among individuals with a lifetime history of CD, 70% reported first use before age 14. (Lopez-Quintero and Pérez de los Cobos J, Hasin DS, 2011) Wittchen and colleagues observed an average of approximately two years from first regular use of cannabis to CUD in those who transitioned from use to CUD. (Wittchen et al., 2008) Feingold and colleagues found that the median time from onset of cannabis use to CUD was approximately four years, and that those who were began use aged 15 years or younger were at greater risk of CUD. (Feingold et al., 2020)

3.3. Meta-analysis results

The pooled prevalence estimate of CUD was 22% (18–26%) in people who have used cannabis (see Tables 2 & S4a). Subgroup analyses from longitudinal studies found that the lifetime risk was 27% (25–28%) and the risk of past year use was 22% (20–24%). Pooled estimates were similar from cross-sectional studies: 28% in those who have ever used; 17% among those who used in the past year; and 22% among past year daily or near-daily users.

The overall prevalence of CA was 13% (8–18%) among all cannabis users (see Tables 2 & S4b). Effect sizes had overlapping confidence intervals, across subgroup analyses with available data for pooling (see Tables 2 & S4b).

The CD meta-analysis found an overall pooled prevalence of 13% (10–15%; see Tables 2 & S4c). Subgroup analyses showed similar effect sizes in longitudinal (9–12%) and cross-sectional studies (8–11%) among people who used cannabis in the past year or their lifetime. Pooling of longitudinal studies that followed up regular cannabis users found that 33% (22–44%) had developed CD at follow-up. Pooled estimates from cross-sectional studies showed that the prevalence of cannabis dependence was 8% among any frequency of recent use and 18% among those who used daily or near daily.

3.4. Meta-regression

Results of meta-regression analyses are presented in S5. The risk estimates were not significantly moderated by study-level age, sex, and recall period, assessment tool and country of sample. The year of data collection significantly moderated the prevalence and risks of CUD ($B = -0.01$, $p = 0.049$; see S5a) and CA ($B = -0.01$, $p = 0.017$, see S5b), but not of CD ($B = 0.00$, $p = 0.270$; see S5c). The effect was small and explained by lower prevalence of CUDs over time in the NSDUH, the only study that reported CUDs across multiple survey years (see S6). (Santaella-Tenorio et al., 2019)

Table 2

Meta-analysis on prevalence and risks of cannabis use disorder, cannabis abuse, and cannabis dependence in people with experience of lifetime use, recent use, or regular use of cannabis.

	Cannabis use disorder		Cannabis abuse		Cannabis dependence	
	Pooled	(95%CI)	Pooled	(95%CI)	Pooled	(95%CI)
Overall	0.22	(0.18,0.26)	0.13	(0.08,0.18)	0.13	(0.10,0.15)
Longitudinal analyses						
Lifetime use	0.27	(0.25,0.28)	–		0.12	(0.07,0.18)
Recent use (past year or month)	0.22	(0.20,0.24)	0.17	(0.14,0.20)	0.09	(0.01,0.19)
Regular use (weekly or daily)	–		–		0.33	(0.22,0.44)
Cross-sectional analyses						
Lifetime use	0.28	(0.10,0.48)	0.20	(0.14,0.26)	0.11	(0.07,0.15)
Recent use (past year or month)	0.17	(0.12,0.23)	0.10	(0.03,0.19)	0.08	(0.06,0.10)
Regular use (weekly or daily)	0.22	(0.17,0.28)	0.08	(0.02,0.16)	0.18	(0.12,0.24)

Forest plots, Q, I², p-values, and studies included in each of the subgroup analyses are available in [Supplementary material S4](#);
– meta-analysis no conducted due to lack of data

4. Discussion

This study is the first systematic review and meta-analysis of epidemiological studies on the prevalence risk of CUD, CA, and CD among people who use cannabis. In people who used cannabis, 22% (18–26%) had a CUD, 13% (8–18%) had CA, and 13% (10–15%) had CD. The risks were higher in people who used cannabis daily or weekly, and in young people.

