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Abstract

Emerging research claims that social-distancing measures implemented during the COVID-19 pandemic caused significant changes in individuals' daily living conditions and mental well-being. Increased isolation and the experienced stress during this period might also affect cannabis use patterns. In the light of inconsistent results on the link between COVID-19 and cannabis use, a comprehensive search of PubMed and Web of Science was conducted for the papers examining changes in cannabis use during this period. Thirteen eligible studies were identified, and two meta-analyses were performed using random-effects modeling. There was a small significant increase in cannabis use as the pooled estimates of the proportion of cannabis use was 13% (95% CI = 0.01, 0.24; $p = 0.034$). and substantial heterogeneity between studies ($I^2 = 92.97$ %, $p < .001$) was observed. However, this could not be explained by various moderator variables. The pooled correlation coefficient for the remaining five studies was 0.06 (95% CI = -0.014, 0.136 ; $p = 0.110$), suggesting no significant increase in cannabis use as opposed to the previous meta-analysis. Sensitivity analysis restricting meta-analysis to articles measuring self-reported cannabis consumption changes, yielded significant results 0.09 (95% CI = 0.01, 0.17 ; $p = 0.025$). The pooled data confirmed that cannabis use increased during COVID-19, implying the potential beneficence of interventions targeting coping strategies for isolation. Further studies are needed to support this finding, especially with diverse samples of cannabis users, different methods for consumption, and study designs.

Introduction

The rapid transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has brought significant changes in individuals' daily living conditions (Brooks et al., 2020; Charles et al., 2021). The escalation of the infection rates turned the disease into a worldwide pandemic and resulted in rigid restrictions imposed by national authorities (Zhu et al., 2020; Charles et al., 2021). Those safety measures (e.g., social distancing, lockdowns, shelter at home orders) have been essential in reducing transmission rates, yet they also may have had adverse psychological consequences of increased isolation and distress.

COVID – 19 and substance use

Yuan and colleagues (2020) claimed that, despite public awareness, quarantines brought anxiety that affects the quality of life during epidemics. Other researchers highlighted this for the context of COVID-19 and reported elevated rates of stress, depression, and sleep difficulties due to social isolation (Gao et al., 2020; Yu et al., 2020). Being a female, being younger than 35, or being a student were also associated with experiencing more negative impacts (Huang & Zhao, 2020; Liu et al., 2020).

Alongside pandemic's influence on mental health, the use of substances like alcohol and opioids were also increased during this period, presumably because drug use helps to reduce painful internal states or enhance/maintain positive ones (Silczuk, 2020; Salas– Nicas et al., 2021; Goeders, 2004; Johnston & O'Malley, 1986; Sinha, 2005). Increased levels of worry concerning health, increased loneliness, or sudden job loss might be some of the underlying psychosocial stressors triggering individuals' self-medication motivations during this period (Rogers et al., 2020; Ausín et al., 2021; Emerson, 2020; Kotwal et al., 2021; Krendl & Perry, 2021; Posel et al., 2021).

In non-pandemic times, cannabis was claimed as the most commonly used substance in the U.S. (Carliner et al., 2017). Despite the lowered perceived risk of consuming, cannabis use disorder was showing significant increases over the years (Hasin et al., 2015; Hasin et al. 2016). Since stress was associated with increased cannabis use, COVID-19 might also affect cannabis consumption due to increased concerns regarding health and financial problems (Taylor et al., 2021; Lorant et al., 2021; Sinha, 2007; Briand & Blendy, 2010).

COVID-19 and cannabis

The cannabis literature, out of scope of the pandemic, revealed that its primarily used in social contexts (Reilly et al., 1998; Buckner et al., 2012). However, despite the absence of a social context, the studies conducted during COVID-19 repeatedly reported that social distancing measures didn't intervene with its consumption, and users increased their use (Rolland et al., 2020; Van Laar et al., 2020; Bartel et al., 2020). For instance, Bartel and colleagues (2020) examined the consequences of social isolation in Canada and found that participants were using 20% more cannabis after the lockdowns (Bartel et al., 2020). Moreover, the study conducted with 1316 high-school students during the pandemic suggested an increase in use and revealed that 49.3% of the adolescents were consuming it in solitary (Dumas et al., 2020). This study's implications were significant because, compared to the social use of cannabis, solitary users were more likely to experience psychosis and report more symptoms of cannabis abuse/dependence (Spinella et al., 2019; American Psychiatric Association, 2000).

Likewise, European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) (2020) claimed a shortage of cannabis in some countries during the pandemic. Similarly, although between March and April 2020, 17 million new unemployment claims were received in the U.S., cannabis sales showed a significant rise in some states (Bartik et al., 2020; Bayer et al., 2020; Cherkasova, 2020; Van Laar et al., 2020).

Nevertheless, the literature yielded conflicting results regarding cannabis use during COVID -19. For instance, one study conducted in Belgium found that participants surveyed during the social-distancing measures portrayed no significant changes in their cannabis use patterns (Vanderbruggen et al., 2020). Likewise, one Canada-based longitudinal study reported no change in cannabis consumption due to COVID-19 (Leatherdale et al., 2021). This suggests the literature yielded inconsistent results respecting the changes in cannabis use during this period, and researchers could not agree on how the isolation measures influenced cannabis use patterns (Killgore et al., 2020; Ingram et al., 2020). Although independent researchers' work is valuable, conflicting findings in the existing literature might obstruct synthesizing conclusions and mislead readers (Gagnier et al., 2012). Therefore the main goal of this paper is to resolve this issue by performing a meta-analysis on the literature investigating cannabis use during the pandemic.

Potential reasons underlying variability among findings

These conflicting findings proposed heterogeneity in the existing literature, which might be due to the use of differential settings, participant characteristics, or study protocols (e.g., study designs) (Higgins, 2008). For instance, the differences in countries that the participants were recruited might influence the findings as cannabis was legal in some countries or states (e.g., Canada, Washington) and not in others (e.g., Belgium) (EMCDDA, 2015). Alternatively, the use of different populations can explain the diversity among results. For example, although the survey study conducted with participants with sleep problems reported no change in use, studies conducted with medical cannabis users and recreational users reported an increase (Busse et al., 2021; Vidot et al., 2020; Dumas et al., 2020).

