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Cannabis and sleep: A complex and unfinished story

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Introduction

There are many strongly held beliefs in the community about cannabis and sleep. Early studies on the effects of cannabis use identified its potential to impact on the nature and quality of sleep.[1-7] These studies showed that although the timing of different stages of sleep was typically interrupted, overall sleep time was not consistently affected. Unfortunately, the current understanding of how cannabis use affects sleep is clouded by the mixed findings of studies and the lack of statistical control for confounding factors. Notably, cannabis use has been described as alleviating sleep problems by "medicinal" users[8-13] as well as contributing to problems in the community[14-17] with long-term use being associated with increased sleep problems compared to no use.[18-20] Moreover, experiencing sleep problems is common when abstaining from cannabis use.[21-23] Unfortunately, research to develop a better understanding of the extent to which cannabis use is associated with changes to sleep architecture is rarely conducted. In addition, the proportion of cannabis users who experience problems sleeping, or who use to alleviate sleeping problems, has not been well described.

Recognising the proportion of cannabis users who have sleeping problems or who use cannabis to assist their sleep may be clinically helpful when assisting individuals interested in abstaining from cannabis use. This information would allow clinicians to assist individuals using cannabis to improve their sleep by encouraging better sleep hygiene, such as avoiding caffeine, daytime napping and providing evidence-based cognitive behavioural strategies. Further, information advising that cannabis use may lead to sleeping problems could be helpful for those deciding whether or not to use cannabis.

In recognition of the need to clarify the association between cannabis use and sleep, we conducted a systematic review of all papers including the descriptor 'cannabis use' and 'sleep'. This review consisted of 1) a consensus on the quality of the articles reviewed; 2) an overview of articles describing the prevalence of sleep problems among current cannabis users; 3) an overview of articles investigating whether early sleep problems predict later cannabis use and vice versa; 4) an overview of articles reporting the prevalence of cannabis as a medicine for the purpose of assisting sleep; and 5) conclusions and suggestions for future research.

Method

Literature search

English language studies on human participants were located through online searches of nine electronic databases (Embase, CINAHL, Cochrane Library/EBM Reviews, Medline, PsycINFO, and Google Scholar for published studies and Project Cork, DRUG, and PsycEXTRA for grey literature). The search strategy included the keywords "cannabinoid/s, or, tetrahydrocannabinol, or THC, or

cannabis/marijuana" and "sleep, or sleep onset, or sleep apnoea, or sleep treatment, or sleep wake cycle, or sleep deprivation, or REM sleep, or NREM sleep, or sleep disorder, or insomnia". In addition, we attempted to contact primary investigators who had conducted studies including measures of both cannabis and sleep, but did not describe the two in the results of their manuscripts. Review papers, qualitative articles, opinion pieces, letters or editorials, case reports, and published abstracts were not included. This review included all papers current to the end of 2012 and did not *prima facie* exclude studies on the basis of methodological flaws. For the purposes of this bulletin only those studies describing the correlations between sleep problems and cannabis use and the prevalence of medicinal use for the purpose of assisting sleep were included and studies involving the administration of cannabis (15 articles) and/or on withdrawal when administration ceased (27 articles), as well as clinical trials involving the use of cannabis as a medicine for health conditions such as pain and cancer (28 articles) and studies investigating the prevalence of sleep problems among recent cannabis abstainers (17 articles) were excluded.

Initial searching resulted in 2215 manuscripts being identified, and after duplicates (n=730) were removed, a title and abstract search on a total of 1485 manuscripts was conducted. Following the application of exclusion criteria (n=1444), 44 relevant articles remained and these articles fell into three different categories:

1. Studies describing medicinal cannabis use for the purpose of assisting sleep (11 articles)
2. Studies describing the correlations between sleep problems and current cannabis use (27 articles)
3. Studies describing sleep problems among babies of mothers who smoked cannabis during pregnancy (3 articles)

Article Quality

When considering the results of individual articles and in summarising results, it is important to consider the quality of the articles reviewed. Specifically, an attempt should be made to identify the extent to which authors attempted to minimise the risk of bias. In order to assist with this, we constructed an assessment of article quality and risk of bias. Following suggestions from the Cochrane Collaboration's Risk of Bias Assessment Tool,[24] and Effective Practice and Organisation of Care Review Group Data Collection Checklist[25] and the assessments of risk of bias by Viswanathan and colleagues,[26] the specific factors assessed included (when appropriate):

- an appropriate randomisation of groups or group matching
- a valid and reliable measure of sleep was consistently applied across groups
- a valid and reliable measure of cannabis use was consistently applied across groups
- a valid and reliable measure of confounding variables was consistently applied across groups
- appropriate statistical controlling for confounding variables in relevant analyses
- included sample size is adequate to "power" the statistical analysis performed
- appropriate descriptions of inclusion and exclusion criteria for all participant groups
- appropriate blinding of research staff conducting assessments and analysis
- appropriate blinding of participants
- description of participant demographics, drug use and history of previous cannabis use and sleeping problems
- appropriate administration of cannabis in a standardised manner
- all measures in the article methods are reported in the article results

- unintended exposure to variables affecting sleep is controlled or managed between interviews and applied equally across groups, and
- adequate statistical controls are used when more than 15 per cent of data is missing

For each of the relevant items assessed, a ratio (reported as a percentage) was created to show the number of these items that the article had adequately addressed by the number of these items left unaddressed. These 'quality percentages' are detailed in Tables 1 to 5 (following the description of study type). Following the assessment of article quality it was apparent that, with very little exception, the included articles were methodologically poor (average quality rating was 46.0%, range: 19.4% to 71.9%). The major limitations of these articles are detailed throughout.

