Are Youth Differentially Impacted by Cannabis Advertising? An Ecological Momentary Assessment of Demographic and Psychosis Risk Factors in a Canadian Post-legalization Context

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Abstract

The Canadian government's efforts to prevent cannabis use among youth are warranted, as early cannabis use greatly increases risk of harm. Although it is illegal, cannabis companies continue to advertise their products to youth, potentially influencing cannabis expectancies and use intentions. Some youth groups may be more susceptible to advertising based on demographic risk factors (urbanicity, gender, ethnicity, age) and psychosis risk. Ecological Momentary Assessment (EMA) enables youth to track a range of phenomena, *in vivo*. Using EMA, this research describes: How cannabis advertising is reaching youth, how such exposures may impact cannabis expectancies and use intentions, and whether at risk (demographics, psychosis risk) youth groups are differentially impacted by cannabis advertising exposures. Over a nine-day EMA protocol, 120 youth aged 14-18 completed demographic and psychosis-risk questionnaires, captured cannabis advertising exposures, and rated their reactions (expectancies and use intentions) to exposure(s) and during two daily randomly issued (control) prompts. Altogether, most ($n = 85$; 70.83%; range 1-30) youth reported being exposed to cannabis advertisements through various channels. Using multilevel models, this study also found that advertisement exposure increased cannabis use intentions, while it did not increase cannabis expectancies. Interaction effects for all demographic predictors and psychosis risk on expectancies and use intentions were also nonsignificant. As the expectancy measure used may not have captured cannabis-related constructs affected by advertising exposure(s), a comprehensive measure tailored to youth is needed. Future research involving a more representative, diverse sample would also enable researchers to determine whether moderating effects of demographic factors and psychosis risk exist. Given the general effect of advertising exposure(s) on use intentions, this study underscores the incompatibilities in regulation and enforcement of cannabis advertising, particularly with the proliferation of retailers and a shift toward digital advertising. These findings also call for additional or enhanced prohibitions on cannabis promotion to protect youth from harms associated with increased advertisement exposure.

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Thesis Overview

Although Canada recently legalized cannabis for adult recreational use (Government of Canada, 2018), the Canadian government has taken several steps to prevent or delay cannabis use among youth. Such actions are warranted, as youth cannabis use is associated with increased risk of harms such as persistent psychosis, impaired functioning, and cannabis-related morbidity in later life (Duperrouzel et al., 2020; Levine et al., 2017; Morin et al., 2019). One such action intended to protect youth is prohibiting cannabis companies from advertising directly to youth (Government of Canada, 2018). Based on the actions of tobacco and alcohol companies with similar prohibitions (e.g., Bond et al., 2010; Sargent et al., 2020; Trangenstein et al., 2019) and new research from our group (Noël et al., 2021), we expect that advertisers will disregard these prohibitions and target youth regardless, thereby influencing their cannabis attitudes, beliefs, and use intentions (D'Amico et al., 2018; Rup et al., 2020) and ultimately cannabis use.

Some youth groups may be particularly susceptible to cannabis advertising based on social and environmental vulnerabilities (Lake et al., 2020) such as younger youth living in ethnically diverse and socioeconomically disadvantaged neighbourhoods (Krueger et al., 2021; Rup et al., 2020; Shih et al., 2019). Moreover, youth with mental health concerns are known advertising targets for tobacco companies (De Hay et al., 2012) and may thus also be targeted by cannabis companies. Youth at risk of psychosis, with cognitive impairments in interpreting information, decision-making, and considering potential risks and rewards of an activity (MacKenzie et al., 2017), may be particularly susceptible to pro-cannabis messages, increasing the likelihood of risky cannabis use and adverse outcomes (Lake et al., 2020).

Advertising prohibitions imposed by the Canadian government may help reduce underaged cannabis consumption, but to our knowledge, none of the extant research describing cannabis advertising impacts has been conducted in cannabis-legal environments, nor in Canada. In other words, no empirical information about whether, how, and to what extent cannabis companies are targeting advertising to youth is available in the current Canadian regulatory landscape. Thus, the purpose of my thesis research is to describe if and how exposures to cannabis advertising – as they occur in real time and real-world situations – influence youth cannabis use risk in Canada's post-legalization context. In particular, I seek to explore if individual psychosis risk and demographic (i.e., urban vs. rural residence, age, gender, ethnicity) vulnerabilities differentially predict cannabis expectancies and use intentions following advertising exposures. Findings that illustrate between-group differences in youth exposure and response to cannabis advertising can help alert policymakers to the need for policy enforcement and additional preventive actions to equitably protect all youth.

Literature review

My thesis proposal begins with a brief literature review of the circumstances leading to cannabis legalization for recreational use in Canada and parallel restrictions, laws and measures put in place to protect the public from cannabis-related harm. Next, I discuss the possible impacts of illegal cannabis advertising on youth cannabis expectancies, use intentions, and use, followed by a discussion of youth who may be targeted by cannabis companies and are more vulnerable to cannabis advertising impacts based on demographic, and psychosis risk. Subsequently, I will discuss current evidence for cannabis advertising-related impacts and associated methodological limitations. Lastly, I will discuss how Ecological Momentary Assessment (EMA) may be used to overcome these methodological limitations to create information about the frequency, type, and possible differential impacts of youth cannabis advertising exposures of value to policymakers,

public health, and communities. Although the definition of youth varies considerably in the literature, the term "youth" generally refers to those in the stage of life from adolescence to adulthood (Canadian Heritage, 2021). In line with the government of Canada (Canadian Heritage, 2021), throughout this document, we define "youth" as young people between the ages of 14-29.

History of Recreational Cannabis Use in Canada and Beyond

Over the past century, recreational cannabis use has led to criminal penalties and generated societal strain between those who use cannabis recreationally and the authorities enforcing cannabis-restricting laws (Cox, 2018). Despite being used for thousands of years, and some governments granting exemptions for medical use, cannabis remains illegal in many countries around the world (Bewley-Taylor et al., 2020). Prior to its legalization in Canada, nearly half of Canadians reported using cannabis in their lifetime (Health Canada, 2018a). This shows a disconnect between law and societal practices related to cannabis use and a need for regulatory changes that take the wants and needs of Canadians of all ages into account.

Canada's Tangled Medical and Quasi-medical Cannabis Framework

Medical cannabis use was first legalized in Canada in 2001, in accordance with claims stating that existing prohibitory laws deprived Canadians of their constitutional right to make decisions related to their health and how its managed (Leung, 2011; *R v. Parker*, 2000). The *Marihuana Medical Access Regulations* (2001) laid the federal regulatory framework enabling medical cannabis users to be exempted from criminal penalties for the possession of cannabis. Following legalization, several Canadians were granted access to medical cannabis, and this number exponentially increased over time from 37,800 in 2013 to over 200,000 in 2017 (Health Canada, 2019). Further regulatory changes in medical cannabis access introduced in 2014 minimized the government's role in regulating cannabis, placing the responsibility on physicians to determine and grant access to cannabis and leaving pricing schemes and distribution up to the

private industry (Cox, 2018). A substantial increase in Canadians seeking access to legal forms of cannabis allowed for the proliferation of quasi-recreational cannabis use, with inconsistent provincial approaches to dealing with grey areas of cannabis businesses (Cox, 2018; Government of Canada, 2018; Hayward, 2017).

In recognition that a prohibitory approach to cannabis had been unsuccessful, and with accumulating evidence supporting a reduced risk for harm associated with adult recreational cannabis use, the Canadian government first committed to legalizing cannabis in 2015 to allow for the *recreational* consumption and possession of cannabis (Cox, 2018). Because of public misconceptions related to the safety and legality of cannabis, unregulated cannabis market development and consequent inconsistent police intervention, a cannabis legalization Task Force was created in 2016 to engage the public and formulate a framework to regulate manufacturing, distribution, sale and marketing of recreational cannabis across Canada, alongside established medical exemptions. In line with the Task Force's foundational framework, the recreational use of cannabis was legalized in Canada on June 19, 2018, under Bill C-45 (An Act respecting cannabis and to amend the Controlled Drugs and Substances Act, the Criminal Code and other Acts, 2018; Crépault, 2018; Department of Justice, 2018).

Shift in Cannabis Policy and Regulatory Changes

The shift to legalize and regulate adult recreational cannabis constitutes a fundamental policy change, and a landmark reform internationally, with Canada being the only G-20 nation to legalize recreational cannabis at the federal level and the second nation to do so, following Uruguay (Cerdá & Kilmer, 2017; Government of Canada, 2016; Pardo, 2014). In removing criminal penalties for cannabis consumption and enforcing a regulatory framework, the Canadian government aimed to shift federal focus and central policy on harm minimization, restriction of youth access to cannabis, public education, and the maintenance of public health and safety

(Government of Canada, 2018). Moreover, this shift in policy aimed to align public health and community safety with public opinion and actual societal usage of cannabis (Cox, 2018).

Rationale for Minimum Age Restrictions: Developmental Impacts and Functional Impairments Associated with Early Cannabis Use

Prior to, and following legalization in Canada, protecting youth from potential harms associated with cannabis use has been regularly employed as a rationale against legalization (Haines-Saah & Fischer, 2021). While cannabis use initiation often occurs during adolescence and heaviest use occurs in the late teens to early twenties (Chen & Kandel, 1995; Leos-Toro et al., 2019), recent evidence demonstrates that cannabis use prior to age 25 may irreversibly alter brain development (Haines-Saah & Fischer, 2021; Kelsall, 2017). More specifically, research over the past two decades has shown that the human brain continues to develop and mature into an individual's early 20s and that exposure to cannabis before this time may have greater adverse effects among youth as compared to adults with brains that are fully developed (Giedd et al., 1999; Lenroot & Giedd, 2006).

Delta-9-tetrahydrocannabinol (delta-9-THC; hereafter, "THC"), a main chemical responsible for the perceptual and emotional changes from cannabis use, stimulates the cannabinoid receptors modulating the secretion of gamma-aminobutyric acid and glutamate within the central nervous system, two neurotransmitters incurring important neurodevelopmental effects on the brain (Hurd et al., 2014). During early critical neurodevelopmental periods, the frontal cortex, responsible for higher-order cognitive processes including executive functioning, is also undergoing rapid change and is thus more susceptible to the effects of THC (Anderson et al., 2001; Blakemore, 2013; George & Vaccarino, 2015). The endocannabinoid system involved in the maturation of cortical neuronal networks through dopamine modulation is concurrently affected; as exogenous THC enters the body, exogenous THC competes more effectively for cannabis receptors than endogenous cannabinoids and receptors become 'flooded' with the exogenous THC, resulting in decreased

receptor system effectiveness and toxic changes to neurons that are involved (Bossong & Niesink, 2010). Available neurocognitive research also demonstrates that youth who regularly use cannabis must compensate for altered brain integrity when performing tasks (Jager et al., 2010) and that such individuals have lower brain volumes, different folding patterns and thinning of the cortex, decreased neural connectivity, and less integrity of white matter, indicating damage from THC (Lisdahl et al., 2014).