The existing heterogeneity might also imply the potential existence of moderators, which will be tested as part of this project.

Three Stages of Addiction

To better understand how the pandemic influenced cannabis consumption, the addiction model proposed by Koob and Volkow (2016) could be used. According to this model, there were three stages of addiction resulting in varying disruptions in brain functionality and neurophysiology (Koob & Volkow, 2016). While the binge-intoxication stage led to the impulsive use of drugs (for example, individuals who were experiencing high levels of distress during the pandemic might start using cannabis to relieve), the withdrawal-negative affect stage was characterized as anxiety symptoms and irritability due to abstinence (after a period of time those individuals might start experiencing discomfort while not using cannabis) (Zehra et al., 2008). Following this phase, during the preoccupation-anticipation stage, the consumers portrayed increase salience at drug cues (after the abstinence period, individuals might start paying heightened attention to cannabis-related information) (Zehra et al., 2008). As each stage contributed to the emergence of different behaviors, individuals' conditions and required interventions should be evaluated regarding their position in the model (Koob & Volkow, 2016).

Protective Factors

As everyone exposed to cannabis did not develop substance use disorder or experienced adverse consequences at the same extend, individuals’ particular characteristics should be

examined as well. Protective factors were claimed to lower the likelihood of negative consequences (Rutter, 1979). These factors could further be considered while analyzing individual differences in cannabis consumption during this period. While the individual domain included the factors such as personal beliefs and internal controls, the family domain involved the parent-child relationship (Eassey et al., 2015; Hawkins et al., 1992). On the other hand, non-familial components indicated larger social influences (Akers, 1998).

As Wright and Cullen suggested (2004), the number of hours worked per week (following individual domain) led to less use of cannabis for young adults and teens. Likewise, initiation of cannabis use could be prevented by parental discipline (Kosterman et al., 2000). Lastly, being less exposed to peer pressure was negatively linked to frequency of use (Eassey et al., 2015).

Researchers also examined more specific cannabis protective behavioral strategies (PBS), which led to lowered cannabis use quantity, frequency, and cannabis use disorder symptoms (Pedersen et al., 2016; Caffrey et al., 2018; Wong et al. 2019). Some examples for cannabis PBS were, limiting use to weekends or avoiding using other drugs while using cannabis (Pedersen et al., 2016).

Risk factors for cannabis use addiction

Individuals' unique risk factors should be discussed to explain the full spectrum of cannabis users (Zehra et al., 2008). These can be defined as the predictors that might increase the likelihood of adverse outcomes (Hawkins et al., 1992). For instance, according to Manning et al. (2019), negative affectivity was associated with greater withdrawal symptoms and greater cannabis-related problems. Emotion dysregulation, anxiety sensitivity, and emotional vulnerability were other risk factors that led to more frequent - heavy use (Manning et al., 2019).

Alongside the personal aspects of cannabis addiction, contextual factors that might increase the odds of cannabis use should be noted. For instance, having permissive parents, spending more time with friends who were also using cannabis, and having parents with a history of drug use were linked to increased use (Harakeh et al., 2012; Gaete & Araya, 2017). Furthermore, the qualitative study conducted by Fedorova et al. (2020) explained how problematic versus recreational cannabis users varied in consuming other drugs. They revealed that illicit drug use was prevalent in problematic users to escape emotional pain

caused by traumatic events. However, this was not the case for occasional users, as traumatic events didn't lead to a desire to use other drugs (Fedorova et al., 2020). Besides, concurrent behavioral factors like alcohol consumption with cannabis use were associated with more problematic cannabis use (Manning et al., 2019).

Lastly, cannabis use motives were significant predictors of individuals' cannabis use frequency, quantity, and the number of problems they encountered (Manning et al., 2019). These motives will be explained in the next section.

Cannabis use motives

According to Cooper (1994), individuals' motives should be identified to understand why some people use substances. Typically, cannabis-specific motives among adolescents were summarized as fun, compliance, boredom, and relaxation (Hendin & Haas, 1985). On the other hand, adults tended to use cannabis to deal with the frustration caused by unhappy relationships and escape problems (Hendin & Haas, 1985). Enjoyment, boredom, altered perception, relatively low risk was associated with consumption in greater frequencies (Lee et al., 2009). These might explain the stockpiling behaviors of recreational users in Canada to manage potential difficulties during the lockdowns (Cherkasova, 2020).

Furthermore, social, expansion, enhancement, and coping motives were linked to more frequent use; problems experienced due to cannabis consumption were associated only with affective enhancement and coping motives (Pearson et al., 2017; Manning et al., 2019).

Lastly, the popular gateway theory proposed by Kandel (1975) suggested cannabis users' vulnerability towards using and abusing other drugs. For instance, one study conducted with 3853 poly-substance users attempted to reveal subjective experiences for different drugs and how these experiences predict the problematic use of other drugs (Zeiger et al., 2012). These authors reported that cannabis users were also consuming alcohol and tobacco more frequently, and the most substantial relationship was observed between alcohol and cannabis (Zeiger et al., 2012). However, findings also exhibited the instrumental value of cannabis as it aided the treatment of alcohol and cocaine addiction (Mikuriya, 2004; Dreher, 2002). Similarly, for methamphetamine users, cannabis was helpful for long-term abstinence (Boeri et al., 2009). Further studies are needed to realize the link between cannabis and other drugs.

