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The effect size and nonlinearity of the relationship between cannabis consumption and consumer self-perceived mental health: A study based on eight national surveys in Canada

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Abstract

Previous research suggests a negative association between cannabis consumption and consumer mental health, but the magnitude and linearity of this association require further investigation. Therefore, this study analyzed eight suitable national survey datasets from Statistics Canada from 2009 to 2021. In the general population, the mean effect size between cannabis use (yes/no) and self-perceived mental health is negative but very small in magnitude ($\overline{R} = -0.096$). Moreover, in the cannabis user sub-population, the mean effect size between cannabis usage frequency and mental health is small in magnitude ($\overline{R} = -0.157$). More importantly, among cannabis users, a nonlinear negative relationship between cannabis use frequency and mental health was identified. Specifically, as cannabis use becomes more frequent and people's self-perceived mental health worsens, the association becomes

stronger. These findings have significant implications for social marketing and health promotion.

KEYWORDS
cannabis consumption, consumer mental health, effect size

1 | INTRODUCTION

Cannabis consumption became more and more common after the push for its legalization in many areas across the world, so research is in great need to understand its outcomes and its predictors. Consumer self-perceived mental health, a key component of consumer well-being, can be affected by cannabis use and may also influence consumers' cannabis consumption decisions. Therefore, examining the relationship between cannabis consumption and consumer self-perceived mental health is an important research topic attracting more and more research attention from different disciplines, such as marketing and consumer behavior (Fergusson et al., 2003; Green et al., 2003; Kees et al., 2020; Kosiba et al., 2019; Simkins & Geiger-Oneto, 2020), epistemology (Adamson et al., 2010; van der Pol et al., 2013), psychology (Macleod et al., 2004; Moore et al., 2007; Patton et al., 2002), economics (e.g., van Ours & Williams, 2011, 2012), social policy (Bahji & Stephenson, 2019; Hammond et al., 2020), and so on. Even so, since this relationship is highly complicated and multifaceted, there are still many important research questions left to be answered.

One prominent knowledge gap pertains to the magnitude of the relationship between cannabis consumption and consumer mental health. While existing literature acknowledges a negative and significant association between cannabis consumption and consumer mental health, research explicitly examining this relationship's effect size is limited. Understanding the effect size is crucial as it provides valuable insights into this relationship's strength and practical implications for public health, health promotion, social marketing, and public services. Furthermore, among the limited research, most studies examine the effect size in specific samples (Henquet et al., 2005; Østergaard et al., 2017; Semple et al., 2005), resulting in a significant gap in our understanding of the effect size in the general population.

Another research gap in the existing literature is the linearity of the relationship between cannabis use frequency and consumer mental health. Most of the current research assumes a linear relationship between these two variables. However, intriguingly, studies focusing on heavy cannabis users (e.g., Hamilton, 2017; Sideli et al., 2020) or people with pre-existing mental health problems (e.g., Marshall et al., 2020; Smith et al., 2022) tend to identify a significant and strong relationship between cannabis consumption and mental health. This body of research points toward a nonlinear relationship between cannabis use frequency and mental health, suggesting that the strength (i.e., the effect size) of the association between these two variables may vary. However, empirical research examining this nonlinear association has remained very limited.

The overall research objective of this paper is to examine the association strength and linearity of the relationship between cannabis consumption and consumer self-perceived mental health. First, this paper utilized data from eight national survey datasets from Statistics Canada to examine the mean effect size between cannabis consumption behaviors and consumer self-perceived mental health in both the general population and the cannabis user sub-population.

Second, the nonlinear relationship between cannabis use frequency and consumer mental health among cannabis users was examined for further insights.

2 | LITERATURE REVIEW

2.1 | Cannabis consumption

Cannabis is the most used illicit drug globally and was estimated to have 192 million users worldwide (Bahji & Stephenson, 2019). The cannabis market expanded rapidly beyond medical use after the recent trend toward legalization and decriminalization (Hammond et al., 2020). Currently, cannabis is only legally allowed in limited jurisdictions, such as Germany, Canada, the Netherlands, Uruguay, Spain, and select American states.

Cannabis products include traditional dried plant forms and cannabinoid extracts used in various consumer goods like edibles, tinctures, extracts, and beauty products (Collins, 2018). They can be classified into two categories: THC (tetrahydrocannabinol)-containing products with psychoactive effects are used for recreational and medical purposes, and CBD (cannabidiol)-based products without THC populate the everyday and holistic medicine industries (Hawes et al., 2020; McGrath, 2022).

The line between medical and nonmedical cannabis consumption is often blurred, as some consumers consider their use as "medical" even when exhibiting patterns of recreational consumption and lacking medical authorization (Smith et al., 2022). Many individuals who identify as medical users also engage in recreational consumption, making it challenging to distinguish which instances of use are genuinely "medical" for these individuals. In Canada, medical cannabis is authorized rather than prescribed, and consumers determine their own cannabinoid dosing for health maintenance or symptom management (McGrath, 2022).

Information about the effects of cannabis is varied and sometimes contradictory. Individuals using cannabis to alleviate mental health issues, such as anxiety, may be vulnerable to addiction as they seek to fulfill various needs like loneliness, pain relief, or escapism (Lowe et al., 2019). These issues are usually the outcomes of long-term or high-volume cannabis use. On the other hand, cannabis is claimed to offer benefits such as mood enhancement, anxiety reduction, pain relief, short-term enjoyment, substitution for other substances, and improved social interactions (Gould et al., 2020). In some cases, individuals may prefer cannabis over prescription treatments like opioids, despite potential negative side effects (Reiman et al., 2017; Smith et al., 2022). It can also substitute recreational substances that are perceived as more harmful (Gould et al., 2020). Some research (Fergusson et al., 2003) shows that a moderate level of cannabis use may provide short-term positive experiences without significant long-term consequences.

Given the prevalence of cannabis consumption behavior and the lack of conclusive research on its effect on consumers, research on the relationship between cannabis consumption and consumer mental health is in great demand.

2.2 | Consumer mental health

Research into consumer mental health has a long history, but still lacks a commonly accepted definition. There are generally two approaches to defining consumer mental health. One approach focuses on consumers' satisfaction or contentment, while the other approach focuses on consumer mental illness with an emphasis on functional deficits (Keyes, 2006).

As for the measurement of consumer mental health, there are generally two methods: objective and subjective mental health. (1) Objective measures are usually administered by health practitioners to diagnose mental illnesses or assess people's mental health state (Lusczakoski et al., 2016). However, objective measures may not capture individual experiences or be equally applicable across demographics (Gould et al., 2020; Lowe et al., 2019; Lusczakoski et al., 2016). (2) Subjective measures focus on individuals' self-perceived mental health state. These measures provide the flexibility to consider personally impactful factors rather than a prescribed value. Subjective measures are particularly relevant in consumer mental health assessments, as they encompass internal experiences that vary greatly between individuals and influence their consumption behavior. To sum up, the main distinction between objective and subjective mental health measures lies in whether they capture the consumers' own evaluation of their mental health state.

While research using objective measures is valuable, they have limitations. First, objective measures may not accurately capture changes in consumer mental health unless they reach a threshold considered problematic by standard metrics (Das et al., 2020). Second, research using objective measures primarily focuses on high frequency or problematic users, making their results less applicable to general consumers. Third, research using objective measures fails to address individual motivations for consumption. The literature suggests that consumers make decisions based largely on their own perception of cannabis and its effects, regardless of the actual outcome (Lowe et al., 2019; Smith et al., 2022). Furthermore, objective measures tend to capture the effects of cannabis from an addiction/dependency perspective and may overlook the broader range of consumer needs, such as symptom management and social reasons (Wallis et al., 2022). As a result, these objective measures cannot contextualize cannabis-use interactions from a consumer perspective. Therefore, this paper mainly focuses on consumers' subjective mental health (i.e., consumer self-perceived mental health).