Health Canada, a federal institution responsible for reducing health risks, has warned the public and healthcare professionals that youth cannabis use risks are both time- and dose-dependent (Health Canada, 2018b; 2018c). Earlier and more frequent cannabis use poses a greater risk of harm to the developing brain (Fischer et al., 2017; George & Vaccarino, 2015; Levine et al., 2017) and may lead to various adverse outcomes, including impaired neurocognitive functioning and affect regulation, suicidality, cannabis dependence syndrome, psychosis, and cannabis-related morbidity in later life (Duperrouzel et al., 2020; Levine et al., 2017; Morin et al., 2019). Importantly, cannabis that is available today has two to four times higher THC content than cannabis products that were typically available 40 years ago, and the increased THC content of cannabis similarly increases cannabis-related impacts on youth (Cascini et al., 2012; Fischer et al., 2017; George & Vaccarino, 2015; Levine et al., 2017).

Concerns related to greater risks for adverse events due to cannabis exposure during early critical periods of development have resulted in advocacy campaigns recommending against early cannabis use among all youth (Grant & Bélanger, 2017). Moreover, reducing risks associated with cannabis exposure among youth is a high priority of the Canadian government and Canadians at large (Watson & Erickson, 2019). Indeed, the overall burden of illness on society stemming from youth incurring acute (e.g., injury) or long-term (e.g., cannabis use dependence, lower educational attainment) problems from cannabis use is markedly higher than if these issues occur among adults,

because youth will require subsequent services and supports for more extended periods of time (Degenhardt et al., 2013).

Numerous Canadian groups highlight the potentially harmful impacts of cannabis legalization on youth (Fischer et al., 2017; Tibbo et al., 2018; Windle et al., 2019). For instance, both the Canadian Psychiatric Association's position statement on cannabis legalization and Canada's lower-risk cannabis use guidelines emphasize the potential impacts of early cannabis use on youth brain maturation (Fischer et al., 2017; Tibbo et al., 2018). Specifically, these documents highlight the impacts of high-frequency cannabis use on cognitive function, depression, and psychosis risk, and thus recommend against early initiation (Fischer et al., 2017; Tibbo et al., 2018). Taken together, public health-oriented substance policy strategies (see *Cannabis Control Act*, 2017) to prevent or reduce underaged cannabis use are warranted, as they have the potential to mitigate the substantive and well-documented harms related to early, frequent, and high-potency cannabis use (Carliner et al., 2017).

Policy Design and Implementation Considerations (Minimum Age and Market Creation)

The impact of cannabis legalization on youth cannabis use is influenced by specific federal and provincial policy measures regulating the legal cannabis market (Hammond et al., 2020). In light of global health policy discourse related to advertising of recreational drugs such as tobacco and cannabis over the past decade (Sheikhan et al., 2021) and the finding that increased promotion through advertisements may increase the prevalence of cannabis dependence, along with other harms to regular cannabis use (Fischer et al., 2017), strict federal regulations prohibiting marketing, branding and promotions to youth are outlined in Canada's federal policy framework. These regulations have the explicit purpose of "protect[ing] public health and public safety, including ... the health of young persons by restricting their access to cannabis, protecting young persons and others from inducements to use cannabis, and enhancing public awareness of the health risks associated with cannabis use." (An Act respecting cannabis and to amend the Controlled Drugs and

Substances Act, the Criminal Code and other Acts, 2018). Specific Canadian regulations imposed

by the Canadian government following legalization for recreational use include prohibitions against

promoting price, presenting misinformation, marketing including persons or animals, and

promotions that may be viewed by youth (Bill C-45, Promotion). In particular, the federal *Cannabis*

Act prohibits any form of lifestyle advertising or promotion that may appeal to youth under the age

of 18 years old (Bill C-45, Promotion). This includes restrictions on brand imagery on cannabis

packaging, most forms of traditional advertising (e.g., TV and print), and promotion through

sponsorships including references to cannabis brand elements, creating an image about the lifestyle

of cannabis users, using a person, character or animal in advertisements, and the discussion of

product price (Bill C-45, Promotion).

  In contrast, not all cannabis policies are solely motivated by the need to protect the public

from the adverse health risks associated with early frequent cannabis use. Multiple influences,

including considerations around efficient enforcement and pressure from lobbyists, also contribute

to establishing Canadian policies and regulations. For example, provincial and municipal

regulations on retail access and public consumption dictate minimum age requirements for

purchasing cannabis, however, none are at or above the minimum age of 21 recommended by the

Canadian Medical Association (Kelsall, 2017), and are instead harmonized with alcohol minimum

age requirements already in-place within individual provinces and territories. This multistakeholder

approach to policy and regulation purports to provide access to a safer and regulated supply while

avoiding social costs related to interactions with illicit markets and youth criminalization due to

drug possession (Haines-Saah & Fischer, 2021) but instead has resulted in lowered minimum age

requirements for cannabis sale and consumption, putting more youth at risk. In Ontario,

specifically, in accordance with the provincial drinking age, cannabis use, limited possession, and

distribution are legal for youth aged 19 and older (Cannabis Control Act, 2017) and under the

Canadian Cannabis Act, sale of cannabis to youth under 19 years of age is punishable by up to 14 years in prison (Department of Justice, 2019).

Underage Cannabis Use Rates Pre and Post Recreational Legalization

Despite policies to restrict youth cannabis use, youth cannabis use in Canada remains prevalent (Grant & Bélanger, 2017; Hurd et al., 2014). Almost a quarter of Canadian youth report using cannabis in the past year, while some 40% report past-year use by grade 12 (Boak et al., 2017; Wiens et al., 2020). Moreover, out of 40 countries surveyed, Canadian youth rank second highest for past-month cannabis use (World Health Organization, 2014). At the same time, concerns related to increases in prevalence and frequency of youth cannabis use in Canada are growing as cannabis use becomes more socially acceptable, the price of cannabis falls, its access increases, and attractive cannabis products are increasingly developed and illegally advertised to youth (Hall et al., 2020; Hopfer, 2014).

How does this compare to other jurisdictions in which recreational cannabis use was legalized? The evidence is mixed. Early evidence from the first states to legalize cannabis use suggests little or no impact on cannabis prevalence among youth, despite some evidence of the increased frequency of use among youth who already use cannabis (Smart & Pacula, 2019). Beyond prevalence of use, however, availability and access to cannabis have increased (Carliner et al., 2017), risk perception associated with cannabis use has decreased, cannabis-related driving incidents have increased (Couper & Peterson, 2014; Reed, 2018), and adverse outcomes due to over-consumption (e.g., unintentional ingestion of edible products) have increased following legalization in U.S. states (Cao et al., 2016; Wang et al., 2016).

To date, there is limited data from Canada related to the impacts of recreational cannabis legalization (Fischer et al., 2020; Hawke & Henderson, 2021). The Ontario Student Drug Use Survey demonstrates that the prevalence of cannabis use has remained stable among students before

and after legalization (Boak et al., 2020). Meanwhile, 14% of surveyed Canadian high school students have stated that they perceived that their friends had been using cannabis more often following legalization, as compared to only 1.3% who believed their friends were using it less often (Boak et al., 2020). Although information related to the impacts of legalization is scarce, survey findings demonstrating that use among youth has remained prevalent may suggest that the Cannabis Act is failing, at least initially, to meet its objective to "restrict youth access to cannabis" (Health Canada, 2018b).

Possible Cannabis Advertising Impacts on Youth Expectancies, Use Intentions and Actual Use

As mentioned above, prohibitive advertising laws enhanced by the Canadian government following the legalization of cannabis are warranted, especially among youth. Advertising is defined as "the use of media to create positive product imagery or positive product associations or to connect the product with desirable personality traits, activities or outcomes. Promotion, also called marketing, can be defined as "the mix of all activities which are designed to increase sales" (Saffer, 2000). Research in other consumer markets (e.g., alcohol, tobacco) has demonstrated that policy measures (i.e., appealing to youth through packaging or advertising, and the restriction of sale and direct advertisement of tobacco and alcohol to youth) related to such advertising have direct impacts on social norms, risk perception, substance use, and prevalence (Hall & Kozlowski, 2018; Pacula et al., 2014; Sheikhan et al., 2021), especially among youth (World Health Organization, 2013). Moreover, a growing body of research demonstrates that affective-cognitive factors, including substance-related expectancies, are related to substance use and use intentions (e.g., Aiken et al., 2018; Fleming et al., 2004; Gentile et al., 2019; Roberts et al., 2019; Scharf et al., 2013).

Expectancies and Behavioural Intentions: Constructs and Theories Underlying Substance Use

Behaviours

Expectancies (i.e., expected social and personal consequences; Bandura, 1977) and use

intentions (i.e., the likelihood of engaging in future substance use) are interrelated constructs

identified in psychological research as some of the most proximal predictors of subsequent

substance use. Below, I describe two constructs, expectancies and behavioural intentions, that play

a central role in well-supported theories underlying substance use behaviours.

Expectancy Theory and Cannabis Expectancies, Intentions and Use

Expectancy theory is a long-standing psychological theory (James, 2007; Tolman, 1949)

derived from a social learning basis that combines principles of learning established through

research on observed behaviour with constructs based on cognitive processes that are not directly

observable (White et al., 1990). This theory proposes that behaviour is associated with individuals'

expectations of specific reinforcing effects as the outcome of performing the behaviour in question

(Jones et al., 2001). Outcomes of performing the behaviour in question include positive and

negative emotions that may influence the future likelihood of engaging in said behaviour (Bandura,

1977).

Expectancy theory is primarily applied in the explanation of substance use behaviours,

including alcohol, tobacco, and cannabis use (e.g., Buckner & Schmidt, 2008; Cohen et al., 2002;

Morean et al., 2012), as well as disordered eating, including symptoms of anorexia and bulimia

nervosa (Culbert et al., 2015; Pearson et al., 2014). In line with other substance-use behaviour-

related research, cannabis expectancies, especially those related to positive effects of cannabis use,

are found to be strongly and consistently associated with cannabis use and failure to quit using

cannabis (Boden et al., 2013; Patrick et al., 2011).