Our 13% estimate for CD is slightly higher than the 1 in 10 estimate from the USA's 1990–1992 NCS⁴ and Australia's 2007 NSMHWB. (Slade et al., 2009) Our findings showed that closer to 1 in 8 people who have used cannabis will develop CD. Clinicians, researchers, and policy-makers in health and medicine can have confidence in using this updated figure, because it is based on pooled estimate from the latest epidemiological studies.

Few studies have examined the risk of dependence among more frequent cannabis users. The pooled estimate for CD from the two longitudinal studies that followed people engaging in cannabis use daily or weekly was 33% (22–44%) at follow-up. Cross-sectional estimates of people who used cannabis daily or near daily showed that 18% (12–24%) had CD. The risk of CD increased with frequency of cannabis use. This is consistent with findings from NESARC-III, which found that the number of days of cannabis use was associated with higher severity of CUD. (Hasin et al., 2016)

Several studies only included people who had used cannabis a minimum number of times (e.g. 4–6 times), but no consistent cut-off was used. (Palmer et al., 2009; Degenhardt et al., 2018; Wittchen et al., 2008) In the CADD study of young people aged 17–23 who used cannabis, only 60% had used more than six times. (Palmer et al., 2009) The risk of cannabis dependence was 10.6% (7.1–14.1) among those who reported ever using, compared to 18.1% (12.4–23.8) when lifetime use was defined as having used cannabis more than six times.

Since it is unlikely that someone who had *tried* cannabis once or twice would be at risk of developing a CUD it would be more informative to document risks of CUDs among those who used cannabis some minimum number of times. Caulkins suggested defining lifetime use of cannabis as having used 100 or more times, as in the definition of a cigarette smoker (Caulkins, 2017). However, cigarette smoking may not be a good analogy because cannabis intoxicates, and users of cannabis and tobacco differ greatly in their frequency of use. On average, people who smoke cigarettes smoke 10–20 cigarettes per day, while people who use cannabis regularly may only use 50–150 times per year. (SAMHSA. Key substance use and mental health indicators in the United States: results from the, 2016) Epidemiological studies are needed to identify the levels of cannabis use that increase the risk of CUDs.

A 2006 narrative review of epidemiological longitudinal studies on adolescents who have ever tried cannabis in Australia, New Zealand

and the United States concluded that 1 in 6 or 7 developed lifetime CD. (Anthony, 2006) In studies published in the past 10 years, only the VAHCS and CanDep study followed adolescents who used cannabis frequently to examine their risk of CD later in life. This is an important area for future research because regular cannabis use during adolescence also increases the risk of other adverse psychological and social consequences, including school outcomes, cognitive impairment, and mental disorders through to adulthood. (Hall, 2015)

The heterogeneity of studies was a limitation of this review. Estimates that varied by methods used and setting may be too different to pool. Our meta-regression analyses found that the year of data collection showed a significant result. We had limited statistical power to detect the effects of other potential moderators of the risk of CUDs.

Another limitation is that 60% of our estimates were from cross-sectional surveys, which are susceptible to recall bias. (Coughlin, 1990) Ideally we would only have included longitudinal cohort studies, that commenced before onset of cannabis use and identified the development of CUDs during follow up. There were too few longitudinal cohort studies so we included both cross-sectional and longitudinal studies in our review. A strength of this study was the stratification of meta-analysis of estimates from cross-sectional and longitudinal studies, which found very similar pooled prevalence risks that had overlapping confidence intervals. This supports the overall pooled estimate, but it does not necessarily mean that risks estimates from longitudinal and cross-sectional studies are equivalent.

The estimated risks of a cannabis use disorder among those who used cannabis in the past year and those in their lifetime may differ in perspective. Han and colleagues, for example, reported that the past year prevalence of CUD was 15.4% in 18–25 year-olds who used cannabis that year as against 9.8% among 18–25 year-olds who reported lifetime cannabis use. (Han et al., 2019) Therefore, caution is required in interpreting findings on CUDs in these different time frames.”