2.3 | Relationship between cannabis consumption and self-perceived mental health

The relationship between cannabis consumption and self-perceived mental health is highly complicated and multifaceted, so we reviewed and categorized the relevant literature according to the following four angles.

2.3.1 | The impact of cannabis consumption on mental health

The conclusions vary based on the duration of the effect on mental health. For immediate reactions to cannabis use, the causal effect of cannabis on acute intoxication and consumption dependency is well-established. Feelings of depression, anxiety, and paranoia are common acute reactions to cannabis (Green et al., 2003; Smith et al., 2022; Zablocki et al., 1991). Problematic cannabis use can lead to cannabis use disorder, clearly a negative impact on consumer mental health (Connor et al., 2022; Patton et al., 2002). However, the long-term effects of cannabis consumption, especially moderate to infrequent use, on consumer mental health are less conclusive. Although most research has tried to establish the causal effect of cannabis on poor mental health using longitudinal data (Thompson et al., 2018), these studies cannot fully control confounding variables, nor eliminate the possibility of an inverse relationship (D'Amico

et al., 2016; Macleod et al., 2004; McGee et al., 2000). Furthermore, the conclusions also vary based on the subjective and objective mental health. The effect of cannabis use as a risk factor and potential trigger for objective mental health like psychosis is more conclusive than its effect on subjective mental health like anxiety and depression (Sideli et al., 2020).

There are mainly four theories explaining why cannabis consumption has a negative impact on consumer mental health. (1) The most widely used explanation is that cannabis is used as a coping mechanism for other problems (e.g., struggles with mental or physical health, academic performance, social problems, etc.), which may cause unexpected mental health issues (Bartholomay et al., 2023; Smith et al., 2022). (2) Regular cannabis use may have negative long-term impacts on the user's neurocognitive function, which would have a negative impact on mental health (Duperrouzel et al., 2020; Kalant, 2004). (3) Consumers may also notice a reduction in the occurrence of positive or euphoric effects after continued use (Green et al., 2003), which results in poor self-perceived mental health. (4) Cannabis withdrawal can mimic mental health symptoms like anxiety and depression. These effects are temporarily mitigated by continuing use, which results in a perpetual cycle where consumption is motivated by poor mental health while simultaneously exacerbating the problem (Lowe et al., 2019).

2.3.2 | The impact of mental health on cannabis consumption

Much research in this field examines how mental health may impact cannabis consumption (Henquet et al., 2005). Consumers with poor mental health are more likely to develop substance use problems, which can then make their mental health problems worse (Green & Ritter, 2000; Lowe et al., 2019; Wallis et al., 2022). The presence of a relationship where negative mental health precedes cannabis use does not necessarily contradict an inverse relationship.

Many studies suggest a causal effect of mental health on cannabis consumption (Hall & Degenhardt, 2009). For example, many longitudinal studies show that at-risk youths are more likely to use substances (D'Amico et al., 2016; Degenhardt et al., 2013; Schiff et al., 2014). Furthermore, some studies suggest that treating affective mental health conditions may lead to a reduction in problematic alcohol and marijuana consumption (Bartholomay et al., 2023). Moreover, managing affective mental health symptoms is commonly given as a motivation for cannabis consumption (Hathaway, 2003; Kosiba et al., 2019; Smith et al., 2022). Those who use cannabis to self-medicate tend to exhibit more positive expectancies for cannabis than those who consume it for purely recreational purposes, another risk factor for problematic usage (Fergusson et al., 2003; Pederson et al., 2014).

There are mainly two theories in this literature explaining the impact of consumer mental health on cannabis use. (1) People with poor mental health are more likely to use substances to cope with their existing mental health symptoms. This is evidenced by the high comorbidity rate between substance use and poor mental health (Bonn-Miller et al., 2010; Degenhardt et al., 2001). Individuals with certain psychotic or mood disorders often exhibit a strong motivation to seek immediate gratification, which can contribute to substance use (Lowe et al., 2019). (2) Self-perceived poor mental health can lead to more cannabis use, due to the expected positive effects of cannabis. There are numerous widely circulated claims regarding the potential effectiveness of cannabis in treating affective mood disorders (Hawes et al., 2020; Soleymanpour et al., 2022). Despite the available evidence often contradicting these claims, individuals' self-reported motivations for consuming cannabis often align with the common beliefs surrounding

its positive effects on anxiety and depression (Hawes et al., 2020; Lowe et al., 2019; Smith et al., 2022). These positive expectancies for cannabis can predict an intention toward later use (Pederson et al., 2014).

2.3.3 | The natural of the relationship between cannabis consumption and mental health

In current cannabis literature, the nature of the relationship between cannabis consumption and mental health is still unclear, with two possible perspectives.

First, some researchers (e.g., Richardson, 2010) argue that they may mutually influence each other, forming a bi-directional relationship akin to a closed loop. Consumers experiencing mental health issues may use cannabis as a form of self-mediation or coping mechanism to alleviate their existing symptoms. Conversely, cannabis use may lead to the development or deterioration of mental health conditions. As a result, cannabis consumption and mental health continuously influence each other, creating a feedback loop.

Second, some researchers (e.g., Lowe et al., 2019) think that they may have a cyclical relationship, where cannabis consumption or mental health conditions initiate negative changes in the other, subsequently influencing the initial factor in return, thus forming a vicious cycle. For example, consumers experiencing mental health symptoms may use cannabis as a coping mechanism, leading to increased consumption. Simultaneously, excessive cannabis use may worsen their mental health conditions or lead to the development of new issues. As mental health deteriorates further, consumers may increasingly rely on cannabis, leading to a downward spiral in both cannabis consumption and mental health.

Both perspectives underscore the complex relationship between cannabis consumption and mental health, highlighting the need for future research to evaluate the relative plausibility of these two perspectives.

2.3.4 | Other factors impacting the relationship between cannabis consumption and mental health

The confounding variables in this relationship have been frequently discussed, such as socioeconomic status, familial relationship dynamics, psychotic disorders, genetics, age, and so on (Degenhardt et al., 2003; Schiff et al., 2014; Thompson et al., 2018). For example, socioeconomic status may impact cannabis use, because low-income communities and communities of color are disproportionately more exposed to substances, like cannabis, while also lacking the resources to moderate and prevent risky consumption (Richter et al., 2023). Simultaneously, the mental health level of these communities is also found to be lower than that of other communities (Gresenz et al., 2001; Keating & Robertson, 2004). Regarding familial relationship dynamics, research shows that adolescents without healthy parental attachments or family relationships are more likely to develop problematic substance use and mental health problems simultaneously (McGee et al., 2000). In addition, regarding psychotic disorder, research shows that people with psychotic disorders usually have poor mental health and are also more likely to use cannabis and other substances (Hamilton, 2017; Østergaard et al., 2017; Sideli et al., 2020). Controlling for these confounding variables can help to more accurately estimate

the association between cannabis consumption and mental health, but not sufficiently increase our understanding of the causal relationship between them.

The instrumental variable approach (Bowden & Turkington, 1984) can be beneficial by addressing the endogeneity issue inherent in examining causal effects using correlational data. For instance, in examining the causal effect of cannabis consumption on mental health and vice versa, identifying and controlling for instrumental variables, that affect cannabis consumption (e.g., friends' cannabis use in Amialchuk & Ali, 2023) or mental health (e.g., genetic variants to schizophrenia in Treur et al., 2021) but are not directly related to the other, can substantially enhance our understanding of the direction and strength of the causal effects. Despite its potential, research adopting this approach is scarce with tentative conclusions in the cannabis literature, indicating a great need for future research.[1]

To sum up, the literature reviewed above generally suggests a negative relationship between consumer mental health and cannabis consumption. In this paper, two types of cannabis consumption behavior are investigated: cannabis use (i.e., whether people used cannabis or at all in their lives) and cannabis use frequency (i.e., how frequently people used cannabis recently). Both types of cannabis consumption behaviors have been widely examined in current literature and have been identified to have a negative association with consumer mental health. However, given that these two types of behaviors pertain to distinct research questions and population groups and yield different implications, two hypotheses were developed as follows.