As the pandemic demonstrated a distinctive experience for many, it is of paramount importance to understand specific motives that might influence cannabis use during COVID-

19. For example, one study with 1563 cannabis users in the early lockdown period reported that 78.4% of the participants increased their use due to boredom (Van Laar et al., 2020). Another study reported a positive relationship between cannabis use intentions and emotional manifestations of stress (Liébana-Presa et al., 2020). Because in non-pandemic periods, individuals' most common motive for cannabis use was to relieve, cannabis users might expect to cope with pandemic-specific difficulties through increased cannabis consumption (Hyman & Sinha, 2009). This might be in line with the self-medication hypothesis, which asserted that individuals might engage in specific behaviors (like substance use) to relieve their psychological distress (Khantzian, 1997). That is the main standing of this meta-analysis as well. Namely, the pandemic brought significant distress regarding personal health and economic consequences and more specific issues like boredom (Taylor et al., 2021; Lorant et al., 2021; Van Laar et al., 2020). Even though the precautions taken by the governments were essential in controlling infection rates, the increased isolation was associated with increased anxiety and fear (Gan et al., 2020). Since cannabis users showed low tolerance to stress in regular periods, these findings might be particularly alerting in this context (Mahvan et al., 2017). Moreover, unemployed young adults were more likely to develop cannabis use disorder (Henkel, 2011). Thus, the overwhelming distress experienced during the pandemic and the increased job loss might escalate cannabis use to alleviate discomfort.

Why should we be concerned?

Cannabis, the biggest drug sector in the European Union, was also reported as the most commonly used illicit drug in regular periods (EMCDDA, 2019; UNODC, 2018). This might be due to adopted permissive beliefs of consumers, as cannabis was usually perceived as harmless (Hyman & Sinha, 2009). However, findings repeatedly revealed potential adverse consequences linked with its use, such as psychiatric symptoms and serious disorders like schizophrenia (Burns 2013; Arseneault et al. 2004; Hall 2006). Moreover, cannabis use was associated with cognitive impairments, lower job performance, and lower social functioning in relationships (Meier et al., 2012; Solowij et al., 2008; Solowij et al., 2002; Raver et al., 2013; Bolla et al., 2005; Feeney & Kampman, 2016; Palamar et al., 2014; Jager & Ramsey, 2008). Interestingly, one study with a small sample measured risk-taking behaviors of cannabis users and revealed that high doses of cannabis affected decision-making by altering individuals' sensitivity to consequences (Lane et al., 2005). As risky decision-making and the

resulting adverse incidents might lead to stress, consumers might maintain using cannabis to manage the negative affect, since stress relief was the most common reason for cannabis consumption (Copeland et al., 2001; Hyman & Sinha, 2009).

This should be further explained in the context of the spiraling distress model (Heatherton et al., 1994). As Heatherton and colleagues (1994) claimed, experienced emotional distress due to self-regulation failure might perpetuate additional self-regulation failures, and negative affect might occur repetitively. For instance, chronic cannabis use to manage stress might lead to negative affect (abstinence symptoms), and the experienced stress might lead to more drug use (Koob & Le Moal, 1997, Koob & Le Moal, 2001). However, although using cannabis to avoid issues might provide a short-term solution, the unsolved problems might aggravate, or adverse life events might increase due to poor decision-making (Lane et al., 2005; Hyman & Sinha, 2009). Therefore users might consume cannabis in more significant amounts. Because, cannabis users coped with stress less flexibly in non-pandemic times, increased use during the pandemic might be critical (Kruczek et al., 2017). The endorsement of (or intensified) unhealthy coping styles during COVID-19 might produce new unhealthy habits that might persist after the pandemic.

To the best of the author's knowledge, no meta-analysis has been conducted to investigate the influences of COVID-19 on cannabis consumption. The most previous meta-analyses focused on substance use disorder in general or mental health consequences of COVID-19 (Kim et al., 2020; Ismael et al., 2021; Ren et al., 2020; Wu et al., 2020). Therefore, this study aims to perform a systematic review and meta-analysis on the literature about COVID-19 and cannabis use and test the moderating effects of various variables such as gender, age and, country.

Methods

Search Strategy

This study was a part of a broader project investigating the changes in substance use patterns during the pandemic. Therefore the literature review was conducted for studies including main drugs and COVID-19. Studies were located by searching electronic databases PubMed and Web of Science using the following MESH (Medical Subject Headings) search terms: (“covid” OR “covid-19” OR “coronavirus” OR “corona virus” OR “SARSCoV-2”

OR “severe acute respiratory syndrome coronavirus 2”) AND "Alcohol-Related Disorders" OR “Alcoholic” OR “Prescription Drugs” OR “substance use” OR “substance misuse” OR “substance abuse” OR “substance-related disorders” OR “Substance-Related Disorders” OR “Opioid-Related Disorders” OR “Opiate” OR “Opioid” OR “Prescription Opiate” OR “Prescription Opioid” OR “Opiate Overdose” OR “Heroin” OR “Opium” OR “Cannabis” OR “Marijuana” OR “Cocaine Hydrochloride” OR “Cocaine-Related Disorders” OR “sedatives” OR “tranquilizers” OR “major tranquilizers” OR “Amphetamine” OR “Tobacco” OR “Nicotine” OR “benzodiazepines” OR “psychoactive” OR “psychotropic” OR “psychopharmacology” OR "psychiatric medications" OR “anticonvulsant” OR “antidepressant” OR “antipsychotic” OR “anxiolytic” OR “recreational drug” OR stimulant medications” ; between 01-01-2020 - 01.04.2020.

After determining the initial results through the search string above, articles that examined cannabis use were set apart and used for this project.

Inclusion and exclusion criteria

The studies were included if changes in the relevant substances were measured as a function of exposure to COVID-19. Both general and clinical populations were comprised. In addition, the eligible languages were: English, Dutch, German, Arabic, Spanish, Greek, Turkish, and French. Studies that did not report original data, such as reviews, commentaries, editorials, or other meta-analyses, were excluded.

Procedure

The studies that investigated the changes in relevant substance use in relation to exposure to the COVID-19 were pooled. The duplicate studies were removed, and initial screening was conducted based on the names and abstracts. After this step, articles were examined exhaustively, and the following data were extracted using a pre-prepared table: Demographic data (e.g., gender distribution), operationalization, clinical data (e.g., method of diagnostic assessment), results (e. g., increase/decrease/no change) and type of study (e.g., self-report).