Indeed, while positive and negative outcome expectancies have both been associated with frequency and quantity of cannabis use and dependence criteria, positive expectancies generally have larger, more immediate effects on use intentions and actual cannabis use (Altman et al., 2019; Anthenien et al., 2021). This is because the negative effects of cannabis use may not be immediately experienced, and discomfort associated to cannabis use (e.g., anxiety, irritability, low mood) may only become evident once the drug's effects start to wear off (O' Donnell et al., 2021). This delay can weaken the association between drug use and negative expectancies, making them less salient in an individual's mind compared to the immediate positive effects (e.g., feeling high, relaxed, having fun) of using cannabis and associated positive expectancies (O' Donnell et al., 2021).

Social Norms, Cannabis Expectancies, Intentions and Use

Other theorists have shifted their attention away from substance-specific beliefs among youth to the possible causes (e.g., context and priming effects) of these beliefs, which play a central role in these rational models of choice behaviour (Krank & Robinson, 2017). For example, social-ecological theories have also been used to predict youth substance use (Lee et al., 2007; Van Den Bree & Pickworth, 2005). Social cognitive (Bandura, 1986) and social learning theory (Akers, 1998) highlight the interplay between social environments and substance-related expectancies, wherein media (e.g., social media, news, TV, movies, radio etc. advertising products or representing substance use behaviours) is a feature of the social-cultural environment that may greatly influence cognitions and decisions preceding behaviour (Flay, 1994). Altogether, these approaches to early substance use emphasize learning about substance use from social experiences and the retrieval of these associations as the proximal influence on expectancies and subsequent substance use decisions (Krank & Robinson, 2017; Mares et al., 2013; Whiteman et al., 2016).

Cognitive-Affective Theories of Health Behaviour and Substance Use

Cognitive-affective theories applied to substance use (e.g., theories of reasoned action and planned behaviour; Ajzen & Fishbein, 1975; Ajzen, 1991) suggest that substance use is primarily determined by behavioural intentions. Moreover, such integrative theories underlying use intentions highlight the independent and reciprocal influences of current substance use, expectancies, normative beliefs, and self-efficacy related to the performance of a behaviour (Trudeau et al., 2003). Where the theory of reasoned action posits that normative beliefs and attitudes directly affect intentions and behaviours, the theory of planned behaviour (TPB) proposes an additional predictor of substance use – perceived behavioural control (Petraitis et al., 1995).

Attitudes may be differentiated based on expected consequences of substance (e.g., cannabis) use, including positive and negative expectancies, and affective or evaluative aspects (e.g., using cannabis will make me feel good) associated with substance use (Petraitis et al., 1995). On the other hand, social norms are a set of standard acceptable behaviours, rules, and sanctions adopted among members of a social group (Gilliard-Matthews et al., 2015) and comprise two component parts: perceived prevalence (i.e., descriptive norm) and perceived acceptability (i.e., injunctive norm) (Zaleski & Aloise-Young, 2013). Descriptive and injunctive norms are shown to exacerbate cue (e.g., advertisement) sensitivity and reinforce substance use behaviours via the drugs' rewarding properties and conformity to social norms. Perceived social norms are shown to be some of the strongest predictors of substance use among youth, who are especially sensitive to social perceptions of their peers (D'Amico & McCarthy, 2006; Kelly et al., 2012; Trucco et al., 2011). Behavioural and normative beliefs, which are also affected by individual personal values, are thought to be antecedents of attitudes and social norms (Maher & Rickwood, 1998). Finally, the notion of perceived behavioural control (i.e., perceptions of control over the successful completion of a particular behaviour, which is thought to represent one's past experience and anticipated

barriers and facilitators (e.g., one's perceived ability to refrain from substance use in the face of temptation, or to overcome obstacles to accomplish a specific behaviour) is similar to Bandura's (1977) concept of self-efficacy as it represents one's personal beliefs regarding how easy or difficult accomplishing a particular behaviour may be. The TPB presumes that normative beliefs, attitudes, and perceived behavioural control precede intentions and that behavioural intentions, in turn, precede actual behaviour (Malmberg et al., 2012). Altogether, the TPB has been successfully used to identify predictors of cannabis use among youth (Ito et al., 2015; Kam et al., 2009; Malmberg et al., 2012). Thus, it may offer a valuable cognitive-emotional and contextual framework to explain behavioural (substance use) intentions, as well as the development and maintenance of behavioural patterns via substance-related expectancies (i.e., attitudes), social norms, and behavioural control. I will review a sample of studies substantiating this claim below.

The majority of studies on TPB factors among youth have been conducted in the fields of alcohol and tobacco (e.g., Cameron et al., 2003; Jones et al., 2001; Kam et al., 2009; Patrick et al., 2009). Among youth, having favourable attitudes, a greater sense of approval, and lower self-efficacy have been shown to predict stronger intentions and increased use of alcohol and tobacco (Cameron et al., 2003; Jones et al., 2001; Kam et al., 2009; Patrick et al., 2009). Similarly, research demonstrates that TPB factors also predict cannabis use behaviours among youth (e.g., where having positive attitudes, experiencing greater approval from one's social environment, and having decreased self-efficacy or behavioural control all indicate stronger intentions to use and subsequent cannabis use; Ellickson et al., 2004; Kam et al., 2009; Malmberg et al., 2012; Skenderian et al., 2008; Stephens et al., 2009). Of concern, research shows strong correlations between youth exposure to advertising and earlier initiation and higher consumption among those already using cannabis through increased expectancies and use intentions following advertising exposures (Whitehill et al., 2019).

Next, I will provide a brief summary of available research examining the impacts of substance-related advertising on subsequent substance-related expectancies, use intentions, and actual use.

Advertising and Substance-related Expectancies, Use Intentions, and Actual Use

Evidence from restricted consumer markets (e.g., alcohol, tobacco) demonstrates that exposure to substance-related advertising increases positive substance-related expectancies, use intentions, and actual use. Health warnings for cigarettes have shown to increase risk perception, decrease tobacco use, and increase use of smoking cessation services (Hammond, 2011), while other factors that may impact youths' perceptions of social norms and behavioural control such as proximity to retail environments and in-store advertising also impact tobacco consumer behaviour (US Surgeon General, 2012). Similarly, the relationship between exposure to alcohol advertising and underage drinking is found to be causal, and exposure to alcohol advertising has been shown to be one cause of binge drinking among youth (Sargent & Babor, 2020).

Building upon the impacts of advertising-related policy measures for other substances, exposure to cannabis advertising is likely a key influence in determining youth cannabis attitudes, beliefs (i.e., expectancies), and use intentions. Evidence for this hypothesis comes from research investigating the impacts of medical cannabis advertising exposures on American and Canadian youth (i.e., D'Amico et al., 2015, 2017, 2018; Firth et al., 2022; Park & Holody, 2018; Rup et al., 2020; Sheikhan et al., 2021; Trangenstein et al., 2019; Whitehill et al., 2019). Results from these studies demonstrate that self-reported exposures to medical cannabis advertising predict greater positive cannabis expectancies, higher intentions to use cannabis, and negative consequences from cannabis. Moreover, higher frequencies of exposure to medical cannabis advertising are found to be associated with greater increases in medical cannabis expectancies, use intentions, use itself, and negative cannabis-related consequences over time. Altogether, given the negative impacts of

medical cannabis advertising exposures among youth, the approach to reduce or eliminate exposure to cannabis advertising is both evidence-based and likely essential to prevent further youth cannabis use in Canada's recreational cannabis context.

Illicit Substances and Targeted Advertising Tactics: Are Older Youth Prime Targets?

In addition to the creation of laws aiming to eliminate youth exposure to cannabis advertising in Canada's recreational context, monitoring the effectiveness of such policies and prohibitions is critical. Other research on age-restricted substances, including alcohol, tobacco, and e-cigarettes, demonstrates that companies ignore prohibitive advertising laws and intentionally target their products to youth (Barry et al., 2018; Farber & Folan, 2017; Padon et al., 2016). Similarly, a recent Guardian exposé and preliminary evidence from our group (Noël et al., 2021) and others (Sheikhan et al., 2021) suggests that companies are advertising cannabis using imagery that directly appeals to youth and violates Canada's advertising prohibitions. Older youth closer to the minimum legal age (MLA) are thought to be prime advertising targets as they are impressionable, with reduced decisional capacity to effectively weigh long-term risks and benefits of using a substance (Silveri, 2012) and increased access to cannabis (Nguyen et al., 2023). Moreover, their youth enhances their potential to become long-term product users, while they are also less likely to already be users themselves, thereby comprising a market with considerable opportunities for growth (Hopfer, 2014). Altogether, cannabis companies stand to make considerable profit by recruiting users from the youth market. This incentivizes them to violate existing prohibitions on advertising cannabis to youth. In this section, I review the literature demonstrating how youth are targeted by advertisers to purchase drugs such as alcohol and tobacco, as well as cannabis, where studies are available.

Targeted Youth Cannabis Advertising Tactics

Cannabis-related advertisements reach youth through various traditional advertising channels, including billboards/posters, storefronts, product packaging, in print (magazines/

newspapers), television, movies, and radio (Noël et al., 2021; Rup et al., 2020), and youth and young adult advertising exposure is highest in jurisdictions with legalized cannabis (Rup et al., 2020).

As the online presence of youth continues to grow, digital marketers have also begun to view online advertising as a lucrative advertising channel (Montgomery et al., 2012) and to use digital media to promote unhealthy commodities such as alcohol and tobacco (Barry et al., 2018; Brodwin, 2013; Buchanan et al., 2018; Hébert et al., 2017) among youth. Recent evidence demonstrates that tobacco companies are marketing their products in new, largely unregulated ways – through online platforms, including social media (Cruz et al., 2019; O'Brien et al., 2020), which may disproportionately affect youth who have a greater online presence, and rely more heavily on the internet, as compared to adults (Montgomery et al., 2012; Pew Research Center, 2019). As online advertising venues, including social platforms, have shown to have a potent influence on youth expectancies, intentions, and substance use, companies have increasingly diverted the majority of advertising funds to online social media platforms that collect a wide array of data points for each user (Barry et al., 2016; Federal Trade Commission, 2014; Jackler et al., 2019). These data points (e.g., gender, location, ethnicity, hobbies, and popular culture references) are leveraged to target and promote their products to youth through paid promotional advertisements such as 'sponsored posts' and 'boosted posts' (Business insider, 2017; Dewey, 2016; Facebook Business, 2018; Jackler et al., 2019). Unpaid or 'organic' content posted through companies' pages and social media influencers to create a community of interested users is an additional, frequently complementary approach to advertising to youth (Facebook Business, 2017; Jackler et al., 2019).