H1a. Cannabis use (yes/no) and consumer self-perceived mental health have a negative association in the general population.

H1b. Cannabis use frequency and consumer self-perceived mental health have a negative association in the cannabis user sub-population.

2.4 | The effect size between cannabis consumption and self-perceived mental health

The research on the effect size between cannabis consumption and consumer mental health is relatively limited and shows mixed results. (1) The effect size varies for different mental health conditions in question. Research focusing on psychotic disorders (e.g., schizophrenia, shown by Arseneault et al., 2004; Henquet et al., 2005; Semple et al., 2005) shows a medium effect size, while research examining affective mental health conditions like anxiety and depression (Green & Ritter, 2000; Moore et al., 2007; Sideli et al., 2020; Van Laar et al., 2007) shows very small to medium effect sizes. (2) The effect size varies based on how cannabis is used. Earlier use, high-quantity, and high-potency cannabis use are found to be associated with an increased risk of developing mental health conditions like psychotic symptoms, suicide thoughts and attempts, and mania (Cheung et al., 2010; Hamilton, 2017; Moore et al., 2007; Sideli et al., 2020; van Ours et al., 2013). (3) The effect size varies by the age of the sample being examined. Longitudinal studies using adolescents found stronger effect sizes than research using adults (Degenhardt et al., 2013; Thompson et al., 2018). (4) The effect size also depends on the presence of pre-existing mental health conditions. The effect sizes found in people with pre-existing mental health issues are larger in magnitude than those found in the general population (Marshall et al., 2020; Smith et al., 2022).

Research on the effect size between subjective mental health and cannabis consumption remains relatively limited, with a few studies focusing on specific samples. For example, when using self-reported metrics, the effect size magnitude is generally small for moderate cannabis users (Degenhardt et al., 2003; Van Laar et al., 2007; van Ours & Williams, 2012). Some studies noted that positive or negative expectancies could impact the consumers' experience with acute intoxication (de Dois et al., 2010; Pederson et al., 2014), which in turn affects their future consumption patterns (Fergusson et al., 2003). Those who develop more positive acute responses are more likely to engage in heavy cannabis use, which is generally associated with a smaller effect size magnitude in its relationship with mental health (Pederson et al., 2014). Moreover, research indicates that regular cannabis users tend to perceive more positive effects of cannabis use than the objectively measured effects, which may result in an under-estimated effect size (Kosiba et al., 2019; Lowe et al., 2019; Smith et al., 2022). None of this research examines the mean effect size between cannabis use and self-perceived mental health at the population level.

Given the two types of cannabis consumption behavior investigated in this paper and the literature reviewed above, we expect that at the population level, the association (i.e., effect size) between cannabis use (yes/no) and self-perceived mental health is small in magnitude. In the cannabis user sub-population, we expect that the association between cannabis use frequency and mental health for cannabis users is modest. Therefore, we propose the following two hypotheses.

> **H2.** The mean effect size of cannabis use (yes/no) and self-perceived mental health is small in magnitude in the general population.

> **H3.** The mean effect size of cannabis consumption frequency and self-perceived mental health is medium in magnitude in the cannabis user sub-population.

2.5 | Nonlinearity between cannabis consumption and self-perceived mental health

One interesting pattern that can be observed in this literature is that heavy cannabis users are more likely to develop more mental health problems (Hamilton, 2017; Sideli et al., 2020; van Ours et al., 2013), and people with pre-existing mental health conditions tend to engage in more frequent and larger quantity of cannabis use (Marshall et al., 2020; Smith et al., 2022). Furthermore, a particular study (Cheung et al., 2010), focusing on Ontario in Canada, found that compared to nonusers, the risk of anxiety and mood disorder was significantly greater for infrequent cannabis users and heavy cannabis users but not for those in between. Given this literature, the association between cannabis use frequency and consumer mental health may not follow a linear pattern. This leads to the next hypothesis.

> **H4a.** Among cannabis users, the relationship between cannabis consumption frequency and self-perceived mental health is nonlinear.

More specifically, for heavy cannabis users or people with mental health problems, there may be a strong link between their cannabis use frequency and their mental health state. Conversely, for occasional users or people with minor or no mental health issues, there may be a weak or no direct link between their mental health and their cannabis use behavior. When

depicted graphically, when cannabis use becomes more frequent and mental health worsens, the line illustrating the relationship between cannabis use frequency and mental health initially shows a slight negative slope, suggesting a weaker association. However, upon reaching a threshold, the negative slope becomes notably steeper. To test this nonlinear relationship using effect sizes, we expect that initially, the negative mean effect size between cannabis use frequency and mental health is very small in magnitude, when cannabis use is not excessive and consumer mental health is stable. Beyond a threshold in cannabis use frequency or mental health state, the mean effect size magnitude becomes much stronger. Therefore, the next hypothesis is proposed as follows.

> **H4b.** Among cannabis users, when cannabis use becomes more frequent and consumers' self-perceived mental health worsens, the association between use frequency and mental health becomes stronger (i.e., the mean effect size magnitude becomes stronger).

3 | METHODS

In this study, we chose to use secondary datasets from Statistics Canada instead of collecting primary data for the following reasons. First, the sampling method used by Statistic Canada was mostly random sampling (see Table 1). This means that the sample collected is representative of general consumers across Canada. Second, the sample size of each survey by Statistics Canada is generally larger than that of any individual study. Third, there are yearly available datasets by Statistics Canada, although the survey varies yearly, leading to unavailable data on relevant variables for some years. Still, it provides better data than a single cross-sectional study.

Moreover, we chose to use datasets from Statistics Canada instead of meta-analyzing all available academic study results for the following considerations. First, the quality of the data collected by Statistics Canada is generally consistently higher than that of individual studies. The relevant information, such as sampling error, measurement error, and data collection method, may not be available in individual studies, preventing us from correcting the estimated effect size. This may lead to over-estimated or under-estimated effect sizes. Second, almost all existing academic research used nonrandom sampling methods, so the generalizability of the results cannot be compared to the data collected using random sampling methods by Statistics Canada. Lastly, the measures used by Statistics Canada for mental health and cannabis consumption are consistent across surveys over the years, while individual studies use very different measures, leading to incomparable results.

3.1 | Data and sample

The datasets used in this study were selected from the Public Use Microdata Files of national surveys conducted by Statistics Canada. We screened all publicly available datasets from Statistic Canada and identified eight suitable datasets (see Table 1), because those surveys include the focal research variables of this paper (i.e., consumer self-perceived mental health and cannabis consumption).[2]

TABLE 1 Datasets summary and social and demographic characteristics of participants.

Study	Sampling method	Response rate	Sample size	Weighted sample size	Gender (%)		Age (%)			Marital status (%)		Employment status (%)	
					Male	Female	15–44	45–64	>65	Married/ partnered	Single	Working	Not working
Canadian Perspectives Survey Series 6, 2021: Substance Use and Stigma During the Pandemic	Convenient Sampling. A subset of participants from the impacts of COVID-19 crowdsource collection, who agreed to be contacted for additional data collection, were invited[a]	54.4	3,941	31,191,902	49.4	50.6	46.9	31.8	21.3	60.8	39.2	59.5	40.5
Canadian Alcohol and Drugs Survey, 2019	Stratified two-phase random sample	50.7	10,293	30,995,450	49.3	50.7	47.2	31.9	21	67.8	30.2	65.1	34.9
Canadian Tobacco, Alcohol and Drugs Survey, 2017	Two-phase stratified random sample of telephone numbers	70.4	16,349	30,291,071	49.4	50.6	47.3	33.1	19.6	60.8	39.2	62.9	37.1
Canadian Tobacco, Alcohol and Drugs Survey, 2015	Two-phase stratified random sample of telephone numbers	79.0	15,154	29,670,184	49.3	50.7	47.8	33.5	18.7	67.5	32.5	64.4	35.6

(Continues)

TABLE 1 (Continued)