Quality Assessment

The methodological quality/risk of bias of the studies was assessed using the method proposed by Lievense et al. (2002). Namely, by using a standardized set of criteria, two raters

independently scored the quality of the articles and tried to achieve consensus if there was a disagreement (Lievense et al., 2002). This did not determine the inclusivity of the articles; however, it was related in meta-regression analyses to the outcome of the studies.

Effect Size Calculation and Statistical Analysis

Statistical analysis was performed in Jamovi, an open-source platform for statistical analysis (version 1.8.0, standard version plus the "MAJOR" meta-analysis module) (The jamovi project, 2021). The means and standard deviations were extracted, and Pearson's correlation coefficients (*r*) of the associations between COVID-19 and cannabis use were computed for each primary study. For outcomes reported as rates of users who increased/decreased/not changed their cannabis consumption pre- to post-COVID-19, proportions were extracted.

The random-effects model was chosen to estimate the weighted mean of effect sizes. In comparison to the fixed-effect model, this model did not assume that the variability between effect sizes was solely due to sampling error (Field & Gillet, 2010). Instead, the systematic sources of variability accounted for the variability among effect sizes (Lipsey & Wilson, 2009). Namely, because the studies differed in many characteristics (e.g., study protocol, settings), the variability among their effect sizes might not be solely due to sampling error. I^2 statistics were calculated to display the percentage of variation across studies due to heterogeneity rather than chance (Higgins & Thompson, 2002; Higgins et al., 2003). A p-value <0.05 was considered significant for both meta-analyses (Fisher, 1950).

Lastly, unlike other articles which examined the changes in cannabis use quantity, one study conducted by Liébana-Presa et al. (2020) measured changes in cannabis use intentions. As previous research suggested strong associations between intentions and behaviors, this article was assumed to be suitable for this project (Armitage & Conner, 2001; Sheeran, 2002). Sensitivity analysis was conducted after omitting this article to test this assumption.

Moderator Analysis

Three moderator analyses were performed to analyze the effects of varying characteristics of studies that might account for between-study heterogeneity. The following characteristics were assumed to influence the heterogeneity in effect sizes:

1- Country of the study, as cannabis use might be affected by the substance use culture of the region.

2- Age group of the participants, since cannabis use was more common among young adults (Bergen-Cico & Cico, 2017).
3- Gender of the participants since cannabis abuse and dependence were more common among males (Haberstick et al., 2014).

Publication Bias

Publication bias was assessed by Egger's regression test, and Begg-Mazumdar rank correlation (Egger et al., 1997; Begg & Mazumdar, 1994). Additionally, the funnel plots, a graphical representation of estimated effect sizes in studies against an estimate of its precision, were visually inspected (Field & Gillet, 2010; Simmonds, 2015). While the observed asymmetry would suggest potential publication bias, an unbiased sample would create a funnel shape (Field & Gillet, 2010).

Results

Searches

Fifty-five studies met the inclusion criteria (see Figure 1). Thirty-four were excluded because original data was not reported. Six studies were excluded due change in cannabis use pre- to post-COVID-19 was not mentioned. Two studies were excluded solely on the basis of the insufficient description of substances that were studied. The remaining thirteen papers were eligible for inclusion in the meta-analysis (see Figure 1). Sample sizes ranged from 67 to 11,391, and the total N for this meta-analysis was 19.875, representing five countries (United States, Netherlands, Spain, and Canada). The mean sample ages ranged from 14.04 to 47.70 years. The summary of the characteristics and outcome measures can be viewed in Table 1.