Altogether, a shift to online advertising channels is especially concerning, given that youth account for a large percentage of internet and social media (e.g., Facebook, Twitter, Instagram) adopters and users, and their likelihood to engage in online content increases their exposure to

advertising, and subsequent negative impacts on substance-related expectancies, intentions, and use (Barry et al., 2016; Casswell, 2004).

Illicit Substances and Differential Susceptibility to Targeted Advertising

While previous research has mostly overlooked the possible effect of individual differences among youth on advertising susceptibility (i.e., differential susceptibility; Hoek et al., 2022; Valkenburg & Peter, 2013), existing evidence demonstrates that certain youth groups may be directly targeted by substance-related advertising, and more susceptible (i.e., have greater increased expectancies and/or use intentions following exposure) to illicit substance-related advertisements, based on social and environmental vulnerabilities (Lake et al., 2020), and mental health concerns (De Hay et al., 2012). In this section, I review the ways in which sociodemographic and psychological vulnerabilities may be leveraged by Canadian cannabis companies to increase profit through targeted cannabis advertisements.

Sociodemographic Vulnerabilities

Marginalized populations (e.g., gender and racial/ethnic minorities, and populations of lower socioeconomic status) are shown to use tobacco and cannabis products at higher rates as compared to national averages (Barger et al., 2021; Dai & Hao, 2017; Du et al., 2019; Peters et al., 2018). At the same time, historically, these groups are shown to be disproportionately exposed to advertisements (e.g., tobacco) targeted specifically to marginalized populations (Cruz et al., 2019; Dauphinee et al., 2013; Emory et al., 2019; Higgins et al., 2019; Lienemann et al., 2019; Rising & Alexander, 2011).

The greatest proportion of the literature related to sociodemographic vulnerability to targeted and non-targeted tobacco-related advertising focuses on race and ethnicity (Cruz et al., 2019). Altogether, most of the literature focuses on the exposure and impacts of tobacco advertising on U.S. populations, including Black, Hispanic/Latino, Asian/Pacific Islander and Indigenous populations, along with Multi-ethnic minorities (Cruz et al., 2019). Most notably, flavoured

menthol cigarettes have historically been marketed and advertised to Black communities using culturally targeted messaging and images which imply potential health-related benefits, building upon cultural perceptions that mint is medicinal (Anderson, 2011; Cruz et al., 2010; Gardiner, 2004; Hafez et al., 2006). Moreover, tobacco companies have shown to capitalize upon such cultural perceptions (e.g., by creating stronger menthol-flavoured cigarettes to appeal to these taste preferences or featuring hip-hop culture and music in advertising) and violate restrictions related to targeted marketing to youth (Anderson, 2011; Cruz et al., 2010; Gardiner, 2004; Hafez et al., 2006; Richardson et al., 2015). Compounding these targeted efforts, in the past, tobacco advertisements have also shown to be more prevalent in Black neighbourhoods (Feighery et al., 2008; Kirchner et al., 2015; Seidenber et al., 2010; Widome et al., 2013), near schools with more Black students (Henriksen et al., 2012), and in newspapers and magazines targeted towards Black populations (Cohen et al., 2011; Landrine et al., 2005; Trinidad et al., 2017; Richardson et al., 2015), while stores were more likely to have discount promotions and lower prices for menthol cigarettes (Cruz et al., 2010; Henriksen et al., 2012). Available research examining whether and how tobacco companies advertise directly to or target other ethnic/racial minority groups is scarce, but shows some evidence that other ethnic/racial minority groups are similarly targeted by tobacco companies (Cruz et al., 2019). Considering this evidence, it is possible that ethnic minorities may also have greater cannabis use expectancies and use intentions through targeted advertisement exposures. Canada has a large Indigenous population that has been subject to myriad negative impacts of Colonialism. As such, Canadian research is needed to investigate whether Indigenous youth are targets of cannabis advertising.

In terms of urbanicity, research demonstrates that rural youth report more cigarette smoking, along with higher exposure to tobacco advertising as compared to urban youth (Bernat & Choi, 2018). Moreover, rural areas are shown to be targeted by tobacco advertising aimed at men with low SES (Meija & Ling, 2010), with evidence showing that marketers capitalize on perceptions of

masculinity in rural communities to promote tobacco use initiation and continued use and qualitative information confirming ease of obtaining tobacco and how packaging and advertisements reflect male cultural standards among rural communities (Nemeth et al., 2012). Altogether, like evidence from the tobacco industry, urbanicity may potentially moderate the relationship between cannabis advertising exposures and cannabis expectancies and use intentions. Youth living in rural locations may have a greater increase in cannabis use expectancies and use intentions, following advertisement exposures, as compared to those living in urban locations.

When examining gender-based differences in relation to tobacco advertising vulnerability, as above, the tobacco industry has shown to leverage gender norms through advertising to increase tobacco likeness and use, while tobacco exposure has shown to be distributed unequally across segments of society, interacting with social class, occupation, age, geographical location, etc. to reinforce tobacco advertising exposure and risk (Tan et al., 2021; Terry-McElrath, 2007). More specifically, marginalized sexuality and gender groups (e.g., lesbian, gay, bisexual, transgender, queer or questioning, intersex, asexual, and more; LGBTQIA+) youth are disproportionately exposed to advertisements targeting marginalized populations (Cruz et al., 2019; Dauphinee et al., 2013; Emory et al., 2019; Higgins et al., 2019; Lienemann et al., 2019; Rising & Alexander, 2011; Washington, 2002). Moreover, although male youth are more likely to smoke, females are shown to have stronger emotional reactions to tobacco advertising, especially those portraying positive emotion (DiRocco et al., 2007; Shadel et al., 2004). Likewise, female youth are shown to identify more strongly with gender-targeted tobacco advertising, which may, in turn, influence advertising reactivity (Amos et al., 2012)., Altogether, like evidence from the tobacco industry (Mays et al., 2014), gender may potentially moderate the relationship between cannabis advertising exposures and cannabis expectancies and use intentions. Specifically, marginalized gender groups and females may have a greater increase in cannabis use expectancies and use intentions following advertisement exposures, as compared to males.

While the impacts of disproportionate exposure to tobacco advertising are well explored, little is known about whether or how exposures to advertising for new and emerging cannabis products differs across sociodemographic characteristics in the current Canadian legalization context. However, emerging research demonstrates that sociodemographic differences are found with regard to advertising susceptibility for illicit substances (Krueger et al., 2021), with recent evidence demonstrating that youth and racial/ethnic minorities may have disproportionately higher exposure to cannabis promotions in the U.S. (Park & Holody, 2018). Beyond the scope of this study, factors above and beyond targeted youth advertising through digital venues, including proximity to cannabis retailers, are also shown to moderate the relationship between exposure to advertising and cannabis use intentions, as well as positive outcome beliefs and intentions (Hust et al., 2020), indicating that additional considerations such as retailer location in relation to neighbourhoods and advertising regulations should be considered to reduce the appeal of cannabis to youth.

Psychological Vulnerabilities

Psychological vulnerabilities may similarly increase youth susceptibility to advertisements. For example, evidence from the tobacco industry demonstrates that advertising companies directly target populations with neurocognitive, environmental, and social mental health vulnerabilities through various strategies, including the development of brand affinity (i.e., marketing approaches aiming to increase overall positive sentiment, perception, or value attributed to a brand) to bolster sales (Apollonio & Malone, 2005; Hirshbein, 2012; Prochaska et al., 2008). Moreover, existing research suggests that youth experiencing moderate to high levels of mental health distress may be more likely to engage with tobacco advertising, which is associated with an increased risk of tobacco use initiation and decreased likelihood of tobacco use cessation – possibly widening existing disparities in tobacco use among youth with behavioural and emotional disorders (Soneji et al., 2018).

Cannabis marketing and advertising have shown to be rampant in many U.S. states, and policy researchers expect that cannabis companies will similarly capitalize on lax restrictions and effectively engage in advertising practices that are designed to prompt use, particularly among those with, or at risk of developing mental health problems (e.g., individuals at risk of developing cannabis use disorders; Barry & Glantz, 2016; Caulkins et al., 2016; D'Amico et al., 2018; Kilmer, 2014; Pacula et al., 2014). Evidence from the U.S. demonstrates that the cannabis industry advertises cannabis products for the treatment of mental health conditions without clinical evidence of therapeutic efficacy and despite existing evidence for the adverse effects of cannabis use on most psychiatric conditions (Borodovsky & Budney, 2018; Budney et al., 2019). For example, research demonstrates that cannabis advertising companies make unsupported therapeutic claims to appeal to consumers psychological needs and motives for use intentions through the use of themes including stress relief; reduction of pain, anxiety and depression; performance and sleep enhancement; and increased sociability (Luc et al., 2020). Future research to determine the extent to which Canadian cannabis advertising companies make unsupported therapeutic claims is needed, although it is beyond the scope of the current study. All told, as cannabis companies may employ similar advertising tactics through their respective media campaigns in Canada's post-legalization context, youth with mental health vulnerabilities may be similarly targeted and exploited.

Youth Psychosis Risk and Advertising Vulnerability

Cognitive Impairments and Possible Impacts on Cannabis Expectancies, Use Intentions and Use

Risks related to cannabis use and the development of substance-use disorders, along with their potentially devastating impacts among youth at risk of psychosis or in the early prodrome, are much better known. Below, I describe the ways in which youth at risk of psychosis may be particularly susceptible to cannabis advertising, relationships between cannabis use and psychosis onset, and the potentially devastating impacts of cannabis use among youth at risk of psychosis.

Individuals at risk of developing psychosis may be particularly susceptible to cannabis advertising due to impairments in cognition (e.g., deficits in social knowledge acquisition, emotion perception and attributional abilities, planning, mental flexibility, decision-making, weighing risks and reward of an activity, and problem-solving; Lake et al., 2020; MacKenzie et al., 2017). Previous research demonstrates that these cognitive impairments are present prior to the onset of psychosis, and most commonly emergent during childhood and adolescent years (Lake et al., 2020; MacKenzie et al., 2017).