Is cannabis use associated with sleep problems?

A total of 28 papers included in this review described sleep problems following cannabis use. To assist in summarising the information provided, these articles were divided by those investigating sleep problems among babies (3 studies),[27-29] adolescents (8 studies),[18-20,30-34] adults (13 studies)[35-47] and both adolescents and adults (6 studies).[14-17,48,49]

Sleep problems among babies

Three studies focused on the effects of cannabis use during pregnancy and the resulting sleep problems among babies.[27-29] Each of these studies included a measure of cannabis use by self-reported quantity and frequency during pregnancy (specified by trimester) and non-using control participants. In contrast, sleep architecture among the newly born was measured objectively by electroencephalogram (EEG) readings. As summarised in Table 1, each of these studies demonstrated statistical increases on at least one objective measure of sleep disturbance among babies born of cannabis-using mothers. In particular, this was the case in babies aged one year when cannabis was smoked during the first trimester of pregnancy. Notably, each of these studies included statistical control for the mother's age and other substance use among other demographic variables such as income (Table 1). In summary, babies from cannabis-using mothers were more likely to be classified as having irregular or active sleep over quiet sleep and showed greater arousal time at one and three years of age compared to babies of cannabis naïve mothers. There was little evidence, however, for a reduced total sleep time, or in the differences in the proportion of time spent in each of the five stages of sleep.

The generalizability of these studies suffered from two main limitations. Firstly, they were each conducted in the US with an over-represented proportion of mothers reporting their ethnicity as black (47%-61%). Secondly, the sample size was low (final Ns of 38-57) and no study confirmed that the samples included were adequately powered to conduct the comparative analyses that were shown. Finally, it should be noted that the ongoing health impact of these sleep irregularities demonstrated in early age remains unclear without further longitudinal study.

Table 1. Cannabis use and sleep: Associations among babies born from cannabis-using mothers

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Scher et al.	1988	US	4th and 7th month of gestation and day after delivery Longitudinal (56.3%)	Quantity and frequency in pregnancy by trimester	Polysomnograph (EEG readings)	Age, gender, other drug use, mother's education, race, income, maternal age, marital status, infant birth weight, Dubowitz score, ponderal index, EEG technician	Mothers were an average of 22.2 years old (range 18-32 years) and 53% mothers were white, 47% black. Babies were 49% male	55/55	No significant difference in percentage of time awake or number of or time of arousals for babies of cannabis-using and non-using mothers. Total REM "irregular sleep" and "quiet sleep" and body movements was predicted by 1st trimester use
Scher et al.	2000	US	Day after delivery and one year after birth Longitudinal (68.8%)	Quantity and frequency in pregnancy by trimester	Polysomnograph (EEG readings)	Age, gender, other drug use, mother's education, race, income, maternal age, marital status, infant birth weight, Dubowitz score, ponderal index, EEG technician	Mothers were an average of 26 years old (range 18-41 years) and 39% white, 61% black. Babies were 45% male	71/57	No significant difference in total sleep time, time in REM sleep or body movements for babies of cannabis using and non-using mothers. At one year, "arousal time", "active sleep", "quiet sleep" and reduced Beta energies were predicted by mother's cannabis use
Dahl et al.	1995	US	8-36 months after birth Longitudinal (61.3%)	"Average daily joints" in pregnancy by trimester	Polysomnograph (EEG readings)	Age, gender, other drug use, maternal mental health, attitudes toward child, household environment, social support, life events, prescription meds	Mothers were typically between 22 and 23 years old and 42% white, 58% black. Babies' gender not provided	38/38	Babies of cannabis-using mothers slept for less time compared to non-using mothers, and had less efficient sleep. No difference in percentage of time in stages of sleep, or time to bed

Sleep problems among adolescents

A total of eight studies included analyses of the associations between cannabis use and sleep problems among adolescents.[18-20,30-34] As shown in Table 2, each of the eight studies found a significant association, with three exceptions: in one study the significance was lost when a control for internalising problems was included[19]; in a second longitudinal study the association was significant at baseline only[32]; and in a third study, the association was significant only among male participants.[34]

Two large studies of adolescents were of note. The largest study included an analysis of data from 12,154 US students in grades 9 through 12 who had responded to the 2007 Youth Risk Behavior Survey.[31] In this cross-sectional study, past month cannabis use was significantly associated with a greater number of individuals who reported having less than eight hours sleep. This association persisted when controlling for past month alcohol and tobacco use as well as self-reported mood. No further description of these results was provided. The second large study included an analysis of data from 8,349 US students in grades 7 through 12 who had responded to the 1994-2002 National Longitudinal Study of Adolescent Health.[20] This study included a measure of the respondents' and their social networks' cannabis use and reported a significant baseline association between past month cannabis use and fewer hours of sleep. This association persisted when controlling for participant demographics as well as the sleep of friends in their social network.