Figure 1

Flowchart on identification, screening, and inclusion of eligible publication

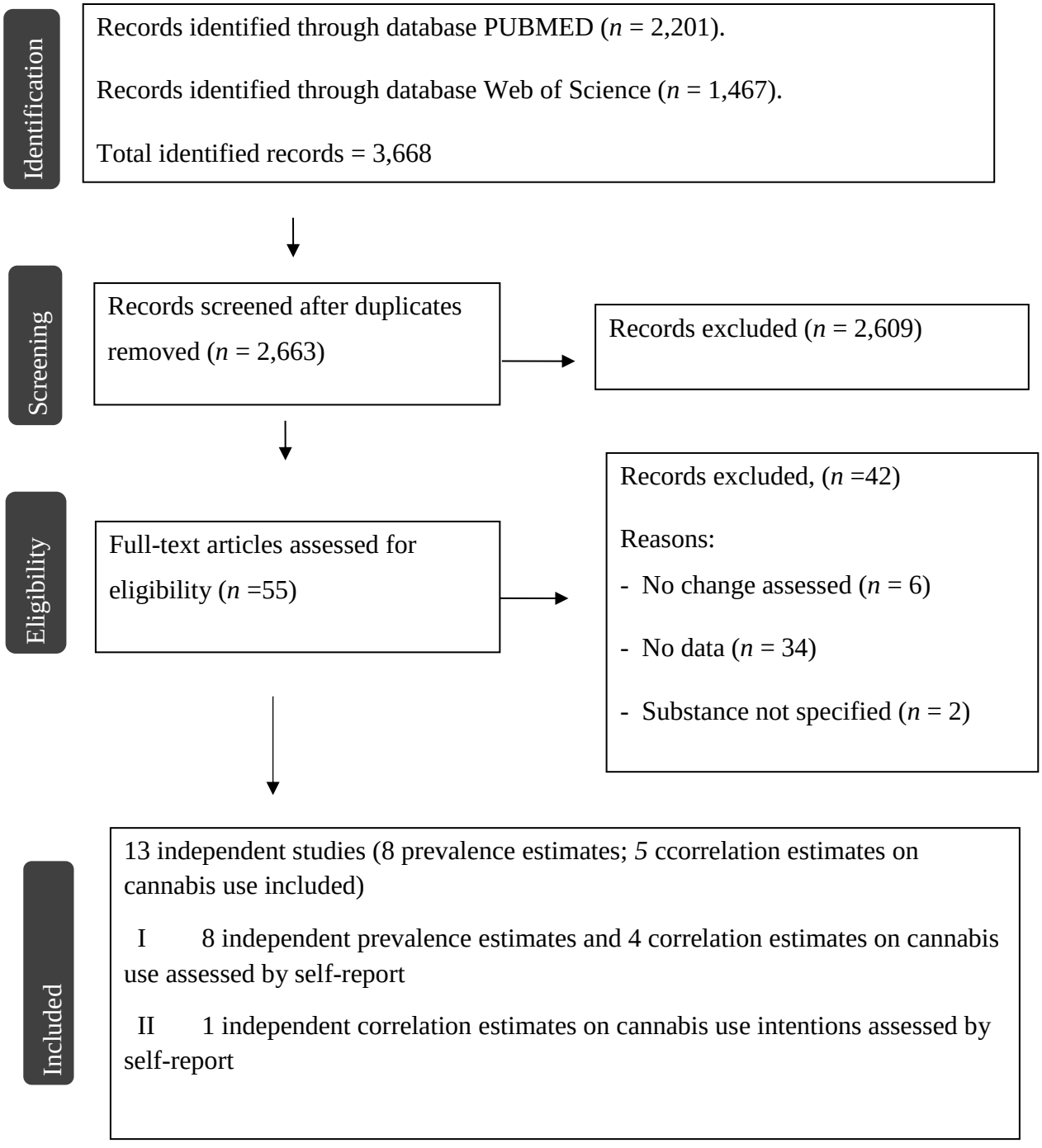


Table 1

Characteristics of included studies

Study	*N*	Av. age	%Female	Country	Outcome measure
Boehnke *et al.* (2020)	353	37	55.5	USA	Self-report
Cousijn *et al.* (2021)	1491	*N.K*	67.4	Netherlands	Self-report
Dumas *et al.*(2020)	1054	16.68	76.4	Canada	Self-report
Firkey *et al.* (2020)	212	22.09	50.5	USA	Self-report
Graupensperger *et al.* (2021)	572	25.14	60.8	USA	Self-report
Liébana-Presa *et al.*(2020)	300	14.04	62	Spain	Self-report
Miller *et al.* (2021)	67	35.11	46.3	USA	Self-report
Palamar *et al.* (2021)	128	23.3	61.7	USA	Self-report
Rolland *et al.* (2020)	11,391	47.70	52.1	France	Self-report
Starks *et al.* (2020)	910	40.53	0	USA	Self-report
Turna *et al.* (2021)	632	40.04	82	Canada and USA	Self-report
Van Laar *et al.* (2020)	1563	32.7	33.7	Netherlands	Self-report
Vidot *et al.* (2020)	1202	47.2	46.9	USA	Self-report

Three articles classified participants' cannabis use by self-reported changes (increase/decrease/no change), and eight studies categorized the frequency of use (e.g., the number of days used in the past three months). One article measured cannabis use intentions, and one study used Cannabis Use Disorder Identification Test-Revised (CUDIT-R) to screen likely cases and severity of cannabis use disorder.

Meta-Analysis

Two meta-analyses were conducted as part of this project. For the articles with outcomes reported as proportions, studies were weighted according to their sample sizes to pool proportion estimates (Higgins & Green, 2008). For the remaining articles, correlation coefficient (*r)* effect sizes were calculated and were pooled to assess the association strength between COVID-19 and cannabis use.

The combined correlation coefficient for five studies was 0.06 (95% CI = -0,014, 0,136 ; $p = 0.110$), suggesting no significant increase in cannabis use (see Figure 2). Moreover, heterogeneity statistics yielded non-significant results ($I^2 = 33.86\%$, $p = 0.101$). As Egger's regression analysis test yielded non-significant results ($p = 0.559$), no publication bias was detected. Separately, the Begg-Mazumdar rank correlation test for funnel plot asymmetry indicated a symmetrical funnel shape ($p = 0.817$) (Figure 3).

Figure 2

Forest plot for evaluating the association of cannabis use and COVID-19

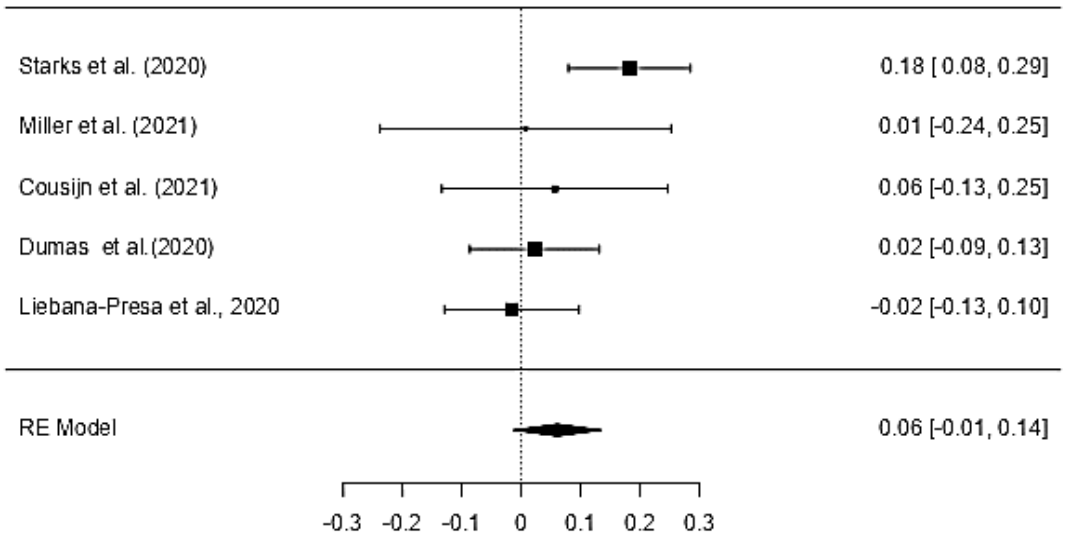
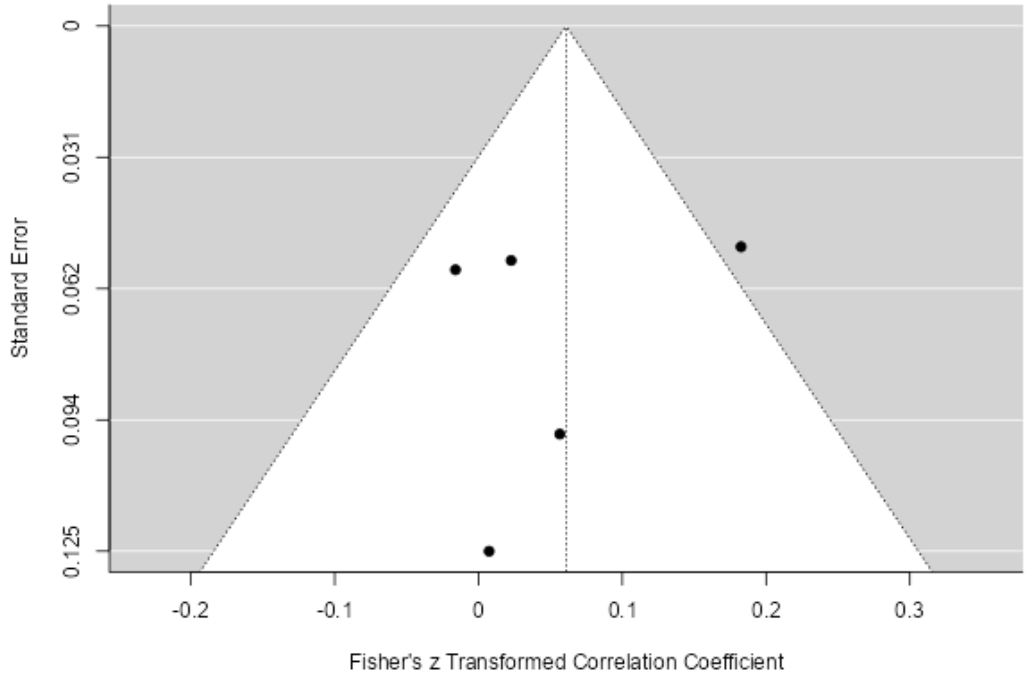