Study	Sampling method	Response rate	Sample size	Weighted sample size	Gender (%)		Age (%)			Marital status (%)		Employment status (%)	
					Male	Female	15–44	45–64	>65	Married/ partnered	Single	Working	Not working
Canadian Tobacco, Alcohol and Drugs Survey, 2013	Two-phase stratified random sample of telephone numbers	81.8	14,565	29,043,884	49.4	50.6	48.5	33.9	17.6	63.2	36.8	63.5	36.5
Canadian Alcohol and Drug Use Monitoring Survey, 2011	Two-stage (telephone household, respondent) random sample stratified by province	45.4	10,076	25,957,435	48.5	51.5	50.1	33.2	16.7	64.9	35.1	61.3	38.7
Canadian Alcohol and Drug Use Monitoring Survey, 2010	Two-stage (telephone household, respondent) random sample stratified by province	42.8	13,615	25,957,436	48.5	51.5	50.1	33.2	16.7	64.1	35.9	60.3	39.7
Canadian Alcohol and Drug Use Monitoring Survey, 2009	Two-stage (telephone household, respondent) random sample stratified by province	44.7	12,703	25,330,718	48.5	51.5	50.1	33.2	16.7	56.9	43.1	62.4	37.6

[a]Although the 2021 survey used a convenient sampling method, however, the inclusion of the personal weight variable supplied by Statistics Canada ensures that the resulting data analysis captures the true characteristics of the population more comprehensively than would be achievable through any individual survey.

3.2 | Focal measures

3.2.1 | Cannabis consumption

We examined two variables related to cannabis consumption. The first variable, *cannabis use* (applying to all survey participants), was whether participants had used cannabis at all in their lives (yes/no). The second variable, *cannabis use frequency (*applying to those who have used cannabis before), was measured as "0: not in the past three months", "1: less than monthly/ once or twice in the past three months", "2:monthly", "3:weekly", and "4:daily or almost daily."

3.2.2 | Mental health

The variable related to *self-perceived mental health* was measured by a question of "In general, how would you say your overall mental health is?" with options: "1:poor", "2:fair", "3:good", "4:very good", and "5:excellent." This single-item measure has proven as reliable and valid as other multiple-item scales (Ahmad et al., 2014; Lundberg & Manderbacka, 1996).

3.2.3 | Control variables

Across all eight datasets, we identified four commonly relevant control variables: gender (male, female), age (15 to 44, 45 to 64, and 65 and older), marital status (married/partnered, single), and the employment status (working, not working). These variables have been recognized and examined as potential confounders in the relationship between cannabis use and various mental health conditions in prior research (Green & Ritter, 2000; Hayatbakhsh et al., 2007; Lev-Ran et al., 2012; McGee et al., 2000; Van Laar et al., 2007).

3.3 | Data analysis procedure

The personal weight provided by Statistics Canada was used for all data analyses (required by Statistics Canada). The personal weight variable is used to adjust sample bias and ensure that the sample data reflects the characteristics of the population. Specifically, the personal weight was directly applied for descriptive analyzes, and the standardized weight calculated from the personal weight was applied for multivariate data analyses.

3.3.1 | Correlation analysis

For the general population, the independent *t*-test was used to measure the association between cannabis use (yes/no) and consumer mental health. For the cannabis user sub-population, the Pearson *R* correlation was calculated to measure the association between cannabis use frequency and mental health.

3.3.2 | Regression analysis

Linear regression was used to validate the association between cannabis consumption and self-perceived mental health by controlling relevant demographic variables. More specifically, mental health was specified as the dependent variable, cannabis consumption (*cannabis use*: yes/no, *cannabis use frequency*) was the independent variable, and gender, age, marital status, and employment status were the control variables. Note that to maintain consistency in effect size conversion, mental health was designated as the dependent variable for the subsequent presentation of results.[3] Moreover, the results are identical when using cannabis consumption as the dependent variable and mental health as the independent variable.

Second, nonlinear regression (i.e., quadratic regression) was used to examine the nonlinear relationship between cannabis use frequency and consumer mental health among cannabis users. Two criteria were used to evaluate whether quadratic regression fits better than linear regression. The first is whether the adjusted R^2 improves, and the second is whether the squared term of the independent variable is statistically significant.

3.3.3 | Meta-analysis

The unit of meta-analysis is an effect size, which is a statistic measure representing the strength of the relationship between two variables in a population. The correlation coefficient, *r*, was used in this study to represent the effect size of the association between cannabis consumption and consumer mental health. More specifically, the *t* values and degrees of freedom (*df*) associated with the independent sample *t*-tests and the estimated coefficients from linear regressions were converted to individual effect sizes (i.e., effect size *r*) by using the following formulas (Borenstein et al., 2009).

$$r = \sqrt{\frac{t^2}{t^2 + df}}. \tag{1}$$

We reported statistics about the effect size in terms of the correlation coefficient, *r*, because this measure has a fixed range (from −1 and 1) and can be interpreted in a similar fashion across applications (Cohen's guideline in 1998: 0.1<: very small; [0.1, 0.2]: small; [0.2, 0.3]: moderate; >0.3: large).

From the individual effect sizes (*r*), the mean effect size ($\overline{R}$) was then calculated as the weighted mean effect size to synthesize effect sizes across multiple datasets, where each effect size was weighted by the sample size. Also, 95% confidence intervals (Higgins & Thompson, 2002) were presented to show estimation precision, assess significance, and compare mean effect sizes. All the computations related to the mean effect size were performed by using MetaExcel (Steel, 2006).

4 | RESULTS

4.1 | Descriptive analysis

The social and demographic profiles of the respondents are presented in Table 1. The weighted sample size, calculated by summing the personal weight assigned to each

respondent in the survey, represented the Canadian population size. Across all eight datasets, females slightly outnumbered males, and there were more married/common-law respondents than single ones. The age distribution reflected the population age changes in Canada, where the percentage of seniors had been increasing, the percentage of people aged between 15 and 44 had been decreasing, and the percentage of middle-aged adults had been stable. The employment status varied from 2009 to 2021, from which we can see the increased unemployment rate due to COVID-19 in 2021. Overall, Table 1 shows that the participants of the eight datasets were representative samples of the Canadian population from 2009 to 2021.

4.2 | The association between cannabis consumption and self-perceived mental health

To test H1, the correlation between cannabis consumption and self-perceived mental health was calculated, and the results are shown in Table 2. For the general population, the t values of the independent sample *t*-tests consistently indicated significantly poorer mental health among cannabis users compared to nonusers, implying a robust negative association between cannabis use and mental health, supporting H1-a. For the cannabis user sub-population, all the Pearson *R* correlation coefficients were negative and statistically significant (except for the 2011 dataset), providing further support for H1-b.

TABLE 2 Mean effect sizes results of the association between cannabis consumption and self-perceived mental health.

	Population						Cannabis users	
Year	Cannabis users' average mental health	*n*	Nonusers' average mental health	*n*	*t*-value	Effect size *r*	*n*	Effect size *r*
2021	2.98	1,153	3.29	2,779	−8.40**	−0.13	1,126	−0.25**
2019	3.65	2127	4.05	8,147	−16.20**	−0.16	1924	−0.14**
2017	3.58	2,378	4.10	13,715	−21.76**	−0.17	3,467	−0.25**
2015	3.94	1,827	4.10	13,117	−7.07**	−0.06	2035	−0.13**
2013	4.05	1,525	4.15	12,859	−4.03**	−0.03	1924	−0.07**
2011	3.82	914	4.20	9,138	−10.10**	−0.10	697	−0.02
2010	3.88	1455	4.15	12,080	−9.89**	−0.09	1,595	−0.15**
2009	3.92	1349	4.15	11,354	−8.25**	−0.07	964	−0.13**
Mean effect size	−0.096; CI: [−0.13, −0.06]						−0.157; CI: [−0.21, −0.11]	

Note. Effect size *r* for population: the correlation between cannabis use (yes/no) and self-perceived mental health, based on independent sample *t*-test. Effect size *r* for cannabis users: the Pearson correlation *r* between cannabis use frequency and self-perceived mental health.