The generalizability of these studies suffered from three main limitations. First, no study of adolescent sleep problems included an objective measure of sleep or a validated scale for measuring overall sleep. As such, it was not clear what specific problems with sleeping were encountered by the participants although the most common measure employed in these studies was usual hours of sleep. Second, no study accounted for frequency of cannabis use and instead only dichotomous outcomes of the presence or absence of use (across varying timeframes) were included. As such, the impact of being a single occasion, occasional, light or heavy cannabis user was not identified. Third, the majority of studies were conducted in the US, with the only two

exceptions conducted in Africa and the Seychelles.[30,34] As such, the influence of differing cultural beliefs regarding cannabis use and sleep as well as variations to the ratio of cannabinoids or cannabis potency from plants which are sourced in different geographic locations remain unaddressed. Notably, in the two African studies, cannabis use was associated with poor sleep although the association was significant only among males in the larger of the two studies.[34]

Table 2. Cannabis use and sleep: Associations among adolescents

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Fakier et al.	2011	Africa	Cross-sectional (53.3%)	Lifetime y/n	Adapted scale from Child Behavior Checklist on trouble sleeping	Gender, age, learning difficulty, other drug use	Students in grades 9-11, 58.6% male, 58% (Asian, European or African), 28% white (61% with a learning difficulty)	703	Cannabis users had significantly more problems sleeping than non-users (3.1[1.9] compared to 2.6[1.9] out of 8)
McKnight-Eily et al.	2011	US	Cross-sectional (55.2%)	Past month y/n	Self-reported hours	Past month alcohol and tobacco use, self-reported mood	2007 Youth Risk Behavior Survey (grades 9-12), 50.3% male, 62.7% white, 14.7% black/ African	12154	68.9 (66.9-70.9)% reported less than 8 hours sleep per night; cannabis use significantly increased this proportion
Wong et al.	2009	US	12 year longitudinal (53.1%)	Age at first use	Parent and self-report of tiredness and trouble sleeping (used together as "sleeping problems")	Gender, age, internalising/ externalising problems, parental alcoholism	Ages 3-8 years at baseline, 76% male, 100% Caucasian	386/ 386	Sleeping problems were predicted by cannabis use at 7-15 years old among boys only. No effect found with control for internalising problems
Wong et al.	2004	US	9 year longitudinal (64.5%)	Lifetime y/n	Self-report of tiredness and trouble sleeping (used together as "sleeping problems")	Gender, age, parental alcoholism	Aged 14.1 (0.74) years at baseline, 100% male, 100% Caucasian	258/ 258	At baseline, 12.5% had trouble sleeping, and 27.6% were overtired (33.5% had sleeping problem); Cannabis use was significantly predicted by composite sleep score at baseline (2.6 times more likely) and being overtired (2.43 times more likely)
Mednick et al.	2010	US	2 year longitudinal (36.1%)	Past month y/n (frequency of use was measured but not included in the relevant analysis)	Self-reported hours (matched with participants' friend network)	Affect of school, friends' sleep, age, race, ethnicity, household income, mother's education	National Longitudinal Study of Adolescent Health; Students in grades 7-12, aged 15.8 (1.6) years at baseline, 49% male	8349/ 8128	Cannabis use was associated with <= 7 hours sleep at baseline and FU and was predicted by baseline sleep. Also, if a friend sleeps less than 7 hours the chances of using cannabis is increased by 4% (1-7%) and this effect was additive
Pasch et al.	2012	US	2 year longitudinal (63.3%)	Past month y/n	Adaptation from the Night Eating Diagnostic Scale (self-reported time at "lights out" and time of "usual" wake on weekdays and weekends)	Tobacco use, socio-economic status, race, pubertal development, body mass index, depressive symptoms	Aged 14.7 (10-17) years at baseline, 49% male, 86% Caucasian, 5.3% black	723/ 704	Higher levels of weekday and total sleep at baseline reduced risk of cannabis use at FU. Baseline cannabis use predicted greater weekend sleep, greater total sleep, and greater weekend oversleep at FU. Cannabis use was associated with increased weekend sleep delay and oversleep at baseline only
Ebin et al.	2001	US	Cross-sectional (51.6%)	Likert-type past year frequency scale (used as y/n in analysis)	Self-reported hours	Age, other substance use, living situation, some health behaviours	Latinos seeking treatment for non-active tuberculosis, 9.9% smoked cannabis, aged 15 (11-19) years, 48.8% male	609	Sleeping less than 7 hours was significantly predicted by cannabis use, as well as tobacco and other drug use (other substance use showed a statistically stronger association)

Table 2. Cannabis use and sleep: Associations among adolescents (continued)

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Alwan et al.	2011	Seych-elles	Cross-sectional (54.5%)	Past month y/n	Likert-type scale on being unable to sleep due to worry (referred to as insomnia)	Age, gender, truancy, parental monitoring, suicidal ideation and "psychosocial variables"	Students in years 7 to 10, (19.2% of males and 3.7% of females used cannabis in past month) aged 14 (1.4) years, 47.8% male	1432	10.0% of boys and 12.1% girls had insomnia. Presence of insomnia was significantly correlated with cannabis use among males only

Sleep problems among adults

A total of 13 studies included an analysis of the associations between cannabis use and sleep problems among adults.[35-47] As shown in Table 3, only three of these studies[37,41,45] reported a significant association between cannabis use and sleep problems, although one of these studies did include the largest sample of adults.[37] This large study was an investigation regarding the validity of the Comprehensive Marijuana Motives Questionnaire.[37] This study was unique in that it included "relaxation and sleep" as a selectable motive to use cannabis and questioned 346 users on the frequency of which cannabis was smoked for this reason. Although the results showed that this was the least common motivation to use cannabis (1.5 out of 5; where 1 was 'almost never/never and 5 was 'almost always/always'), sleep motives predicted a significantly greater frequency of cannabis use and number of negative cannabis-related consequences (but not including cannabis abuse or dependence) compared to other motives for use. Instead enjoyment (3.5 out of 5) and availability (2.85 out of 5) were rated as the most common motives. Importantly, this study did not include any statistical control for confounding variables in their analysis of cannabis motives.[37]