Figure 3

Funnel plot for the meta-analysis of correlation coefficients



Sensitivity analysis was performed after excluding Liébana-Presa *et al.* (2020), as this study measured cannabis use intentions as opposed to the changed amount of cannabis use. Omission of this study yielded significant results with a pooled correlation coefficient of 0.09 (95% CI = 0.01, 0.17 ; p = 0.025). Non-significant heterogeneity was observed (I^2 = 19.45%, p = 0.164).

The meta-analysis conducted with proportion estimates implied substantial, significant heterogeneity between these 8 studies (I^2 = 92.97 %, p < .001) and the pooled estimate of changed cannabis use due to COVID-19 was 13% (95% CI = 0.01, 0.24; p = 0.034). The details are presented in Figure 4. Based on Egger's analysis (p = 0.065) and the rank correlation (p = 0.5484), funnel plot asymmetry was not indicated (Figure 5), suggesting no evidence of potential publication bias. The three moderators tested in these two meta-analyses were age, gender, and country. Since significant effects were not found, these variables could not explain the high amount of heterogeneity observed in this analysis.

Figure 4

Forest plot for evaluating the association of cannabis use and COVID-19

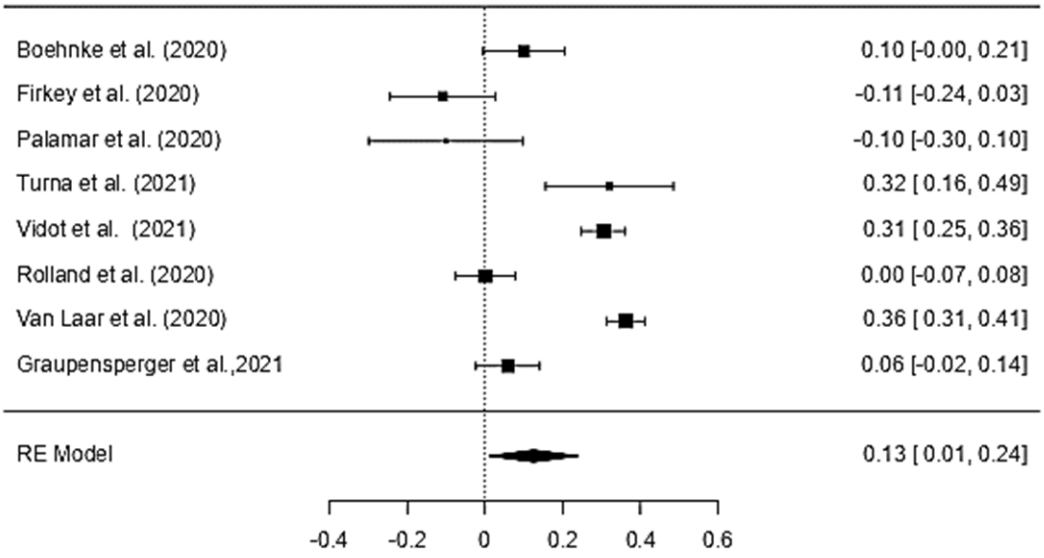
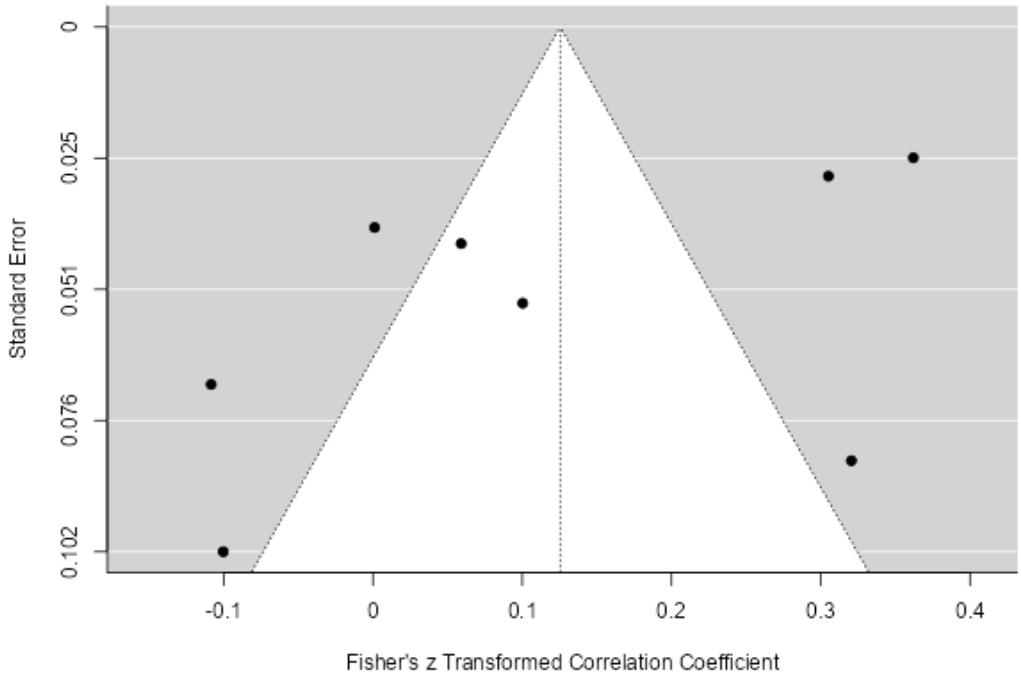