**$p < 0.01$.

4.3 | The effect size between cannabis consumption and self-perceived mental health

The results of effect sizes between cannabis consumption and consumer self-perceived mental health are presented in Table 2, including the individual effect sizes from independent *t*-tests and correlation coefficients, and the mean effect sizes for the general population and the cannabis user sub-population.

For the general population, the individual effect sizes from the eight datasets ranged from −0.17 to −0.03. Furthermore, the mean effect size was −0.096 with a confidence interval of [−0.13, −0.06]. These statistics collectively showed a *very small* mean effect size of the association between whether consumers use cannabis or not and their mental health in the general population. To sum up, contrary to the hypothesized *small* effect size in H2, the mean effect size found was even smaller.

For the cannabis user sub-population, the variation among the individual effect sizes was relatively large, with effect sizes ranging from −0.25 to −0.02. Moreover, the mean effect size was −0.157 with a confidence interval of [−0.21, −0.11]. These statistics suggested a *small* mean effect size between mental health and the cannabis use frequency in the cannabis user sub-population. Contradicting the hypothesized *medium* effect size in H3, the mean effect size observed here was only *small* in magnitude.

To further validate these results, the effect sizes were re-calculated based on regression results, where mental health was specified as the dependent variable, cannabis use behavior was the independent variable, and four relevant variables (i.e., gender, age, marital status, and employment status) were controlled (see Appendix A Table A1). After controlling relevant demographic variables, the mean effect sizes for the general population and the cannabis user sub-population exhibited only marginal variation.

To sum up, the analysis results regarding the effect sizes rejected H2 and H3, because the mean effect sizes within both the general population and the cannabis user sub-population were smaller than hypothesized.

4.4 | Nonlinear relationship between cannabis use frequency and self-perceived mental health for cannabis users

The nonlinear relationship between the two focal variables was examined via a typical approach used in previous literature (e.g., Rodgers et al., 2000). This includes three methods: data visualization, nonlinear regression analysis, and pairwise comparisons among different levels of cannabis use frequency and self-perceived mental health (synthesized by meta-analysis methods across the eight datasets). Furthermore, two analytical perspectives were used to examine the nonlinear relationship. One perspective centered on self-perceived mental health as the focal outcome variable, while the other focused on use frequency as the outcome variable.

4.4.1 | Visualization

To visually examine the potential nonlinear relationship between cannabis use frequency and self-perceived mental health, Figure 1 shows two line charts. The upper one focuses on mental

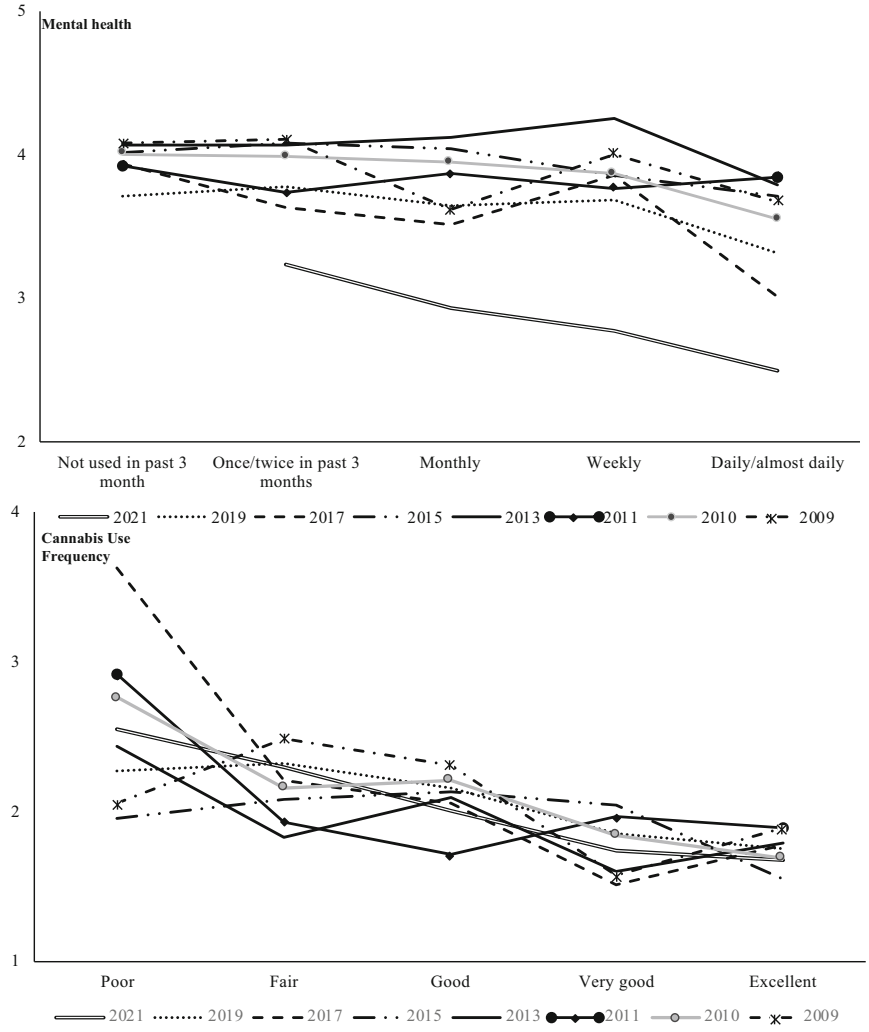

FIGURE 1 Nonlinear relationship between cannabis use frequency and self-perceived mental health for cannabis users.

health (*y*-axis), the bottom one centers on use frequency (*y*-axis), and each line presents data from a specific year.[4]

The top chart in Figure 1, emphasizing mental health, revealed some interesting patterns. (1) The self-perceived mental health of cannabis users showed minimal variance across different levels of usage frequency, ranging from infrequent use (not used in the past 3 months) to moderate use (weekly). (2) A distinct difference in mental health can be observed between individuals who use cannabis on a weekly basis and those who engage in daily usage.

The bottom chart in Figure 1, emphasizing use frequency, also showed some intriguing patterns. (1) Cannabis use frequency did not vary significantly or consistently across mental health levels ranging from fair to excellent. (2) There was a noticeable increase in use frequency when people's mental health deteriorated from fair to poor.

4.4.2 | Nonlinear regression analysis

Various nonlinear relationships (quadratic, cubic, s shape) were examined. For each nonlinear relationship, two regression analyses were conducted: one using mental health as the dependent variable and cannabis use frequency as the independent variable, and the other one vice versa.[5] Only quadratic relationship estimations in some datasets showed some significant improvement over linear relationship estimation. Therefore, the comparison results between linear estimation and quadratic estimations are presented in Table 3.

With the focus on mental health (the top half of Table 3), five out of eight datasets showed the quadratic relationship fitted better than the linear relationship, based on two criteria (i.e., the change in the adjusted R^2 and the significance of the squared term). With the focus on cannabis use frequency (the lower half of Table 3), only three out of eight datasets showed quadratic relationship models fitted better than linear models.

TABLE 3 Results of nonlinear relationship between cannabis use frequency and self-perceived mental health for cannabis users.