The remaining two studies were each an observation of cannabis use among small samples of participants with self-reported insomnia[45] and post-traumatic stress disorder (PTSD).[41] In the first study, insomnia was found to be significantly related to cannabis use in a first order correlational analysis with 30.4 per cent of those without insomnia using cannabis compared to 68.4 per cent of cannabis users experiencing insomnia. In the second study, again in a first order correlation, cannabis use was found to be significantly more prevalent among those with PTSD and problems sleeping (measured using the validated Pittsburg Sleep Quality Index) compared to those without problems sleeping.[41] This was the case only among those who used cannabis to help them cope with their concerns and was no longer significant for any other motive for cannabis use.

The ten studies which did not report a significant association between cannabis use and sleep problems included a variety of sleep measures.[35,36,38-40,42-44,46,47] A minority of studies used validated measures such as the Pittsburg Sleep Quality Index,[35,36,39] the Epworth Sleepiness Scale and the Karolinska Sleepiness Scale.[40] Other studies used self-reported hours of sleep or a proxy,[38,43] various indicators of sleep quality such as "awakening refreshed",[46] or otherwise did not include detail regarding the measure used.[42,44,47] In contrast, only two studies included a description of the measure used to assess cannabis use; one used the Marijuana Smoking History Questionnaire[35] and the other used results from urinalysis to confirm recent use.[36] These two studies were noteworthy in that they also included reliable measures of sleep (the Pittsburg Sleep Quality Index).

The first study was a cross-sectional investigation of factors affecting the time taken to fall asleep (sleep onset latency), focussing specifically on the role of anxiety.[35] As such, cannabis use and sleep were investigated only as part of a larger assessment of behaviours that may impact on sleep latency. When controlling for the participants' demographic profile, feelings of negative affect, use

of prescription medications, as well as alcohol and tobacco use, cannabis use was not found to be significantly associated with anxiety relating to sleep. In contrast, fear of the physical consequences of anxiety was found to be related to sleep onset latency. The second study assessed the health behaviours of methadone inpatients in Israel (including sleep problems and cannabis use among other variables).[36] Notably, overall sleep scores were not significantly different between those who had recently used cannabis and those who had not. Unfortunately, however, this study did not include any statistical control for other confounding variables.

In summary, although the majority of studies found no association between cannabis use and sleeping problems among adults, two significant limitations of these studies prevent conclusive statements being drawn. First, very few controls were included in the analyses presented and in particular, with only two exceptions,[40,42] no study controlled for other illicit drug use. Notably, these two studies found that other illicit drug use was associated with sleep problems while cannabis use was not. As such, the associations between cannabis use and sleep may in fact be explained by other substance use (including caffeine, alcohol, tobacco, and other illicit drug use) or unknown pre-existing medical conditions that are more common among cannabis users that also impact on sleep. Second, the included measures of sleep problems and cannabis use were not standard across the literature and were largely not clearly reported introducing a substantial risk of bias in the results presented.

Table 3. Cannabis use and sleep: Associations among adults

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Babson et al.	2008	US	Cross-sectional (71.9%)	Marijuana Smoking History Questionnaire	Sleep Anticipatory Anxiety Questionnaire and the Pittsburg Sleep Quality Index (sleep onset item only)	Gender, age, tobacco and alcohol use, negative affect, sleep medication	Aged 24.2 (9.3) years, 53.7% male	41	Anxiety about sleep, and sub-scores measuring self-reported cognitive arousal and sleep onset not related to cannabis use, nicotine dependence, or alcohol use. Females were more likely to use cannabis than males
Peles et al.	2006	Israel	Cross-sectional (43.8%)	Urinalysis	Pittsburg Sleep Quality Index (global score)	None	Methadone inpatients aged 40.4 (9.6) years, 78.2% male	16	Cannabis users did not report significantly different overall sleep (9.3 [5.3] compared to 9.0 [4.7] out of 21
Lee et al.	2009	US	Cross-sectional (41.9%)	Past month frequency, DSM-IV abuse/ dependence	Sleep items from the Comprehensive Marijuana Motives Questionnaire	None	Aged 18.1 (0.4) years, 44.8% male, 71.1% white, 14.5% Asian, 6.1% Hispanic, 1.2% black	346	Using cannabis for sleep/rest was uncommon but positively correlated with cannabis use frequency and related problems but not abuse/ dependence
Jean-Louis et al.	1998	US	Cross-sectional (28.1%)	Unclear	Self-reported hours slept on weekdays and weekends and sleep at school y/n	Ethnicity, mood state, gender, age, alcohol use	University students aged 23.8 (7.6) years, 38.8% male	294	Cannabis use was not associated with total sleep time or sleeping on university time
Fiz et al.	2011	Spain	Cross-sectional (45.7%)	Unclear, however history of use, frequency and dose recorded	Pittsburg Sleep Quality Index (global score)	Age, gender, Fibromyalgia symptom severity, employment status, pharmacological treatment	Median age of 50 years (grouped as cannabis-using patients and non-users) 19.6% male	56	Cannabis use or no use showed no difference in overall sleep (14.1 [3.2] compared to 14.4 [3.3] out of 21)