Figure 5

Funnel Plot for meta-analysis of proportions



Discussion

This study aimed to examine the impact of COVID-19 on cannabis consumption. Thirteen eligible articles that studied cannabis use before and after COVID-19 were subjected to meta-analysis. As hypothesized, it's revealed that cannabis use was significantly increased after the pandemic. Moreover, not all studies came to the same conclusion as there was substantial heterogeneity between studies. Taken together; these results suggest a small impact of the pandemic on cannabis use patterns.

Increased distress during the pandemic might be one of the reasons underlying the observed effect, which might lead to heightened self-medication motives (Gao et al., 2020; Yu et al., 2020). Also, stress was related to the development of cannabis addiction and increased use (Briand & Blendy, 2010; Sinha, 2007). In non-pandemic times, users claimed stress relief as their primary motive for cannabis use, and studies conducted during COVID-19, reported increased substance use to cope with pandemic stressors (Copeland et al., 2001; Charles, 2021; Lechner et al., 2020).

Varying stressors that emerged during the pandemic might lead to different motivations for increased cannabis use. One form of distress might be related to prolonged confinement and increased time spent at home due to imposed self-isolation measures. For instance, according to the thematic analysis performed by Emery et al. (2021), regulating emotional distress was the major reason for increased substance use, since participants were spending more time at home and doing less for recreation. Correspondingly, Cousijn et al. (2021) reported increased expansion motives among the users who increased their use during the pandemic. This might be related to increased boredom experienced in isolation as the users were not able to leave their apartments (Van Laar et al., 2020; Graupensperger et al., 2021).

Additionally, non-pandemic literature claimed that being a cannabis user predicted lower self-efficacy, which might be associated with increased boredom motives (Lac & Luk, 2018). Namely, the increased use due to boredom might be explained as users' inability to perform more adaptive behaviors due to low self-efficacy. In the same manner, substance abuse impairs the users' reward mechanism, which might explain increased boredom observed in cannabis users (Martin-Soelch et al., 2009). For instance, cannabis affected reward processing at a behavioral level, and users portrayed lower motivation to monetary reward when compared to non-users (Lane et al., 2005; Martin-Soelch et al., 2009). This might imply

an additional mechanism underlying boredom and increased cannabis use during the pandemic. Since cannabis users portrayed lower interest in rewards, they might lack the motivation to perform alternative rewarding activities due to not perceiving it as rewarding enough (Lawn et al., 2016).

COVID-19 specific worries might explain another form of stressor that might lead to increased cannabis use among the users. Health-related concerns and adverse financial circumstances that emerged during the pandemic might lead to increased use to cope with the negative affect that these stressors brought (Sznitman et al., 2021). One study conducted in the US implied similar results and revealed that individuals who started using cannabis during the pandemic were experiencing higher COVID-19 related worries (Rogers et al., 2020). Likewise, recreational users who reported more socioeconomic and health concerns during COVID-19 consumed cannabis more as a motive to cope with distress (Sznitman et al., 2021). This was supported by non-pandemic studies that proposed that economic crises were related to increased substance use (Dom et al., 2016)

Ingram et al. (2020) claimed that feelings of isolation and loneliness were linked to the heightened use of substances in regular periods. Likewise, in non-pandemic times loneliness was associated with increased cannabis use (Holmes et al., 2016). Since the enacted stay-at-home orders during the pandemic led to increased isolation experienced by individuals, the notion of loneliness should be discussed (Luchetti et al., 2020).

Loneliness might lead to increased use of cannabis as it's associated with increased anxiety, stress, and reduced self-esteem (Hawkley & Cacioppo, 2010). For instance, Liu et al. (2021) revealed associations between loneliness and COVID-19 related distress. Likewise, loneliness was linked with depressive symptoms, sleep problems, suicidal ideation, which might lead to the development of motives to cope with the negative affect and increased cannabis use (Qualter et al., 2010; Eccles et al., 2020; Peltzer & Pengpid, 2017). One non-pandemic study carried with young adults claimed that cannabis users were experiencing more loneliness (Rhew et al., 2021). Therefore, combined with the abovementioned study led by Holmes et al. (2016), a vicious circle between loneliness and cannabis use might be suggested.