There is a lack of data on the frequency of cannabis use that increase the risk of CUD. Only two cohort studies (from Dutch (van der Pol et al., 2013) and Australia (Coffey and Patton, 2016) examined frequency of use and both found that young people who used daily or at least weekly use had higher risks of CD later in life. (Coffey and Patton, 2016; van der Pol et al., 2013) A study of older adults from the 2012–2013 US National Epidemiologic Survey on Alcohol and Related Conditions (NESARC-III) reported that the number of joints smoked at the peak use period (OR = 2.20, 1.37–3.52) and frequency of use (OR = 2.20, 1.37–3.52) were associated with higher odds of lifetime cannabis/other drug use disorders. (Choi et al., 2016) The NSDUH 2002–2017 study reported that the prevalence of CUDs approximately doubled among adult users who used daily or near daily. (Compton et al., 2019)

We found no population studies that estimated the risk of CUD by the potency of cannabis products used. This is an important omission because in the USA the legalisation of cannabis has increased cannabis

product potency and frequency of cannabis use in adults, but there is conflicting evidence on whether CUD has also increased. (Hasin, 2018; Leung et al., 2018) The Michigan Longitudinal Study of high-risk families found that cannabis users who consumed higher potency products had higher risks of developing CUD symptoms. A longer period may be needed to assess the effects of increasing cannabis potency on risks of dependence, use disorders, and associated harms on a population-level. Given the move towards cannabis legalisation in the USA, (Kilmer, 2017) Uruguay, (Cruz et al., 2018) and Canada (Cox, 2018) research is needed to evaluate the impact of legalisation on risks of CUDs.

All studies in this review were from high-income countries and over half from the US. Given there may be geographical and cultural differences in how cannabis is used, our findings may not be generalizable to low and middle-income countries. In the most recent version of the Global School-based Student Health Survey (GSHS) on health risks in adolescents from low and middle-income countries, (WHO, 2019) 7% of 13–17 year-olds in the America region reported cannabis use. We have no data on how many adolescents outside of high-income US, Australasia and Europe who used cannabis developed dependence or CUD.

Different assessment tools were used to derive the DSM diagnoses of CUDs (CUD, CA, and CD) in the included studies. Studies were included if they used any version of the ICD/DSM criteria to define CUD, CA, or CD. We excluded a Canadian study because it used the Severity of Dependence Scale (rather than a structured interview). (Boak et al., 2017) It classified 10.5% (9.2–11.8%) of adolescents who used cannabis in the past year as dependent, which is similar to our pooled estimate. All included studies used DSM criteria to define CUD, including only one DSM-III-R study (Kirisci et al., 2013), and one DSM-5 study. (Feingold et al., 2020) The rest used DSM-IV, in which CUD is defined as meeting criteria for either CA or CD. The differences in criteria between DSM versions used by the included studies were demarcated above (additional details in S2). Studies that compare agreement between DSM-III-R and DSM-IV found reasonable concordance for dependence, but more met abuse criteria using DSM-IV. (Rounsaville et al., 1993; Schuckit et al., 1994) Future longitudinal studies can use DSM-5 to assess the risk of CUD among people who have used cannabis by the severity of the disorder.

Further research is warranted on the effects of comorbidities on CUD. This includes other substance use disorders and non-substance use related mental disorders. (Marel et al., 2019) People with a CUD are two times more likely to have another mental disorder, such as alcohol use disorders and psychotic disorders. (Couvry-Duchesne et al., 2018) Compared to people living with a single disorder, people with comorbid disorders experience poorer wellbeing, which needs to be considered in treatment settings. The trend towards liberalizing cannabis policy and commercialization of its sale may be followed by public health consequences, e.g. increased incidence and prevalence of psychosis with implications for treatment provision. (Murray and Will, 2020)

5. Conclusions

This review provides prevalence and risks estimates for CUDs from using cannabis in developed countries. People who use cannabis have 1 in 5 risks of having CUD (abuse or dependence) and 1 in 8 risk of having CA or CD. The risk of developing CD increases to 1 in 3 among people who use cannabis weekly or more often. These risks may increase in the future if cannabis users more often and use more potent cannabis products after cannabis legalisation. Future studies need to examine how changes in cannabis policies affect cannabis use (e.g. method of administration, product types, and potency of cannabis).

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7. Contributors

WH & JL contributed to the initial concept; JL, WH, GC & LH contributed to the design, study direction, and interpretation of data; JL & GC contributed to acquisition of data and analysis; JL, WH, LH & GC all contributed to drafting sections of the work and revising it critically for important intellectual content. All authors provided final approval of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.addbeh.2020.106479>.

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