Table 3. Cannabis use and sleep: Associations among adults (continued)

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Fisk et al.	2009	UK	Cross-sectional (48.4%)	Unclear	Epworth Sleepiness Scale (ESS; likelihood of dosing off) and Karolinska Sleepiness Scale (KSS; state of general sleepiness) selected questions on "sleep quality", tiredness and hours of sleep	Cognitive deficit, ecstasy use, time since last cannabis use	Aged a median of 21 years, 41.9% male (participants grouped as cannabis users, ecstasy users and drug naïve)	227	Sleep time, sleep quality, ESS and KSS all showed no significant difference between cannabis users and ecstasy users or drug naïve. Ecstasy users showed poorer sleep to drug naïve
Bonn-Miller et al.	2010	US	Cross-sectional (50.0%)	Marijuana Smoking History Questionnaire	Pittsburg Sleep Quality Index (global score)	None	Among post-traumatic stress disorder patients who had recently used cannabis, aged 34.0 (12.0) years, 25% male, 60% white/non-Hispanic	20	Problems sleeping correlated significantly with severity of disorder and using cannabis to help cope, but not with other cannabis motives
Chinet et al.	2007	Switzer-land	Cross-sectional (50.0%)	Unclear	Unclear	Age, gender, other substance use	Attendees of dance-music concerts, aged 22.7 (4.7) years, 60.4% male, 52% were current cannabis and alcohol users	293	Problems sleeping were reported by 15% of cannabis and alcohol users, but by significantly more poly-drug users (45% of light poly-drug users, 75% of regular poly-drug users)
Dingwall et al.	2011	Australia	Cross-sectional (41.9%)	Likert-type frequency scale	Likert-type question on awaking early from sleep	Survey location and type	Indigenous treatment seekers for inhalant use. Aged 27.8 (12.0) years, 55% male, 68% were cannabis smokers, 66% smoked tobacco	407	Neither occasional nor frequent cannabis use significantly predicted awakening early from sleep. Tobacco use and seeking education-type treatment were significant predictors of sleep problems
Duterte et al.	2001	US	Cross-sectional (28.0%)	Unclear	Unclear but reported as an indicator of "sleeping every night"	Housing type	Recent cannabis (34.9%), or heroin or methamphetamine users (65.1%), median of 36 years, 56% male, 49% white	238	Controlling for housing type, 39% of heroin and methamphetamine users did not sleep every night, while 8% of cannabis users did not sleep every night
Logothesis et al.	2007	US	Cross-sectional (45.2%)	Diagnosis of cannabis use disorder	Self-reported insomnia	None	Mental health clinic records of those with a dual diagnosis of schizophrenia and a substance use disorder (40% used cannabis); aged 40.9 years on average, 68% male, 99% white	75	Insomnia was related to the use of cannabis, with 30.4% of those without insomnia using cannabis compared to 68.4% of cannabis users experiencing insomnia
Weller et al.	1982	US	6 year longitudinal (19.4%)	Inclusion criteria only (50 occasions in past 6 months)	Likert-type questions on "restful sleep", "awakened refreshed", "more sleep" and "fewer dreams"	None	Cannabis users aged 22.0 (2.7) years, 61% male, 100% white	100/97	Scores on "more sleep", "more restful sleep", "awakened refreshed" decreased. "Less sleep", "less restful sleep", "awakened tired" and "bad dreams" did not change significantly from baseline to follow-up
Camera et al.	2012	Cross-sectional (35.5%)	Likert-type frequency scale	Unclear	Gender, other substance use, psychotic disorder	Gender, other substance use, psychiatric disorder	Cannabis users aged 22.2 (2.6) years, 48% male, 25% had a psychiatric diagnosis	100	17% reported altered sleeping patterns when using cannabis, no gender effect was found

Sleep problems among adolescents and adults

A total of six studies investigated the association between cannabis use and sleep problems among a sample including adults and adolescents.[14-17,48,49] As shown in Table 4, four of these six studies included a measure of insomnia[15-17,47] with the remaining study investigating hours of sleep,[14] and 'sleep disruption'. Notably, each of these studies included a large sample size with data taken from representative surveys. A total of four of the six population studies reported a significant association between cannabis use and sleep problems.[14-17,48] Only one study found an association between greater cannabis use and decreased 'sleep disruption'.[49] The largest of these studies was a population survey conducted in Canada with 36,984 participants.[16] Results showed that when controlling for participant demographics, substance use, and some psychological factors including stressful life events, cannabis-only users compared to non-users were significantly more likely to have insomnia (18% of users compared to 13% of non-users).

The study which did not find a significant association between cannabis and sleep did not report this finding in the published study results.[47] Instead, the primary author (Freeman) provided the relevant correlational analysis by email contact. The study was regarding associations between the presence of paranoid thinking and certain demographic and psychiatric variables with data drawn from the Adult Psychiatric Morbidity Survey in London. Although it included measures of cannabis use and sleep, the two together were not a focus of the study. Despite this, a zero order correlation analysis demonstrated no significant difference in the proportion of respondents with insomnia between those who used cannabis and those who did not use cannabis.