DV: mental health						
	Linear estimation		**Quadratic estimation**			
Year	**Cannabis use frequency**	**Adjusted R^2**	**Cannabis use frequency**	**Cannabis use frequency squared**	**Adjusted R^2**	**Summary**
2021	−0.25**	0.059	−0.29	0.04	0.058	Linear
2019	−0.14**	0.019	0.17	−0.32**	0.025	Quadratic
2017	−0.25**	0.061	0.02	−0.28**	0.066	Quadratic
2015	−0.13**	0.015	0.12	−0.25**	0.019	Quadratic
2013	−0.07**	0.004	0.28**	−0.35**	0.013	Quadratic
2011	−0.02	0.000	−0.18	0.17	0.000	No significant relationship
2010	−0.15**	0.022	0.11	−0.27**	0.027	Quadratic
2009	−0.13**	0.016	−0.13	−0.00	0.015	Linear
DV: cannabis use frequency						
Year	**Mental health**	**Adjusted R^2**	**Mental health**	**Mental health squared**	**Adjusted R^2**	**Summary**
2021	−0.25**	0.059	−0.40**	0.16	0.059	Linear
2019	−0.14**	0.019	−0.11	−0.03	0.019	Linear
2017	−0.25**	0.061	−1.11**	0.88**	0.092	Quadratic
2015	−0.13**	0.015	0.43**	−0.56**	0.024	Quadratic
2013	−0.07**	0.004	−0.37*	0.31*	0.005	Quadratic
2011	−0.02	0.000	−0.46	0.45	0.002	No significant relationship
2010	−0.15**	0.022	−0.26	0.11	0.021	Linear
2009	−0.13**	0.016	−0.48*	0.36	0.018	Linear

*$p < 0.05$.**$p < 0.01$.

These results partially supported H4-a regarding the existence of a nonlinear relationship between cannabis use frequency and self-perceived mental health for cannabis users. They also partially supported H4-b concerning the specific shape of the nonlinear relationship. Because of the bounded nature of cannabis use frequency (ranging from 0 to 4) and mental health variables (ranging from 1 to 5), the nonlinear relationship resembles the one side of the U-curve (quadratic relationship) depending on the specification of the data, just like Figure 1.

4.4.3 | Meta-analysis of pairwise comparisons

Both the quadratic regression estimation results and the data visualization suggested the existence of a nonlinear relationship between cannabis use frequency and self-perceived mental health in the cannabis user sub-population. To further validate this nonlinear relationship empirically, a meta-analysis approach was used to synthesize pairwise comparisons among various levels of cannabis use frequency and mental health across the eight national surveys. Specifically, individual effect sizes were calculated to measure the difference in cannabis users' mental health (use frequency) between different frequency levels (mental health levels), and then were synthesized into mean effect sizes.[6] For each mean effect size, the negative sign represented whether more frequent use is associated with worse mental health, and the magnitude of the effect size represented the strength of the negative association. The detailed results are presented in Table 4.

From the mental health perspective (the top half of Table 4), the following interesting result patterns emerged. (1) Consumers' mental health did not differ much between not used and once/twice in the past 3 months ($\overline{R} = -0.043$ with the confidence interval containing zero). (2) Cannabis users with monthly use frequency showed worse mental health than users with once/twice use in the past 3 months, but the effect size was very small ($\overline{R} = -0.055$). (3) Consumers' mental health did not differ much between monthly and weekly use months ($\overline{R} = 0.037$ with the confidence interval containing zero). (4) Notably, cannabis users with daily use showed worse mental health than users with weekly use, with the mean effect size significantly larger in magnitude than other mean effect sizes observed ($\overline{R} = -0.204$, a medium effect size).

From the mental health perspective (the bottom half of Table 4), the following result patterns were noteworthy. (1) Consumers' use frequency showed a gradual increase when their self-perceived mental health decreased from excellent to fair. The differences in their use frequency between fair and good ($\overline{R} = -0.035$) and very good and excellent ($\overline{R} = -0.001$) mental health were very small with the confidence intervals of the mean effect sizes covering zero, but the difference between good and very good is relatively larger ($\overline{R} = -0.129$). (2) Consumers' use frequency increased significantly when their mental health status declined from fair to poor, shown by the mean effect size ($\overline{R} = -0.180$) and its confidence interval not covering zero.

In summary, firstly, the relationship between cannabis use frequency and self-perceived mental health, based on the synthesized results of all eight datasets, followed a nonlinear pattern, supporting H4-a. Moreover, the meta-analysis results showed that the magnitude of the effect size between cannabis use frequency and mental health is initially very small and then increases when cannabis use became more frequent and people's self-perceived mental health worsened, supporting H4-b. Furthermore, the threshold where the negative association between cannabis use frequency and mental health became significantly stronger was identified.

TABLE 4 Meta-analysis results of nonlinear relationship between cannabis use frequency and self-perceived mental health for cannabis users.

Focus variable: mental health								
	Not used vs. 1/2 times in past 3 months		1/2 times in past 3 month vs. monthly		Monthly vs. weekly		Weekly vs. daily	
Year	Effect size r[a]	n	Effect size r[a]	n	Effect size r[a]	n	Effect size r[a]	n
2021	-	-	−0.13	734	−0.08	445	−0.12	392
2019	0.03	929	−0.06	866	0.02	555	−0.18	752
2017	−0.16	1,631	−0.06	1,215	0.18	1015	−0.40	1,388
2015	0.04	950	−0.02	594	−0.10	619	−0.07	857
2013	0.00	938	0.03	724	0.07	592	−0.23	684
2011	−0.19	335	0.05	264	−0.04	227	0.04	281
2010	−0.01	725	−0.02	634	−0.05	557	−0.15	613
2009	0.02	437	−0.23	380	0.18	328	−0.15	380
Mean effect size	−0.043; CI: [−0.11, 0.03]		−0.055; CI: [−0.10, −0.01]		0.037; CI: [−0.04, 0.12]		−0.204; CI: [−0.30, −0.11]	
Focus variable: cannabis use frequency								
	Poor vs. fair		Fair vs. good		Good vs. very good		Very good vs. excellent	
Year	Effect size r[b]	n	Effect size r[b]	n	Effect size r[b]	n	Effect size r[b]	n
2021	−0.09	405	−0.13	639	−0.13	621	−0.03	385
2019	0.01	295	−0.05	749	−0.11	1,188	−0.04	1,124
2017	−0.48	489	−0.05	1,340	−0.19	2182	0.09	1,929
2015	0.03	172	0.02	552	−0.03	1,190	−0.16	1,443
2013	−0.15	120	0.07	505	−0.15	1,031	0.07	1393
2011	−0.31	96	−0.07	236	0.08	367	−0.02	448
2010	−0.18	125	0.01	508	−0.13	955	−0.05	1,048
2009	0.13	86	−0.05	303	−0.25	533	0.11	645
Mean effect size	−0.180; CI: [−0.30, −0.03]		−0.035; CI: [−0.08, 0.01]		−0.129; CI: [−0.18, −0.09]		−0.001; CI: [−0.07, 0.07]	

[a]Effect size r is calculated based on independent sample t-test value, where the average mental health levels between two frequency levels are compared.

[b]Effect size r is calculated based on independent sample t-test value, where the use frequency levels between two mental health levels are compared.

Specifically, when cannabis use was more (less) frequent than weekly and consumers' mental health was worse (better) than fair, there was a (no or weak) significantly negative association between cannabis use frequency and consumer mental health with a small to medium (very small) effect size.

5 | CONCLUSION AND DISCUSSION

Although previous research consistently shows a negative association between cannabis consumption and consumer mental health, the magnitude and linearity of the negative relationship are still inconclusive. This study, using eight national survey datasets in Canada from 2009 to 2021, validated the negative association between cannabis consumption and consumer self-perceived mental health. Moreover, in the general population, the mean effect size between cannabis use (whether people used cannabis or not in their lives) and mental health was very small ($\overline{R} = -0.096$) in magnitude. Among cannabis users, the mean effect size between cannabis use frequency and mental health was small in magnitude ($\overline{R} = -0.157$). These findings can contribute to the existing literature by filling an important knowledge gap regarding the magnitude of the association between cannabis consumption and consumer self-perceived mental health in the general population and in the cannabis user sub-population, and serve as a useful reference for future research.

More importantly, within the cannabis user sub-population, a nonlinear negative relationship between cannabis use frequency and mental health was identified. When cannabis use became more frequent and people's self-perceived mental health worsened, the association between these two variables was initially very small and then became stronger. Furthermore, the threshold where the negative association becomes significantly stronger was pinpointed. Specifically, when cannabis use was more (less) frequent than weekly and consumers' mental health was worse (better) than fair, the strength (i.e., mean effect size) of the association between cannabis use frequency and consumer mental health was small to medium (very small). This finding further adds depth to our understanding of the complex interplay between cannabis consumption and consumer mental health and helps to generate meaningful practical implications.