As suggested by Lapierre (Lapierre, 2013, 2019), cognitive development has been shown to play an important role in understanding advertising messages among youth. One important factor of interest is executive function (Büttner et al., 2014; Lapierre, 2019; Lapierre & Rozendaal, 2019; Moses & Baldwin, 2005), referring to a set of cognitive abilities involved in monitoring and controlling thoughts and actions (Moses & Baldwin, 2005), especially as it relates to inhibitory control (Hoek et al., 2022). Inhibitory control is a component of youth executive function that continues to develop into young adulthood (Best & Miller, 2010; Tamm et al., 2002) and refers to one's cognitive ability to inhibit or control certain responses, including in response to advertising exposures (Carlson et al., 2002). This ability enables youth to have 'stop and think' responses when exposed to advertisements by allowing them to shift their attention away from emotionally appealing advertising and controlling their thoughts in order to inhibit desires to acquire or use advertised products (Büttner et al., 2014; Rozendaal et al., 2011). As the relationship between both conceptual and advertising literacy activation and implicit desire for advertised products is moderated by inhibitory control, executive function is important in countering advertising susceptibility (Hoek et al., 2022).

Of concern, a lack of inhibitory control has long been central to theories underlying the development of schizophrenia and psychotic disorders (Ettinger et al., 2018). Neuroimaging and behavioural techniques demonstrate that such deficits may be intermediary phenotypic markers of

psychosis vulnerability, given their attenuated presence among those at risk of developing schizophrenia and psychosis (Fryer et al., 2019; Jacobson Mcewen et al., 2014; Snitz et al., 2006; Van Rijn et al., 2011). Importantly, targeting impairment in inhibitory control has been included as a priority in treatments promoting the recovery of individuals diagnosed with psychotic spectrum disorders (Cella & Wykes, 2019) and even earlier clinical interventions as these impairments are present before illness onset (Quiñones et al., 2021). In short, youth at risk of psychosis may be more susceptible to cannabis advertising exposures due to inhibitory control deficits present prior to illness onset in shifting their attention away from appealing advertisements and controlling their thoughts to refrain from acquiring or using cannabis products present prior to illness onset.

Previous research also highlights a general deficit in decision-making in psychosis as it relates to integrating evidence from one's environment and prior beliefs (Sterzer et al., 2018). More specifically, a review of relevant literature suggests that explicit risk-taking can be characterized by risk imperception (i.e., a decreased ability to perceive and integrate risk-relevant information to adequately discriminate between options and optimize decision-making, possibly secondary to cognitive deficits among those with psychotic-spectrum disorders, or with psychosis risk; Purcell et al., 2022). Notably, some researchers have suggested that risky decision-making may scale up to ecological behaviours (i.e., observable, risky behaviour), including substance use in psychosis. Outcome expectancies are typically impacted by beliefs about both costs and benefits of using substances (Musher-Eizenman et al., 2003; Stacy, 1997). Youth at risk for psychosis, who may also have fewer perceived substance use-related costs, may then have greater positive expectancies following substance-related advertising exposures (e.g., believing that using a substance will result in beneficial outcomes including assertiveness, being sociable or forgetting problems). This is one potential pathway through which advertising exposures may drive substance use among youth at risk of psychosis (Barnow et al., 2004). In sum, these findings suggest that potential consequences

of cannabis consumption may not be fully appreciated among youth at risk of psychosis, and impairments in cognition may lead to greater susceptibility to pro-cannabis messages and increase the likelihood of more dangerous and ill-informed cannabis consumption, and related adverse outcomes (Davidson et al., 2018; Lake et al., 2020; MacKenzie et al., 2017; Thompson et al., 2012).

Increased susceptibility to cannabis advertising is of clinical concern among youth at risk of psychosis, because cannabis use in this population has extra potential to cause harm. Although the biological underpinnings and the exact mechanism of action of the association between cannabis use and a first episode of psychosis are unclear, given the available research evidence (e.g., Bagot et al., 2015), including a recent systematic review and meta-analysis (Kiburi et al., 2021), the use of cannabis appears to increase the likelihood of triggering early psychosis onset, especially among vulnerable youth (Bagot et al., 2015; Kiburi et al., 2021). Moreover, reverse causation or a bi-directional relationship between these two factors may also be observed, wherein psychosis risk may also predict future cannabis use (Gage et al., 2017; Griffith-Lendering et al., 2013). In the next section, I will describe the relationships between early cannabis use, psychosis onset and presentation.

Relationships between Early Cannabis Use, Psychosis Onset, and Presentation

Several lines of research evidence and theories have been advanced to explain the association between psychosis risk and early substance use, along with various potential moderators that may influence this relationship. In this section, I will begin by providing an overview of the available research evidence exploring the relationship between youth cannabis use and psychosis, then provide a summary of potential moderators that may influence psychosis onset among youth who use cannabis, followed by a brief review of theories that have been advanced to explain the association between psychosis risk and early cannabis use (See Figure 1).

Figure 1

Schematic Illustrating Possible Bidirectional Relationship Between Psychosis Risk and Cannabis

Use
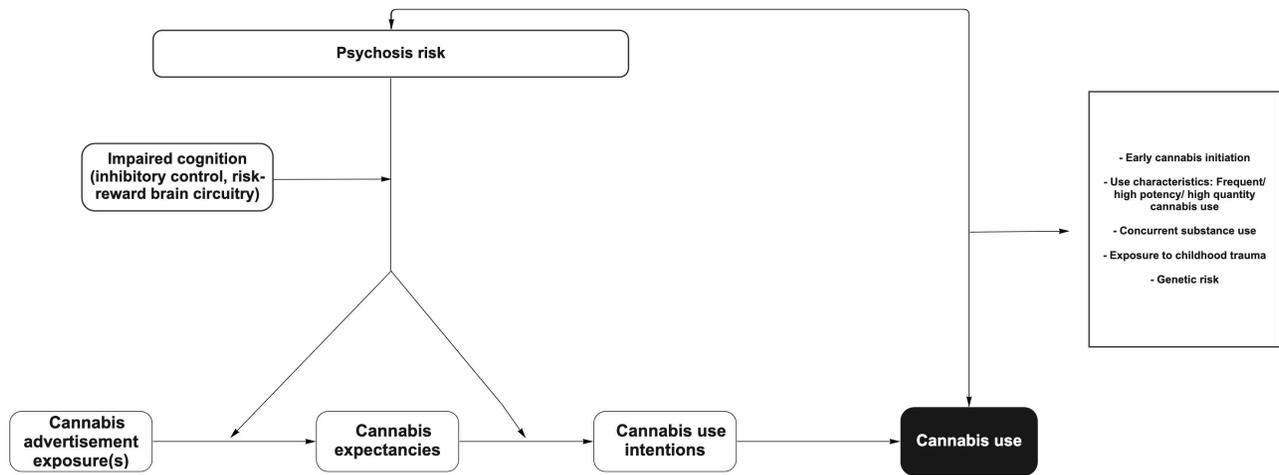
Note: This figure demonstrates the possible bidirectional relationship between psychosis risk and cannabis use (i.e., that increased substance use among youth at risk of psychosis may concurrently enhance risk of future substance use disorder and serve as an additional risk factor for the onset of psychotic symptoms). The possible moderating effect of psychosis risk and impaired cognition on 1) the relationship between advertisement exposure(s) and cannabis expectancies, and 2) the relationship between cannabis expectancies and use intentions is also presented. Risk factors that may concurrently enhance future risk of cannabis use and the development of psychosis are presented in the box on the right.

Youth Cannabis Use is Associated with Earlier Psychosis Onset and Greater Psychological

Impairment for those at Risk of Psychosis: Research Evidence

Despite concerted efforts to prevent or delay youth cannabis use, especially among youth who may be at risk of developing psychosis (e.g., the development of Lower Risk Guide for Canadians) (Fischer et al., 2017), youth at risk of psychosis are more likely to report using cannabis (Addington et al., 2014; Carney et al., 2017; Farris et al., 2020; Henquet et al., 2008; Ksir & Hart, 2016). Moreover, studies of first-episode psychosis populations conducted in Europe, Canada, and Australia suggest that approximately 23-62% have a current or recent cannabis use disorder at intake into treatment (Archie et al., 2007; Cather et al., 2018; Gleeson et al., 2013; Stone et al., 2014; Wade et al., 2005). Di Forti et al. (2009) suggest that for many individuals who go on to develop psychosis, substance use begins before psychosis onset. They demonstrated that patients presenting with a first episode of psychosis were more likely to be daily cannabis users and to have smoked cannabis for more than five years, as compared to healthy controls. Altogether, early cannabis use leads to greater symptom severity among individuals at risk of psychosis who transition to frank psychosis (Carney et al., 2017) and further perpetuates future cannabis use (Hurd et al., 2014).

Several studies have shown that earlier age at onset of cannabis use is associated with greater neuropsychological impairment, while longitudinal studies consistently provide support for associations between youth cannabis use and psychosis (Fontes et al., 2011; Gruber et al., 2012; Volkow et al., 2016), regardless of prior mental illness or vulnerability (Grant & Bélanger, 2017). Moreover, cannabis use has been shown to precede psychosis (Arseneault et al., 2002), independent of alcohol consumption (Andréasson et al., 1987), even when controlling (Fergusson et al., 2003; Van Os et al., 2002) for, or eliminating (Arseneault et al., 2002; Zammit et al., 2002) individuals who use other psychoactive substances (Foti et al., 2010).

Psychotic symptoms exhibited by early cannabis users include depersonalization, paranoia and hallucinations, attenuated negative or disorganized symptoms (e.g., blunted affect and diminished volition or social interest), demonstrating overall cognitive disturbance (Grant & Bélanger, 2017). Although relatively uncommon, experiencing these subclinical psychotic-like experiences during adolescence is associated with poorer global functioning, comorbid psychological difficulties, and increased suicidality (Calkins et al., 2014; Kelleher et al., 2012). Moreover, among youth at risk of psychosis, cannabis use is associated with greater psychotic symptom severity (Carney et al., 2017).