The generalizability of these studies was limited for two main reasons. First, the subjective and broad nature of defining what was considered to be "insomnia" should be considered when interpreting the study results. Notably the study which included the most stringent measure of insomnia – trouble falling asleep or staying asleep almost every day for 12 months – showed a significantly greater number of cannabis users with insomnia than non-users with insomnia (18.3% compared to 11.5%).[17] Second, as with the studies focussing on adults, these studies reported a lack of control for confounding variables, most notably other substance use. One noteworthy exception to this was a study by Tjepkema[16] which did account for other illicit substance use and showed that cannabis-only users were more likely to report insomnia compared with non-users. Moreover, the majority of studies did not include a measure of frequency of cannabis use in the relevant analyses conducted (typically only the presence or absence of use was measured).

Table 4. Cannabis use and sleep: Associations among adults and adolescents

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Glozier et al.	2010	Australia	18 month longitudinal although sleep/cannabis was baseline only (37.1%)	Lifetime y/n	Self-reported hours	None	Provisional licensed driver survey; 48.8% 17 years, 37% 18-19 years, 14.1% 20+ years; 45.5% male	19648	Cannabis use was significantly associated with less than 8 hours sleep
Freeman et al.	2010	London	Cross-sectional (43.3%)	Past month y/n	Insomnia defined as problems getting to sleep or back to sleep for the majority of nights in the past month	Results were weighted for gender, with control for paranoia and emotional issues in analysis	British National Survey of Psychiatric Morbidity; participant demographics not reported	8580	Insomnia (11.9%) increased with age and was more prevalent among women; Each unit on insomnia measure significantly increased risk of cannabis use by 1.17 (assessed at follow-up)

Table 4. Cannabis use and sleep: Associations among adults and adolescents (continued)

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Tjepkema et al.	2005	Canada	Cross-sectional (51.6%)	Unclear	Insomnia defined as "trouble going to sleep or staying asleep most or all of the time"	Demographic, socio-economic, lifestyle, other illicit drug use and several psychological factors such as life and work stress	Canadian Community Health Survey; ‹ 45 years (54.6%), 49.2% male	36984	Cannabis only users were 1.5 (1.1-1.9) times as likely to report experiencing insomnia compared to non-users (18% compared to 13%)
Freeman et al. (from email)	2011	London	Cross-sectional (27.6%)	Past year y/n	Insomnia defined as "trouble going to sleep or staying asleep for over 6 months"	None	Adult Psychiatric Morbidity Survey; participant demographics not reported	7281	Almost one quarter (23.3%) reported insomnia and this was not significantly associated with cannabis use
Roane et al.	2008	US	6-7 year longitudinal (54.8%)	Ever use y/n	Insomnia defined as "trouble falling asleep or staying asleep almost every day or every day over the past 12 months"	Depressive symptoms	Aged 15.8 (1.5) at baseline, 47.6% male, 59.1% Caucasian, 21.1% African-American, 4.4% Latino	4494/ 3582	Significantly more participants with insomnia had used cannabis (18.3%) compared to no-insomnia control (11.5%). Baseline insomnia increased risk of cannabis use at follow-up by 1.66 times
Klonoff and Clark	1976	Canada	Cross-sectional (40.6%	Chronic vs light use	Unclear question on 'sleep disruption'	Education, religious affiliation, gender	Aged 23.9 years, 55% male	213	60% reported effects on 'sleep disruption' was greater among light users

Do early sleep problems predict later cannabis use and/or vice versa?

From the 26 studies including adolescents and/or adults, six studies included a longitudinal analysis with measures of participants' cannabis use and sleep,[17-20,32,46] five of these studies included an analysis of whether baseline sleeping problems predicted cannabis use at follow-up[17,18,20,32,46] and two studies included an analysis of the reverse (whether baseline cannabis use predicted sleeping problems at follow-up).[19,32]

In summary, each of the five studies demonstrated that baseline sleeping problems were a significant predictor of later cannabis use.[17,18,20,32,46] More specifically, combining the results from these studies showed that baseline sleeping problems resulted in an increase in the risk of cannabis use some two to nine years later by 1.7 to 2.6 times. The largest of these longitudinal studies was a two year longitudinal observation of substance use and sleep among adolescents and their friendship network (n=8349).[20] Data was drawn from the National Longitudinal Study of Adolescent Health in the US. In this study, sleeping less than seven hours on a typical night at baseline was significantly associated with risk of past month cannabis use at baseline and at two year follow-up (the magnitude of this relationship was not provided). Further, if a participant's nominated friend slept less than seven hours on a typical night at baseline, the risk of cannabis use by the participant increased by four per cent on average. Interestingly, this effect was additive where a greater number of friends with trouble sleeping increased the risk further. It should be noted, however, that this study did not include statistical control for the participants' other substance use or pre-existing physical or mental health concerns.

In contrast, there was little evidence that baseline cannabis use predicted later sleeping problems. One twelve year longitudinal study of 386 US children (aged 3-8 years at baseline) showed no such significant relationship (when including controls for confounding variables, most notably, internalising problems).[19] Interestingly, this study did demonstrate a significant relationship where sleeping problems at final follow-up (referred to as daytime "tiredness" and "trouble sleeping") were predicted by cannabis use at 7-15 years among boys only. This relationship, however, was no

longer significant when including the effect of participants who reported internalising their problems. Alternatively, a two year longitudinal study of 723 US students (aged 10-17 years at baseline) demonstrated that baseline past month cannabis use significantly predicted *greater* total sleep (measured in hours, influencing weekend sleep more than weekday sleep).[32] Interestingly, this study showed a bidirectional relationship where baseline sleep problems increased the risk of later cannabis use. The authors describe this contradicting finding and suggest that youths engaging in cannabis use, over time, may develop habits of sleeping more when sleep schedules are more able to vary (on weekends).