Theoretical Significance of the Findings

Although adolescent drug use was predicted by having substance-using peers, studies that investigated solitary substance use proposed stronger associations with adverse consequences compared to social use (Kandel, 1985; Creswell et al., 2015; Tucker et al., 2006). Others suggested that solitary use might obstruct individuals' ability to compare their use with peers, consequently enhancing risky consumption (Cooper, 1992). Solitary use of cannabis was also reported to be prevalent, and according to one study, 30% of past-year cannabis users consumed cannabis alone in the previous year (Mason et al., 2020; Tucker et al., 2006). Assuming social isolation measures during the pandemic led to more solitary use, explaining unique risk factors and consequences of this type of consumption displays importance. Moreover, as not everyone who used cannabis pre-pandemic increased their use during the pandemic, these variables might clarify specific factors that contributed to users' cannabis use patterns during COVID-19.

One potential risk factor reported by Tucker et al. (2006) was related to higher expectations anticipated by solitary users. This group of users had stronger beliefs regarding cannabis' affect regulation abilities (Tucker et al., 2006). Moreover, a handful of previous studies suggested that more frequent use of alcohol and cannabis among adolescents was associated with an increased likelihood of solitary consumption (Tucker et al., 2006; Creswell et al., 2015). Lastly, solitary use might be due to higher likelihood of self-medication in the face of a negative affect (Tucker et al., 2014).

Solitary use in adolescence was linked to cannabis use disorder symptoms also more frequent use in the previous month (Spinella et al., 2019). Interestingly, compared to social users, coping-based cannabis use (using cannabis to cope with emotionally salient stressors) was higher among users who consumed cannabis alone (Spinella et al., 2019; Bonn-Miller et al., 2008). However, using cannabis to cope with affective distress (compared to other motives like social, conformity, and expansion) was a predictor of increased frequency of use and the more problems experienced (Bresin & Mekawi, 2019). This was in line with the Swiss-based study that claimed that coping motives (compared to social reasons) for cannabis use were associated with psychosocial distress and more life events (Brodbeck et al., 2007). Likewise, stress-generation theory claimed that avoidance might lead to experiencing more stressors (Hammen, 1991). Due to habitual consumption of cannabis when facing adversities and not practicing problem-solving abilities, the culmination of unsolved problems might lead

to distress and increased cannabis consumption (Hyman & Sinha, 2009). Bonn-Miller et al. (2008) described this pattern as the "avoidance-based forward-feeding cycle" in which cannabis use acted as a short-term emotion regulation strategy, leading to increased anxiety symptoms (p. 863). As the pandemic added significant stressors to individuals' lives already, adopting unhealthy coping styles might be detrimental, including but not limited to the pandemic period.

Limitations

The results of this meta-analysis should be interpreted in the context of several limitations (1) the number of studies included in each meta-analysis was few, leading to small statistical power. This also led to the inability to perform sub-group analysis, as the number of studies was not adequate to divide the groups even further; (2) the meta-analysis of the five articles that measured the pooled estimate of the correlations between cannabis consumption and COVID-19 yielded non-significant heterogeneity. This should not mean that there was no heterogeneity or that the studies were not dissimilar from one another. Instead, because a small number of studies were included, the variability among studies might not be detected due to the low power (Higgins & Green, 2008); (3) the difficulty of studying COVID-19 should be noted. For instance, one potential moderator (the publishment date of the articles) was decided to be important in understanding between-study heterogeneity. Meaning, it was hypothesized that the participants recruited in 2021 might be using cannabis more because they experienced the pandemic in longer durations compared to participants recruited in 2020. However, as the onset of the pandemic and the dates of the enactment of self-isolation measures differed between countries (also, not every government implemented isolation measures as soon as the first case was detected), this moderator could not be tested.

A further limitation of this study was related to ecological validity concerns, as most of the participants came from western countries, and many had higher education degrees. Future studies might benefit from more representative studies to increase the generalizability of their findings.

Lastly, the dominant use of self-report measures might raise concerns regarding their unreliability and potential biases.

Further Directions

It was observed that the cannabis-pandemic literature was lacking diverse samples of cannabis users. Future work might benefit from examining clinical and non-clinical samples, comparing different types of cannabis users (e.g., medical, recreational, occupational) also investigating individuals undergoing serious life issues during the pandemic. For instance, one study conducted with cancer survivors during COVID-19 pointed that, compared to participants with no such background, survivors were more likely to use cannabis to cope with health issues (e.g., headaches, nausea, sleep problems) (Camacho-Rivera et al., 2021). Therefore, it is of paramount importance to examine various vulnerable groups and their unique cannabis use patterns during the pandemic.

Furthermore, the route of administration might affect individuals' cannabis use habits and their addiction patterns. For example, Van Laar and colleagues (2020) reported that during COVID-19 small proportion of cannabis users increased their edible use. On the other hand, most of the users who preferred joints with tobacco (before the lockdown) continued smoking in the same manner, and a small proportion of the users started using less tobacco in a joint during the pandemic (Van Laar et al., 2020). Therefore, examining different routes of administration for cannabis consumption might enrich our understanding of cannabis users' behaviors.

Understandably, pandemic psychology is a novel dynamic area for many, and both the reader and the researcher might be eager to acquire information. That might explain the dominant use of cross-sectional studies as they can be conducted relatively faster than other designs. However, future research should focus more on longitudinal studies to better understand the causal relationships between the pandemic and cannabis use. By discovering the interrelations between distinct risk factors, protective factors, and personality differences, we might advance the field of substance use in general.

Conclusion

The results of this meta-analysis provided support for increased cannabis use during COVID-19 and highlighted the necessity for the development of effective interventions that might reduce users' reliance on cannabis during this period.

For example, boredom motives played a great role in explaining increased cannabis use during this period (Van Laar et al., 2020; Graupensperger et al., 2021). Therefore, internet-based interventions providing adaptive coping strategies for reducing boredom and increasing self-efficacy might be beneficial.

Furthermore, increased loneliness and the negative affect developed during the pandemic was proposed as a potential mechanism underlying increased cannabis use. Hence, cannabis users might benefit significantly from interventions to increase social interactions and improve social skills (Cacioppo et al., 2015).

Lastly, the increased isolation during COVID-19 might lead to the formation of new unhealthy habits such as solitary cannabis consumption. This might have significant clinical implications as solitary-use might require the development of new screening and interventions tools.

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