5.1 | A very small effect size between cannabis use and mental health in the general population

One key finding of this paper is the very small mean effect size between cannabis use (yes/no) and consumer self-perceived mental health, which suggests a weak relationship in the general population. This finding contradicts previous literature that emphasizes the significance of the negative association between cannabis use and mental health.

First, to better understand the very small magnitude of this association, it is crucial to consider the complexity of mental health and cannabis consumption, each influenced by many predictive factors. For example, prior literature has identified various influencing factors on mental health, such as biological, environmental, social, interpersonal, and psychological factors (Parkes, 1990; Sani et al., 2012), and cannabis use is just one of the contributing factors. Similarly, there are many factors influencing one's cannabis consumption behavior, including parenting styles and metacognitions (Brosnan et al., 2020), social influences (Chabrol et al., 2006), and psychological factors (Farris et al., 2016; Hüsler et al., 2005). Among all these factors, consumers' self-perceived mental health may only play a relatively small role.

Second, the interpretation of the very small mean effect size may vary depending on the analytical angle. If interpreted from the causal perspective of mental health's impact on cannabis use, this result suggests that consumers' self-perceived mental health level only has a small influence on their decision to use cannabis or not. However, if interpreted from the inverse

perspective of cannabis use's impact on mental health, this result suggests that the mere use of cannabis, even just once, can negatively impact consumer mental health. Even if the negative impact is to a small extent, this finding at the population level is still alarming and should raise our caution.

Lastly, some researchers (Lowe et al., 2019; Moore et al., 2007) suggest that the effect size between mental health and cannabis use in academic research may be underestimated. The subsequent discussion delves into this possibility in this paper. (1) Individuals may be reluctant to disclose their true state of mental health and real cannabis use behavior in interviews or surveys due to the stigma associated with mental health and cannabis (Corrigan, 2005; Hayward & Bright, 1997; Reid, 2020). However, the eight surveys examined in this paper focus on various types of substance use, and cannabis is only one of them. The chance of underreporting their cannabis consumption behavior, especially after the legalization of cannabis, is slim. (2) Cannabis may bring immediate and temporary relief from mental or physical problems, and self-perceived mental health measure is a subjective evaluation of one's mental health state that may be influenced by the time of the cannabis use (de Dois et al., 2010; Pederson et al., 2014). If people participated in the survey shortly after cannabis use and used cannabis daily, they may report better mental health levels than other participants, resulting in a smaller magnitude of the negative association. However, the percentage of heavy cannabis users in the analyzed datasets is very low, and the time of use before their interview is unknown and can be random, so the chance of under-estimated effect sizes is low. Overall, the effect size results in this paper are less prone to underestimation due to social desirability bias and recall bias.

By considering these complexities, a very small mean effect size between cannabis use and mental health can be better understood within the context of this study and can serve as a useful reference for future research on this topic.

5.2 | A small effect size and nonlinear relationship within cannabis user sub-population

Among cannabis users, the mean effect size between cannabis use frequency and consumer mental health is small in magnitude. This result can also be interpreted from the bi-directional relationship between cannabis use and mental health. Frequent cannabis use can have both long-term consequences like the development or exacerbation of conditions such as depression, psychosis, and substance use disorders (Lowe et al., 2019; Patton et al., 2002; Semple et al., 2005) and short-term consequences like increased anxiety, panic attacks, and impaired cognitive functioning (Green et al., 2003; Kalant, 2004). Poorer mental health can also cause cannabis use in a higher frequency or larger quantity, as a consumer coping mechanism (Kosiba et al., 2019; Wallis et al., 2022). For cannabis users, cannabis use frequency and mental health have a mutual influence on each other, like a closed loop, although the effect size is small in magnitude.

The finding of the nonlinear relationship between cannabis use frequency and mental health contributes to a deeper understanding of this dynamic. The pairwise comparison effect size results identified through meta-analysis methods, which synthesized eight surveys over time, can help better interpret the small mean effect size above. Specifically, this small mean effect is largely driven by the stronger effect size identified among heavy cannabis users and people with bad mental health states. In addition, these results pinpoint the threshold where the association between cannabis use frequency and mental health becomes significantly

stronger. When the cannabis use frequency is higher than weekly and consumers' self-perceived mental health is worse than fair, there is a significantly negative association between cannabis use frequency and consumer mental health with a small to medium effect size. This finding carries meaningful and useful practical implications.

5.3 | Practical implications

Taking all identified results regarding the effect size between cannabis consumption and consumer self-perceived mental health into consideration, one, from a broader perspective, may see another picture. The relationship between cannabis consumption and consumer mental health resembles a cyclic relationship. At the population level, the association between cannabis use and mental health appears weak. This finding is in line with the public policy direction regarding cannabis legalization in many countries (Newman et al., 2021). However, delving into the cannabis user sub-population, a clearer pattern emerges, the negative association gathering strength as we delve deeper into each layer. For those with low cannabis use frequency and stable mental health, the association remains weak, potentially reducing consumers' caution and evoking interest in cannabis. However, among frequent cannabis users and those struggling with mental health issues, a pronounced link between cannabis use frequency and mental health status manifests. After people start to use cannabis and gradually increase their consumption frequency, their mental health level deteriorates. To cope with this, these consumers may self-medicate more cannabis. Eventually, consumers may find themselves trapped in a vicious cycle, struggling to break free, regardless of the initiating factor, whether cannabis use is out of curiosity or a temporary coping method for stress or anxiety. Even so, future research is still needed to empirically examine and validate this possible cyclic relationship.

Our study can yield important implications for many societal stakeholders, including consumers, marketers, governments, social services designers and providers, and so on. First, consumer groups, relevant nonprofit organizations, and the government at all jurisdiction levels can utilize the research findings of this paper to educate consumers about the complicated relationship between cannabis consumption behavior and mental health. Promoting awareness and education (Lupton, 1994) via social marketing and communication (Hastings & Haywood, 1991) is the first step to support informed consumer decision-making about cannabis, especially in regions where cannabis has been legalized. Second, specific health promotion campaigns can also be carried out to target cannabis users to ensure that they understand the potential consequences of frequent cannabis consumption, thereby further preventing them from entering a potentially escalating vicious cycle. Third, relevant social services should focus on developing effective prevention, intervention, and support strategies for vulnerable sub-populations. For instance, for frequent cannabis users and people with mental health conditions, designing and providing proper education and guidance regarding cannabis use, and mental health support and services may prevent them from entering a potentially vicious cycle, help those in this cycle break free, and build and maintain better mental well-being in the long run.

5.4 | Limitation and future research

Some limitations regarding the findings in this paper need to be acknowledged. First, since the consumer mental health measure used in this study was a subjective and self-reported measure,

it is important to acknowledge various response biases of this measurement approach, such as social desirability and recall bias (discussed in last section), confirmation bias and common method bias. Second, the use of single-item measures for mental health may lack the depth and width provided by comprehensive multi-item scales, limiting the ability to capture the full spectrum of mental health experiences. Third, the datasets utilized in this study are sourced from Canada, thereby potentially limiting the generalizability of identified findings. Nonetheless, since Canada is one of the first countries to legalize cannabis, the insights gained from this context can serve as valuable references for other countries considering cannabis legalization.