Importantly, although the available evidence suggests that sleeping problems do increase the risk of later cannabis use (typically measured as any use with no indication of frequency of use), this relationship cannot be concluded to be causal. This is the case particularly as two studies have shown cannabis use to be a predictor of later sleeping problems[19,32] (although this trend was only significant in one study;[32]). Further, the available evidence failed to include other possible explanatory variables such as other illicit substance use or pre-existing health conditions. As such, further more exhaustive research is required to identify whether sleeping problems are generally more likely to precede cannabis use or vice versa.

What is the prevalence of the reported use of cannabis as a sleep medication?

For the purposes of this review, medicinal cannabis use is defined as including any reported use of cannabis for the purposes of alleviating symptoms of a physical or mental health concern (with other cannabis use considered to be 'recreational'). A total of 12 studies included a measure of medicinal cannabis use and sleep.[8-13,39,50-54] Among these studies the results were presented as either: 1) the percentage of users who reported using medicinal cannabis specifically to alleviate a sleep disorder (6 studies[8,9,12,51,52,53]); 2) the percentage of medicinal users who use cannabis to alleviate problems sleeping (as a side-effect of their health concern) (7 studies[8,10-13,50,52,53]); and/or 3) the percentage of medicinal users who find benefit from using cannabis to alleviate their sleep problems (4 studies[9,10,13,39]).

The use of medicinal cannabis specifically to alleviate a sleep disorder was investigated in six studies with a collective sample size of 5085 (143+1746+128+50+49+2969). This collective sample of 509 reported medicinal cannabis use for sleep (that is, 10.0%, individual studies ranged from 0% to 52.9%). These studies included participants from Germany,[50] the US,[8] Australia (two studies[9,12]), Canada[52] and the UK,[54] which included the largest sample size of 2969 medicinal cannabis patients (0.65% reported using cannabis for insomnia).

A total of seven studies on medicinal cannabis use included the percentage of participants who reported cannabis to alleviate sleeping problems.[8,10,12,13,50,52,53] The collective sample size from these studies was 1946 (20+1746+50+32+15+34+49) and a total of 1355 (9+1234+28+24+14+18+28) participants of this collective sample reported medicinal cannabis to alleviate sleeping problems (that is, 69.6%, individual studies ranged from 45% to 78.6%). These participants were from Canada (5 studies[10,13,50,52,53]), Australia[12] and the US.[8] The largest study was by Reinarman and colleagues[8] which included 1746 medicinal cannabis users from the US.

A total of three studies included a percentage of medicinal users who reported that they found at least a "moderate" benefit from cannabis for sleep[9,10,13] and two described an unquantified benefit.[11,53] The collective sample size from those studies reporting at least moderate benefit was 194 (128+32+34) and a total of 150 (105+29+16) participants found at least a moderate benefit from using cannabis to alleviate sleeping difficulty (that is, 77.3%). The collective proportion of those reporting some form of benefit was 128 (12+116) from 162 (15+147) participants (that is, 79.0%). Collectively, these five studies included participants from Australia,[9] Canada (three studies[10,13,53]) and the US.[11]

Unfortunately the generalizability of these studies was significantly limited, as no study included a measure or definition of what comprised "sleeping problems". The majority of studies did not specify current medicinal cannabis use but invited participants with a history of any use. Despite this, the results from the included studies did suggest that cannabis is frequently used to alleviate sleep problems and this is commonly described to be of at least moderate benefit amongst specific subgroups of medicinal users.

Table 5. Medicinal cannabis use to assist with sleeping problems

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Bottorff et al.	2009	Canada	Cross-sectional (36.0%)	Unclear	Unclear	None (descriptive study on medicinal users; unclear for which health problems)	Aged 16 (range: 14-18) years, 65% male, 70% Caucasian	20	45% of medicinal users used cannabis to assist sleep
Grotenhermen et al.	2003	Germany	Cross-sectional (37.5%)	Cannabis motives	Shown only as a motive for cannabis use	None (descriptive study on medicinal users; most commonly for neurological symptoms [28%])	Aged 40.3 (12.4) years, 61.2% male	143	2.8% of medicinal users reported use for a sleep disorder
Reinarman et al.	2011	US	Cross-sectional (54.2%)	Unclear	Shown only as an option of benefit from cannabis use	None (descriptive study on medicinal users; most commonly for pain [30.6%])	45.4% < 35 years, 72.9% male, 61.5% white, 14.4% Latino, 11.8% black	1746	15.7% of medicinal users reported use for a sleep disorder. 70.7% used cannabis to assist sleep
Swift et al.	2005	Australia	Cross-sectional (52.0%)	Unclear	Shown only as an option of benefit from cannabis use	None (descriptive study on medicinal users; most commonly for depression [60%])	Aged 45 (range: 24-88) years, 63% male	128	13% used cannabis to assist insomnia (82% reporting great relief)
Ogborne et al.	2000	Canada	Cross-sectional (44.0%)	Unclear	Shown only as an option of benefit from cannabis use	None (descriptive study on medicinal users; most commonly for HIV/AIDS [22%])	Aged 38 (range: 26-57) years, 66% male	50	No use for sleep disorder but 56% used cannabis to assist sleep (the most common symptom)
Ware et al.	2003	Canada	Cross-sectional (38.5%)	Unclear	Shown only as an option of benefit from cannabis use	None (descriptive study of non-cancer pain sufferers, 15% were medicinal users and 18% were recreational users)	Medicinal users were 47% < 40 years, 46.9% male	32	75% of medicinal users reported "effects on sleep" (92% reported moderate improvement)
Ware et al.	2002	Canada	Cross-sectional (38.7%)	Unclear	Shown only as an option of benefit from cannabis use	None (descriptive study of medicinal users for chronic pain)	Aged 49.5 (range: 24-68) years, 66.6% male	15	Sleep disturbance was a symptom from a medical condition for 93.3% of patients, 78.6% mentioned that cannabis use helped improve sleep
Clark et al.	2004	Canada	Cross-sectional (28.0%)	Unclear	Unclear	None (descriptive study of MS patients, 16.6% were medicinal users)	56% < 45 years, 16% male	34	52.9% of MS medicinal users used cannabis to assist sleep (50% reported at least moderate relief)
Schofield et al.	2006	Australia	Cross-sectional (48.0%)	Psychosis and Drug Abuse Scale	Shown as a motive for cannabis use via Cannabis Use Effects Survey and Reasons for Cannabis Use Questionnaire	None	Study of outpatients with schizophrenia; average age of 25 years, 89% male	48.5% used cannabis (n=49)	43% of cannabis users reported use due to difficulty sleeping, while 58% used to improve sleep. THC amount was positively correlated with difficulty sleeping