Factors Moderating the Relationship Between Youth Cannabis Use and Psychosis Risk

Various factors are shown to moderate the relationship between cannabis use and psychosis risk (Kiburi et al., 2021). The association between cannabis use and persistent psychosis (including a diagnosis of schizophrenia) is greater among individuals who frequently or heavily use cannabis during adolescence (Andréasson et al., 1987; Di Forti et al., 2009, 2015; Di Forti, Sallis, et al., 2014; Fischer et al., 2017; George & Vaccarino, 2015; Zammit et al., 2002), have earlier use (Arseneault et al., 2002), or use cannabis with a high THC potency (Di Forti et al., 2009; Di Forti, Sallis, et al., 2014). Based on available evidence, ever-cannabis use is estimated to produce about a two-fold increase in risk of developing schizophrenia, accounting for between 8%-14% of cases, while frequent use or use of cannabis with high potency THC is estimated to produce a six-fold increase in schizophrenia risk (Andréasson et al., 1987; Van Os et al., 2002; Volkow et al., 2016). Other factors shown to influence the relationship between youth cannabis use and psychosis risk include exposure to childhood trauma and concurrent use of other substances (Kiburi et al., 2021).

Lastly, genetic studies have been used to assess whether associations between cannabis use and psychosis are explained by shared genetic predispositions to use cannabis and develop psychosis (Hall et al., 2020). Of the available evidence, several studies conclude that a considerable proportion of cannabis-attributable psychosis occurs among cannabis users with a family or

personal history of psychosis and that a genetic predisposition to psychosis may be triggered or amplified by cannabis use (Di Forti, Iyegbe, et al., 2014; Giordano et al., 2015; Kraan et al., 2016; Power et al., 2014; Radhakrishnan et al., 2014; WHO, 2016). Under the assumption that psychosis risk from family history and cannabis use are multiplicative, individuals with a first-degree relative with a history of psychosis may have a 10% baseline risk, and this risk would be doubled if they became a regular user (Degenhardt et al., 2009; McLaren et al., 2010). By contrast, increased risk of developing other mental health problems (e.g., depression, anxiety suicide) from cannabis use is not as strongly established (Fischer et al., 2017).

What Comes First: Cannabis Use or Psychosis? A Brief Review of Theories Explaining the Association Between Psychosis Risk and Early Substance Use

Several theories have been advanced to explain the association between psychosis risk and early substance use.

The diathesis-stress model (also known as the two-hit model) posits that the interaction of a neurobiological vulnerability interacting with an environmental stressor (including substance use) would lead to the development of psychotic symptoms (Fowles, 1992). The cumulative risk factor hypothesis is a related model suggesting that individuals with schizophrenia have an increased risk for substance use due to cumulative effects of impaired cognitive, social, educational and vocational functioning, along with the presence of poverty, victimization and deviant social environments (Mueser et al., 1990).

Although there is mounting evidence for cannabis having a causal role in the development of psychosis, there may also be other explanations that contribute to explaining why the prevalence of cannabis use among those with and at risk of severe mental illness is so high. Reverse causation in the context of the relationship between psychosis and cannabis is the hypothesis that experiencing psychosis or psychotic symptoms increases one's likelihood of using cannabis (Gage et al., 2016). Indeed, some evidence from Mendelian randomization studies of genetic risk has

emerged to support the theory of reverse causation; in a bi-directional two-sample analysis using genome-wide data, Gage et al. (2017) found some evidence of a causal effect of using cannabis on risk of developing schizophrenia, but strong evidence consistent with a causal effect of schizophrenia risk on the likelihood of cannabis initiation. However, there is very little research explicitly testing this theory.

Several potential mechanisms for bidirectional effects exist. The self-medication hypothesis is the most well-explored mechanism of reverse causation, suggesting that among individuals with psychotic-spectrum disorders, substance use is initiated to reduce symptoms (e.g., cognitive deficits related to impulsivity or anhedonia, negative affective states such as low mood, boredom or anxiety, or positive symptoms of psychosis including delusions or hallucinations) or decrease the side effects associated with antipsychotic treatment (Katz et al., 2017; Khantzian, 1997). Indeed, there is some evidence demonstrating that youth report using cannabis for the purpose of self-medication and/or regulation of negative symptomology (Gill et al., 2015; Hurd et al., 2014). In contrast, there is minimal evidence supporting the idea that individuals use cannabis to alleviate positive symptoms of psychosis or medication side effects. Overall, available research demonstrates that individuals with, or at risk of, psychosis use cannabis to alleviate negative affective states such as dysphoria, which is often endorsed, common and severe in psychosis, and that, similar to the general population, they use cannabis for hedonic reasons (e.g., to get high, relax, or to have fun) (D'Angelo et al., 2017; Häfner et al., 2005; Kolliakou et al., 2011).

The self-medication hypothesis is of particular interest as it may be a potential pathway for reducing the prevalence of cannabis use through the identification and prevention of increased substance-related expectancies and use intentions. In other words, identifying and intervening upon positive substance-related expectancies and use intentions and reducing likelihood of substance-related advertising exposures that may influence the development of positive substance-related

expectancies (i.e., that using cannabis may reduce psychotic symptom severity) may reduce the likelihood of cannabis initiation among this at-risk group.

Other researchers have proposed a unifying hypothesis (Khokhar et al., 2018) combining recent evidence from epidemiological and genetic association studies with neuroimaging and pre-clinical studies to provide an updated rationale for the basis of substance use among individuals with schizophrenia and those at risk for developing psychosis. Based on this line of inquiry, genetic determinants of risk for schizophrenia (Cariaga-Martinez et al., 2016; Schwab & Wildenauer, 2013), especially within neural systems contributing to psychosis risk and risk for addiction (driven by genes encoding catecholaminergic signalling in the brain; Apud & Weinberger, 2007; Caspi et al., 2005; Ira et al., 2013) or an early environmental insult (shown by the neonatal ventral hippocampal lesion rat model of schizophrenia; Lipska & Weinberger, 2000; Tseng et al., 2009), would lead to dysfunctional mesocorticolimbic brain reward circuitry. As a result, dysfunctional brain reward circuitry (e.g., hypoconnectivity, dopamine hypersensitivity; Chambers et al., 2001; Thompson et al., 2013), would then make individuals vulnerable to substance use. As this vulnerability may exist prior to the onset of psychotic symptoms, increased substance use among youth at risk of psychosis (as well as in non-psychotic first-degree relatives; Smith et al., 2008; Stone et al., 2001) may thus concurrently enhance risk of future substance use disorder and serve as an additional risk factor for the onset of psychotic symptoms. Treating these shared vulnerability factors may be more challenging. As such, targeted intervention measures combined with appropriate regulatory provisions (e.g., imposing and enforcing prohibitions related to cannabis advertising) are needed to adequately protect youth in a post-legalization context (Caulkins & Kilborn, 2019; Hall, 2018; Lee et al., 2020; Parmar & Sarkar, 2017)

On the whole, as cannabis use is considered a preventable risk factor for psychosis (Schizophrenia Commission, 2012) and a viable treatment target in mitigating its onset (Marconi et al., 2016), prevention of early cannabis consumption through the enforcement of strict laws and

regulations related to cannabis advertisements is paramount (Fischer et al., 2017). In addition, the impacts of such targeted measures on cannabis-related risk behaviours and harm outcomes requires consistent monitoring and improved understanding (Fischer et al., 2017, 2020; Hall & Lynskey, 2016). In the next section, I will discuss the current available evidence for cannabis advertising impacts and associated methodological challenges and limitations, highlighting the need for more consistent monitoring and improved understanding of cannabis advertising impacts on Canadian youth.

Current Evidence for Cannabis Advertising Impacts and Associated Methodological Limitations

As mentioned above, the Canadian government's advertising barriers may help to reduce underaged cannabis consumption, but assessing the impacts of advertising-related restrictions following legalization is challenging (Haines-Saah & Fischer, 2021). To the best of our knowledge, none of the extant research describing cannabis advertising impacts has been conducted in the Canadian cannabis-legal context. This is to say, no information related to the impacts stemming from cannabis companies' attempts to target youth is available in the current Canadian regulatory landscape. While a growing body of research suggests that cannabis advertising puts youth at risk (i.e., D'Amico et al., 2015, 2017, 2018; Firth et al., 2022; Park & Holody, 2018; Rup et al., 2020; Sheikhan et al., 2021; Trangenstein et al., 2019; Whitehill et al., 2019), these studies are limited by their use of inexact measures which utilize retrospective recall and are liable to respondent recall error and bias (Shiffman et al., 1997). Limitations imposed by existing retrospective research may thus have a negative impact upon the measured effects of cannabis advertising on youth, including their perceptions following advertising exposure(s), and measures of cannabis use prevalence. Furthermore, current research that seeks to examine the impacts of cannabis advertising exposures in other locations describe their findings in aggregate, thus obscuring important contextual information, (e.g., time and location of individual advertising exposures), as well as other

psychosocial factors that may influence advertising exposure effects (Ebner-Priemer & Trull, 2009). This contextual information is needed to discern the channels through which youth are exposed to cannabis advertising and the ways in which companies violate advertising prohibitions.

Using Ecological Momentary Assessment to Examine Cannabis Advertising Impacts

EMA Advantages

Real-world real-time assessment techniques such as Ecological Momentary Assessment (EMA) have been proposed to enable individuals to record their functioning and interactions as they occur in their natural environments on portable devices such as smartphones (Granholm et al., 2020). EMA is a data-collecting method allowing for individuals to record their behaviours, experiences and thoughts, *in vivo*, within the context they are occurring (Shiffman et al., 2008). EMA methods are shown to be most suitable in assessing individuals' states and perceptions when conducting event-based research, especially as it pertains to the observation of multiple occurrences (Ebner-Priemer & Trull, 2009). When mood or intentions are measured, EMA tools may better represent these considerably time-fluctuating responses, which are likely to be misremembered when recorded retrospectively (Ebner-Priemer & Trull, 2009). EMA methods also offer high ecological validity; such methods allow for the collection of responses as they occur in respondents' natural environments, rather than within clinical or laboratory settings, and may thus be extrapolated and generalized more easily to varying settings and experiences when compared with more structured, clinical, or experimental environments (Ebner-Priemer & Trull, 2009).

EMA Feasibility and Acceptability Among Youth

Our group is investigating the impacts of exposure to cannabis advertising on youth cannabis expectancies, intentions, and use using *in vivo* methods (smartphone Ecological Momentary Assessment; EMA). Our preliminary work shows that EMA is feasible and useful for capturing cannabis advertising exposures and youths' reactions (cannabis use intentions, expectancies, features and type of advertisements) to such exposure events (Noël et al., 2021), and

feasibility of EMA among diverse youth, in general, is well documented across a wide variety of

clinical and non-clinical youth populations (Heron et al., 2017). Moreover, recent studies have not

only used EMA to explore real-life experiences among those with a first episode of psychosis but

have also included youth at risk of psychosis and found correspondence between data collected via

EMA and clinical interviews (Feller et al., 2021; Michel et al., 2022; van der Steen et al., 2017),

indicating that EMA is equally feasible among youth at risk of psychosis.