Investigating the causal relationship between cannabis consumption and mental health remains as a major research challenge. Ethical considerations prevent the direct manipulation of these variables on human subjects. Longitudinal studies offer some insights into the temporal order of the direction of the effect, but implementing randomization is extremely difficult, making it challenging to control for confounding variables. Nevertheless, further research can explore the instrumental variable approach discussed in the literature review. Specifically, for investigating the causal effect of cannabis consumption on mental health, potential instrumental variables include the cannabis use behavior of their peers (Amialchuk & Ali, 2023), consumers' genetic predisposition to drug use, proximity to cannabis dispensaries, and family attitudes toward cannabis. Similarly, to examine the causal effect of mental health on cannabis consumption, potential instrumental variables include consumers' genetic predisposition to and family history of mental health conditions (Treur et al., 2021), availability of mental health care, social and family support, and stigma related to mental health. Given the restrictive conditions of the typical instrumental variable approach, future research could employ the generalized instrumental variable approach (Brito & Pearl, 2012), which imposes less restrict conditions. This approach allows for the exploration of a broader range of instrumental variables, potentially enhancing our understanding of the causal effects between cannabis use and mental health. Moreover, further research can also delve into examining the underlying mechanisms of this relationship and exploring relevant moderators. These future research directions can not only enhance the understanding of the causal relationship between these two focal variables, but also help develop and implement appropriate interventions and support systems for individuals at risk.

An intriguing empirical research direction involves examining whether the effect size between mental health and cannabis consumption changes (increases or decreases) after the legalization of cannabis, when more recent data become available. Canada, being one of the first countries to legalize cannabis with the passing of the 2018 Cannabis Act, presents a suitable context for this research question. The answer to this inquiry could provide valuable guidelines for future regulatory decisions on whether the government should loosen or tighten regulations pertaining to cannabis based on the observed effects.

Continuous future research efforts are still in great need to increase our understanding of the complex relationship between consumer mental health and cannabis consumption, inform public policy decisions, and develop effective strategies to promote public health and consumer well-being.

AUTHOR CONTRIBUTIONS

Qian (Claire) Deng: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; validation; visualization; writing – original draft. **Lun Li:** Data curation; formal analysis; investigation; methodology; validation.

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ENDNOTES

[1] This is further discussed in the future research section of this paper.

[2] Please refer to Online Appendix A: Dataset identification process for detailed information about how we selected the eight datasets for this study.

[3] Using the continuous mental health variable as the dependent variable allows for the use of linear regression to examine its associations with various types of cannabis consumption behavior for different population groups, simplifying the effect size conversation. Since cannabis use (yes/no) is binary and cannabis use frequency is continuous, separate regression methods are necessary: logistic regression for cannabis use and linear regression for cannabis use frequency. This requires different conversion formulas to calculate effect sizes from estimates of logistic regression and estimates of linear regression.

[4] The data used to generate the line charts are presented in Appendix B Table B1.

[5] We opted not to include control variables in the analyses for simplicity, given that the linear regression analyses in Section 4.3 show the four control variables did not significantly change the results.

[6] The descriptive results for the pairwise comparisons are presented in Appendix B.

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APPENDIX A: THE RESULTS OF MEAN EFFECT SIZES WITH CONTROL VARIABLES

TABLE A1 Mean effect sizes results with control variables.

Model 1: population; DV: mental health								
			Age		Gender	Marital Status	Employment Status	
Year	Cannabis use (yes/no)	Effect size	15–44	45–65	Female	Married/ common law	Working	*n*
2021	−0.11**	−0.11	−0.31**	−0.16**	−0.10**	−0.02	−0.09**	3,831
2019	−0.14**	−0.14	−0.14**	−0.10**	−0.06**	−0.12**	−0.11**	9,611
2017	−0.20**	−0.18	−0.01	−0.03*	−0.03**	−0.07**	−0.13**	16,013
2015	−0.08**	−0.07	0.04**	0.00	−0.01	−0.07**	−0.11**	14,813
2013	−0.06**	−0.05	0.10**	−0.01	0.01	−0.04**	−0.08**	14,245
2011	−0.13**	−0.13	0.07**	0.00	−0.02	−0.07**	−0.09**	9,920
2010	−0.10**	−0.10	0.00	0.05**	0.01	−0.02*	−0.12**	13,368
2009	−0.09**	−0.09	0.06**	−0.03	0.02*	−0.05**	−0.09**	12,703
Mean Effect size	−0.107; CI: [−0.14, −0.08]							
Model 2: cannabis users; DV: mental health								
			Age		Gender	Marital Status	Employment Status	
Year	Cannabis use frequency	Effect size	15–44	45–65	Female	Married/ common law	Working	*n*
2021	−0.23**	−0.24	−0.40**	−0.22**	−0.16**	0.03	−0.14**	1,095
2019	−0.15**	−0.15	−0.37**	−0.23**	−0.12**	−0.06**	−0.21**	1,710
2017	−0.22**	−0.23	−0.09*	0.03	−0.20**	0.00	−0.22**	3,454
2015	−0.12**	−0.12	0.02	0.04	−0.05*	−0.09**	−0.10**	2,014
2013	−0.06**	−0.06	−0.04	−0.14	−0.08**	−0.12**	−0.14**	1,904
2011	−0.03	−0.03	−0.19	−0.27	−0.03	−0.01	−0.21**	693
2010	−0.15**	−0.15	−0.08	−0.13	−0.05	−0.07**	−0.07*	1,580
2009	−0.13**	−0.13	−0.22	−0.29*	0.01	−0.02	−0.16**	964
Mean effect size	−0.153; CI: [−0.20, −0.11]							

Note: Model 1: mental health = cannabis use (yes/no) + age + gender + marital status + employment status; Model 2: mental health = cannabis use frequency + age + gender + marital status + employment status.
*$p < 0.05$.**$p < 0.01$.

APPENDIX B: DESCRIPTIVE RESULTS FOR PAIRWISE COMPARISONS

TABLE B1 Descriptive analyses of pairwise comparisons.

Focus variable: mental health														
	Not used in the past 3 months			Once/twice in past 3 months			Monthly			Weekly			Daily or almost daily		
Year	*n*	M	SD	*n*	M	SD	*n*	M	SD	*n*	M	SD	*n*	M	SD
2021	-	-	-	517	3.24	1.09	217	2.94	1.02	228	2.77	1.09	164	2.50	1.09
2019	305	3.72	0.98	624	3.78	1.05	242	3.65	1.06	313	3.69	0.96	439	3.32	1.09
2017	863	3.94	0.91	768	3.64	0.92	447	3.52	0.91	568	3.86	0.96	820	3.01	1.36
2015	584	4.02	1.05	366	4.09	0.9	228	4.05	0.86	391	3.86	0.95	466	3.72	1.01
2013	516	4.07	0.91	422	4.07	0.93	302	4.12	0.98	290	4.26	0.91	394	3.79	1.05
2011	152	3.93	1.03	183	3.74	1.01	81	3.87	1.14	146	3.77	1.19	135	3.85	1.09
2010	347	4.01	0.95	378	3.99	1.01	256	3.95	0.89	301	3.87	0.88	312	3.55	1.17
2009	204	4.08	0.91	233	4.11	0.89	147	3.62	1.11	181	4.01	1.02	199	3.68	1.09
Focus variable: cannabis use frequency															
	Poor			Fair			Good			Very good			Excellent		
Year	*n*	M	SD	*n*	M	SD	*n*	M	SD	*n*	M	SD	*n*	M	SD
2021	101	2.55	1.18	304	2.30	1.17	335	2.01	1.07	286	1.74	0.98	99	1.67	1.03
2019	50	2.27	1.54	245	2.32	1.46	504	2.16	1.49	684	1.85	1.38	440	1.75	1.33
2017	197	3.62	1.06	292	2.21	1.54	1,048	2.06	1.41	1,134	1.51	1.45	795	1.77	1.53
2015	40	1.95	1.83	132	2.08	1.65	420	2.13	1.57	770	2.04	1.52	673	1.55	1.50
2013	27	2.44	1.76	93	1.83	1.41	412	2.09	1.59	619	1.60	1.47	774	1.79	1.42
2011	14	2.91	1.03	82	1.93	1.34	154	1.71	1.52	213	1.96	1.40	235	1.89	1.50
2010	38	2.76	1.57	87	2.16	1.51	421	2.21	1.49	534	1.84	1.35	514	1.69	1.42
2009	16	2.05	1.34	70	2.49	1.45	233	2.31	1.40	300	1.57	1.40	345	1.89	1.44

Abbreviations: M, mean; SD, standard deviation.