Table 5. Medicinal cannabis use to assist with sleeping problems (continued)

Author	Year	Country	Study type (quality score)	Cannabis measure	Sleep measure	Controls	Participants	N (baseline /follow-up)	Cannabis/sleep findings
Fiz et al.	2011	Spain	Cross-sectional (45.7%)	Unclear, however history of use, frequency and dose recorded	Pittsburg Sleep Quality Index (global score)	Age, gender, Fibromyalgia symptom severity, employment status, pharmacological treatment	Median age of 50 years (grouped as cannabis-using patients and non-users) 19.6% male	56	Cannabis use or no use showed no difference on overall sleep (14.1 [3.2] compared to 14.4 [3.3])
Tringale et al.	2011	US	Cross-sectional (45.5%)	Unclear, but with detail on quantity per week, route of administration, and time of day	Unclear – self-reported sleep quality, sleep latency and dreaming	Gender, alcohol use, mental health concerns (medicinal cannabis patients, 76% with pain)	Medicinal cannabis clinic patients reporting difficulty sleeping (49%) or not; < 40 years, 68% male, frequency of cannabis use was unclear	147	21.1% with poor sleep; improved sleep latency, particularly when reported sleep difficulty. 79% of problem sleepers reported improved sleep quality and 8% reported increased dreams
Ware et al.	2005	UK	Cross-sectional (39.1%)	Unclear	Unclear – reported as reasons for cannabis use	None (descriptive study of medicinal cannabis patients)	Aged 52.7 (12.7) years, 39.1% male, 73% at least weekly cannabis users	2969	Only 0.65% reported use for insomnia (pain was 25%, MS 22%, depression 22%, arthritis 21%)

Conclusions and future directions

As is too often the case, after reviewing the studies identifying associations between cannabis use and sleeping problems among the community, the foremost conclusion is that there is a need for further research. This is highlighted by the low average quality score of the available studies of 51.3 per cent. These low quality scores may be explained by two major limitations to the research. Firstly, it was uncommon to identify a study that was designed to specifically investigate cannabis use and sleeping problems as opposed to a study which included the two due to a more general focus on behavioural concerns and health risks. As a result, it was not uncommon for the reviewed studies to include obviously confounding variables in the described analyses such as other illicit drug use, the use of sleep facilitators, or a history of a health condition which affects sleep.

Secondly, it was particularly uncommon for a study to include an objective measure of sleep or cannabis use. Instead, cannabis use was typically measured dichotomously as present or absent and sleep was most commonly measured as self-reported hours on a usual night (where less than seven hours was considered to be a sleeping problem). As such, future research would ideally include longitudinal studies designed to identify the pathways to cannabis use and sleeping problems which include objective measures (such as urinalysis for cannabis and polysomnograph readings of sleeping patterns) or well validated subjective measures (such as the PSQI for sleep[55] and the timeline follow-back method for cannabis use[56]).

Despite a need for further research to clarify the identified trends, a pattern between increased problems sleeping and an increased risk of cannabis use was prominent, particularly among adolescents and among babies of mothers who smoked cannabis during pregnancy. Further, sleeping problems were a common predictor of later cannabis use. The research showing a cross-sectional relationship between sleeping problems and cannabis use among adults, however, was mixed. Further, from the available research it was not clear whether cannabis use was more common among those with sleeping problems because cannabis use was thought to alleviate these problems, or whether long-term use was a cause of these problems, or whether an unmeasured common factor was associated with both cannabis use and sleep (such as mental

health concerns). Two lines of evidence suggest that cannabis is thought by users to alleviate sleeping problems. First, three studies found a significant relationship where sleeping problems were predictive of a later increase in cannabis use prevalence.[17,18,20] Second, although only approximately one in ten medicinal cannabis users were likely to use cannabis mainly to assist sleep, just over two thirds of medicinal cannabis users described using cannabis for this reason over a long history of use and most describe some benefit from doing so.

With further research on the association between cannabis use and sleeping problems will come a better understanding not only of the direction of the relationship but also how the relationship is impacted by long-term and/or intense and frequent cannabis use. This information will assist health providers to better prioritise abstinence strategies and include sleeping-facilitating techniques into these strategies when appropriate.

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