Aims and Objectives

The purpose of my Master's research was to extend our group's previous work by

describing: (1) How cannabis advertising is reaching potentially vulnerable youth; (2) How youth

cannabis expectancies and intentions to use cannabis are impacted by exposure to cannabis

advertising; and (3) Whether at-risk (demographics, psychosis risk) youth groups' cannabis

expectancies and intentions to use cannabis are differentially impacted by cannabis advertising

exposures.

Specifically, using a 9-day EMA protocol (See Noël et al., 2021, and below), I aimed to :

(1) Identify types (e.g., billboard, internet) of advertisements that have the greatest ability to reach

youth, (2) Assess the overall impacts of cannabis advertising exposures on youth cannabis

expectancies and intentions, and (3) Investigate between-group differences in urbanicity, gender,

ethnicity, age, and psychosis risk related to cannabis expectancies and use intentions following

advertising exposure(s).

Hypotheses

Based on this review of relevant literature, three main hypotheses were formulated and are

presented in Table 1.

Table 1

Hypotheses

1) **Advertising frequency** *How often are cannabis companies reaching youth?*	Cannabis companies reach Canadian youth through advertisements with a frequency that will be observable within the 9-day study observation period.
2) **Advertising impacts** *How are youth cannabis expectancies and intentions to use cannabis impacted by exposures to cannabis advertising?*	Exposure to cannabis advertisements will increase cannabis expectancies and use intentions via momentary exposure effects in the overall sample, within the 9-day study observation period.
3) **Differential advertising impacts** *Are at-risk groups' expectancies and intentions to use cannabis differentially impacted by exposures to cannabis advertising?*	**Demographic and psychosis risk variables will predict differences in youth expectancies and use intentions via momentary cannabis advertising exposure effects in the overall sample, within the 9-day study observation period.:**
	3a) urban vs. rural: Youth living in rural locations will have a greater increase in cannabis use expectancies and use intentions, following advertisement exposures, as compared to those living in urban locations
	3b) ethnicity: Ethnic minorities will have greater increased cannabis use expectancies and use intentions, following advertisement exposures
	3c) age: Compared to younger youth, older youth will have a greater increase in cannabis use expectancies and use intentions, following advertisement exposures
	3d) gender: Females and marginalized gender groups (e.g., transgender, gender neutral, non-binary, agender, gender queer, two-spirit) will have a greater increase in cannabis use expectancies and use intentions following advertisement exposures than males
	3e) psychosis risk: Youth at risk of psychosis will have greater increased cannabis use expectancies and use intentions following advertisement exposures than those who are not at risk

The hypothesized relationship between cannabis advertising exposures, cannabis expectancies, use intentions and use is shown in Figure 2.

Figure 2

Hypothesized Relationship Between Cannabis Advertising Exposures, Cannabis Expectancies, Use

Intentions, and Use
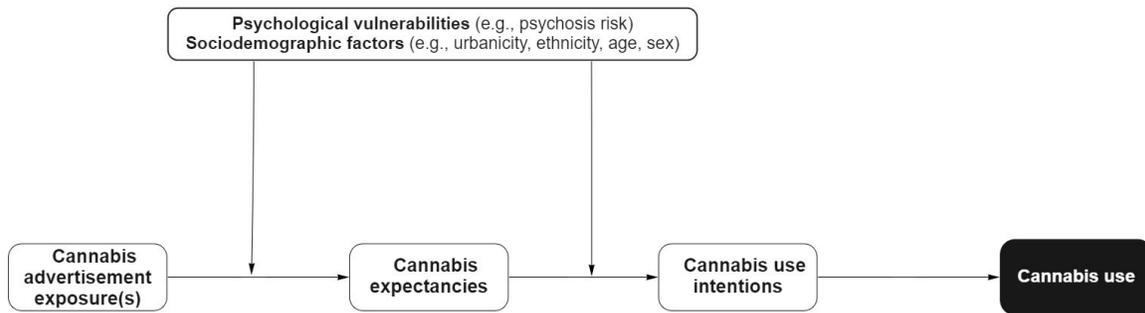
Methodology

Study Design and Data Sources

Study Setting and Participants

A total of *n* = 122 community-dwelling youth were recruited for the current study. Study

participants were deemed eligible if they were: (1) between the ages of 14-18, inclusively, (2) had

the ability to speak, read, and write in English, (3) owned their own cellular phone, and (4) resided

in Ontario. Two participants did not complete any device-issued random prompts during the EMA

period and were therefore excluded. The final analytic sample consisted of 120 participants.

Sample Size Justification

Given that accurate parameter estimates are needed for all estimated model parameters, and

sources of variation are directly influenced by the number of measurement points and participants

included in a study (Bolger & Laurenceau, 2013), power analyses for multilevel models are

complex and seldom reported for studies using hierarchical linear modelling (Trull & Ebner-

Priemer, 2020). As recommended, in order to improve power, researchers should choose adequate

sampling schemes balancing power to detect effects and potential burden to participants based on

similar methodologies employed by previous studies (Trull & Ebner-Priemer, 2020). For this study,

the primary outcomes were cannabis expectancies and use intentions, and to our knowledge, no

previous studies have examined these outcomes as they relate to cannabis advertising exposure

impacts assessed through EMA. However, based on a review of similar EMA research assessing the

effects of tobacco and alcohol media on substance-related cognitions and use intentions among

youth (e,g,, Hébert et al., 2018; Martino et al., 2018; Setodji et al., 2014; Roberts et al., 2019;

Shadel et al., 2012) with samples ranging from *n* = 87-126 and study duration ranging from 10-28

days, a nine-day study period employing *n* = 120 participants should detect a small to-moderate

effect (d = > .3) of three susceptibility predictors on cannabis use expectancies and use intentions among youth with α=.05, β=.8 (Kleiman, 2019).

Smartphone Devices and Software

Study participants recorded cannabis advertising exposures on their own personal smartphones through a customized Expiwell (Expiwell.com) smartphone application ("app").

Procedures

Data collection began in May of 2021, and was completed in May 2022. Participants were recruited through print and digital advertising including Facebook, Instagram, Reddit, and a school-affiliated research participation website (SONA) (See Information Letters and Consent Forms in Appendix A and B). Recruitment materials did not contain information related to cannabis; prospective participants responded to study advertisements with the broad goal of using cell phones to study advertising as it occurs in teens' everyday lives. Participants were screened by the research coordinator (CN) over email or Facebook to determine eligibility. After eligibility was ascertained, and informed consent was provided, eligible participants attended a virtual baseline session via Zoom (duration of 1 hour) with trained research assistants (CA, NM, BR, TS), along with a parent or legal guardian if they were under the age of 18. Participants who were under 18 years of age were required to provide written informed consent from a parent or legal guardian, along with assent, while participants who were 18 years of age provided written informed consent independently.

During the baseline session, all youth completed a baseline questionnaire assessing demographics, social determinants of cannabis use, cannabis use history, as well as a psychosis risk measure (see EMA assessments). Prior to the virtual baseline session, and during the baseline session, parents were advised that they would not have access to their child's study data, and that youth would complete the baseline session independently so that they may ask any questions pertaining to the study, without discomfort.

Participants were trained to download and use the Expiwell app to capture via photographs/ screenshots (when and where possible) and describe individual cannabis advertising exposures that occurred within a nine-day study period through a brief (less than one minute) questionnaire. The questionnaire assessed for advertising channels (e.g., billboard, internet ad), message, and context (e.g., location, social context; list of channels and context items adapted from Martino et al., 2012; Shadel et al., 2012), followed by participants' *in-vivo* ratings of cannabis expectancies and use intentions. Participants also answered two daily randomly issued (control) prompts, which also involved questions regarding cannabis use expectancies, and future cannabis use intentions. Participant compensation included the selection of a $75 gift card (from Amazon, Best Buy, Sportcheck, Skip the dishes, President's Choice/Superstore, or Starbucks), five high school volunteer hours required for a high school diploma in Ontario, or two SONA credits if participants responded to 70% or more of the twice-daily random study prompts within a five-minute window. If participants responded to less than 70% of random of the random study prompts, they were provided with the same selection of a $50 gift card, three and a half high school volunteer hours, or one SONA credit.

All study procedures and materials were approved by Lakehead University's Research Ethics Board (REB).

EMA Training

Participant training occurred on day one of the study and was delivered by trained research assistants (CA, NM, BR, TS) via Zoom. Training included detailed descriptions and images defining each type of each cannabis advertising to be recorded throughout the duration of the study (See Martino et al., 2012) and how to record information related to each study exposure in the Expiwell app. Moreover, participants were trained to respond to the twice-daily, randomly scheduled daytime prompts that occurred between the hours of 10:30 AM and 10:00 PM, with one prompt occurring between 10:30 AM and 4:00 PM, and the second prompt occurring between 4:00

PM and 10:00 PM. These randomly scheduled prompts were issued to measure participants'

expectancies and intentions within neutral, non-advertising exposure moments, and will thus serve

as youths' own controls. Random prompts were also be used to assess for protocol adherence (i.e.,

that youth were carrying their personal cellphone and engaging with the study app). As discussed,

previous studies have shown that youth are highly adherent and comply with similar protocols, and

that they routinely carry study smartphones and respond within two minutes to approximately 80%

of randomly-issued (control) study prompts (Gwaltney et al., 2008; Noël et al., 2021; Scharf et al.,

2013; Van Zundert et al., 2010; Watson et al., 1988).

Mid and Exit Interviews

On study days four and nine, participants completed a mid- and exit-study interview,

respectively, to answer pre-planned questions regarding their study experience (i.e., ease of

completion for study procedures, technological issues encountered with the study app, lapses in

reporting exposures or other gaps in compliance). The mid-study session was completed over the

phone, while the exit session was completed via Zoom. During the exit session, participants were

provided with the opportunity to review and remove any pictures they had taken through the study

app that were unrelated to cannabis advertising, prior to submitting data to the research team.

Participant were also provided with compensation during their exit interview.

Protocol Reactivity

Upon exiting the study, youth were provided with a copy of Canada's Lower Risk Cannabis

Use Guidelines and parents/guardians received Canada's Cannabis Talk Kit: Know How to Talk

with Your Teen (https://www.drugfreekidscanada.org/wp-content/uploads/pdf/Cannabis-Talk-

Kit_EN.pdf) in order to mitigate any risk from attending to cannabis advertising throughout the

study period. Additionally, upon exit, youth were provided with information about substance use

resources for youth.

Measures - EMA Assessments

EMA Assessments

Participants completed a demographic questionnaire and psychosis risk measure during the baseline session. Following the baseline session, participants recorded and logged each cannabis advertising exposure event over 9 days in the Expiwell app by capturing (by photograph or screenshot) the advertisement (when/ where possible) and completing information about the exposure channel/type and context (location, social context), vividness of the exposure, and by assessing their cannabis use expectancies and intentions following exposure. Each item that was used in the study is described in detail below, and is adapted from previous studies using EMA to monitor alcohol and tobacco advertising (Martino et al., 2012; Scharf et al., 2013; Shadel et al., 2012) and validated for use with cannabis in Noël et al. (2021).

Demographics

Demographics including age, gender identity, school grades, ethnicity, and location of residence were assessed using select questions adapted from the Ontario Student Drug Use and Health Survey (OSDUHS) – secondary Form A at the end of baseline session through the Expiwell app. This survey is the longest Ontario-wide biennial cross-sectional cohort survey of youth grades 7 to 12 (Boak et al., 2017). Per the survey authors, concurrent validity of the survey is maximized by reusing various international guidelines, validated student surveys, scales and screeners to derive questions (Boak et al., 2017).

Cannabis Use History

Cannabis use history was assessed with the OSDUHS cannabis history item (Boak et al., 2017), "In the last 12 months, how often did you use cannabis (also known as marijuana, "weed", "pot", "grass", hashish, "hash", hash oil, etc.)?" Responses are "1–2 times", "3–5 times", "6–9 times", "10–19 times", "20–39 times", "40+ times"; "used, but not in the last 12mos"; "never used in lifetime"; "don't know what cannabis is". This substance use item of interest on the OSDUHS

was taken from the National Survey on Drug Use and Health (NSDUH), a primary source of data

for population-based prevalence estimates of mental health and substance use indicators in the U.S.

(Hedden et al., 2012). Statistics related to reliability among individuals 12 years of age or older may

be found in the 2006 NSDUH Reliability Study. Validation and diagnostic studies conducted on

substance use measures from the NSDUH provide evidence for good reliability of past year

substance use variables, including the past year cannabis use item, with an inter-rater reliability

statistic (kappa) of .75 (*SE* = .04) (Substance Abuse and Mental Health Services Administration,

2010).

Psychosis Risk

Psychosis risk was assessed using the Prevention through Risk Identification, Management,

and Education (PRIME; Miller, 2004) Screen Revised, developed by the Symptom Assessment in

Schizophrenia Prodromal States (SIPS; Miller et al., 1999) author group. This screening tool was

developed in an effort to simplify and increase efficiency in the screening of individuals for

psychosis-risk syndromes, which typically requires several hours of background education related

to the psychosis-risk assessment procedure, while such assessments themselves can take over an

hour to administer (e.g., the SIPS) (Owoso et al., 2014). The PRIME measure contains 12 Likert-

type items describing attenuated psychosis symptoms (sensory, psychological, emotional, and

social experiences) and asks respondents to choose from 7 response choices ranging from

"definitely disagree" to "definitely agree". Items scored as 5 (somewhat agree) or 6 (definitely

agree) are counted as positive responses, and the screener total is obtained by counting how many

items the respondent endorses by selecting 5 or 6 (response items). Items include statements such

as: "I think that I have felt that there are odd or unusual things going on that I can't explain", "I

wonder if people may be planning to hurt me or even may be about to hurt me", and "I have had the

experience of hearing faint or clear sounds of people or a person mumbling or talking when there is

no one near me". Authors of the tool recommend using a threshold of three or more 'somewhat

agree' (5) item endorsements or two scores or more of 'definitely agree' (6) item endorsements to

categorize positive versus negative responders. Using this cut-off, the PRIME screening instrument

shows a sensitivity of 0.90 and perfect specificity in comparison to SIPS-obtained diagnoses, an

assessment measure that has good validity and reliability and been used for more than 18 years

(Miller et al., 2003). The PRIME tool is identified as a successful screening tool for psychosis

vulnerability among youth and adolescents (Kline et al., 2012) with substantial predictive validity

shown by an overall psychosis transition risk at two years of 27.4%, and excellent reliability

demonstrated by an r_{icc} value of 0.95 for the total score and above 0.75 for all four subscales

(Fusar-Poli et al., 2012; Miller et al., 2003) . Moreover, reading grade level for this tool is estimated

to be appropriate for this study's targeted population, with a Flesch-Kincaid reading grade level

estimate of 6.8, and an average administration time of 1 minute and 40 seconds (Kline et al., 2012).

Advertising Channel Type and Context

Participants categorized each advertising exposure type (labelled as "I see an ad" in the

Expiwell app) as one of: print (within newspapers, magazine, or flyers), billboard/poster (including

billboards, signs and placards in arenas, stadiums, and shopping malls; and any other

advertisements placed outdoors, regardless of their size), internet (in between posts on social media

or the sides of webpages, and explicitly marked as "ads"), point of sale (window displays, cannabis

store signs in or at physical cannabis retailers), personal item (clothing, backpack, sticker), coupon

(e.g., coupons for cannabis products or free admission to a concert), sponsored activity (concert or

sports-event support, or support of individual athletes or musicians/actors), radio/podcast,

TV/movie/game, or promotion by public figure (social media posts on sites including Youtube,

Instagram or Snapchat about cannabis by creators or under topics [hashtags, subreddits] youth may

follow; See Noël et al., 2021; Shadel et al., 2012). The list of exposure types we used in the current

study was adapted from previous studies using EMA to monitor alcohol and tobacco advertising

(Martino et al., 2012; Scharf et al., 2013; Shadel et al., 2012). Participants were provided with multiple visual representations of each form of advertising during training (via PowerPoint).

Following advertising exposures and during study check-ins (random prompts), participants were also asked to report where they are (1 = 'School', 2 = 'Community centre', 3 = 'Outside in my neighbourhood', 4 = 'Outside somewhere else', 5 = 'Restaurant', 6 = 'Mall', 7 = 'Friend's house', 8 = 'Home', 9 = 'Car', 10 = 'Store', 11 = 'Bathroom', 12 = 'Other'), to describe their social context (who they are with; Alone, Alone – Socializing on-line, Parent, Sibling, Other relative, Friend, Boyfriend/Girlfriend, Classmate, Stranger, Other Adult), and what they are doing (1 = 'Internet browsing', 2 = 'TV/Music/Game', 3 = 'Talking', 4 = 'Exercise/Sports', 5 = 'Walking', 6 = 'Homework', 7 = 'Work', 8 = 'Eating/Drinking', 9 = 'Phone call', 10 = 'Lesson/Practice', 11 = 'Reading/Writing', 12 = 'Chores', 13 = 'Resting/Sleeping', 14 = 'Thinking/Planning', 15 = 'Other').

Cannabis Expectancies

Cannabis expectancies were measured following each exposure and during random (control) prompts questions related to the negative affect management from the Smoking Consequences Questionnaire (SCQ; Brandon & Baker, 1991), assessing participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1 (disagree) to 5 (agree), wherein higher scores indicate greater positive cannabis expectancies. SCQ Items assessing participants' cannabis expectancies were: "When I'm feeling down, cannabis can really make me feel good", "Cannabis is good for dealing with boredom", "When I'm alone, cannabis can help me pass the time", "When I'm upset with someone, cannabis helps me cope", "When I'm angry, cannabis can calm me down", and "Cannabis calms me down when I feel nervous". The SCQ is validated (α-coefficient = .90) for use with adolescent cigarette smokers (Wahl et al., 2005).

Intentions to Use Cannabis

Cannabis use intentions were assessed through cannabis-adapted items following each exposure and during random (control) prompts from the well-validated (α-coefficient = .91)

Smoking Intentions Scale (Choi et al., 2001), wherein higher scores indicate a stronger intention to

use cannabis. The items assessed participants' likelihood of using cannabis with three statements:

"Do you think you will use cannabis any time soon"?, "Do you think you will be using cannabis

one year from now"? "If one of your best friends were to offer you cannabis right now, would you

use it"? On a 5-point Likert scale from 1 (definitely not) to 5 (definitely yes).

Exposure Saliency

Exposure saliency of each cannabis advertising exposure was described with items

consistent with the advertising saliency self-report approach (Simola et al., 2011). These items

assessed participants' level of agreement with five questions: "About the cannabis marketing you

just saw: How vivid/ new/ noticeable was it? And how interested/ ashamed did it make you feel?"

on a five point-Likert scale from 1 (very slightly or not at all) to 5 (Extremely).

Analytic plan

Hypotheses, data sources and analyses are presented in Table 2.

Table 2

Analyses and Data Sources Addressing Study Hypotheses

Hypotheses	Data sources	Analyses
1) Cannabis companies reach Canadian youth through advertisements with a frequency that will be observable within the 9-day study observation period.	**Advertisement channels:** Participants' categorization of each advertising exposure (labelled as "I see an ad" in the Expiwell app) – see above "Advertisement channel and type" for a list of specified categories	Descriptive statistics (frequency, mean, standard deviation) for advertisement channels
2) Exposure to cannabis advertisements will increase cannabis expectancies and use intentions via momentary exposure effects in the overall sample, within the 9-day study observation period.	**Advertisement exposures:** Each advertising exposure labelled as "I see an ad" by study participants in the Expiwell app. **Expectancies:** aggregate measure with six questions related to cannabis expectancies during each advertising exposure labelled as "I see an ad", and during non-exposure moments captured through random study prompts	**HLM 1:** (covariates: ever-cannabis use, time) **IV:** advertisement exposure **DV:** cannabis expectancies **HLM 2:** (covariates: ever-cannabis use, time) **IV:** advertisement exposure

	Use intentions: an aggregate measure of the likelihood of using cannabis with three statements during each advertising exposure labelled as "I see an ad", and during non-exposure moments captured through random study prompts	**DV:** cannabis use intentions
Demographic and psychosis risk variables will predict differences in youth expectancies and use intentions via momentary cannabis advertising exposure effects in the overall sample, within the 9-day study observation period: 3a) urban vs. rural: Youth living in rural locations will have a greater increase in cannabis use expectancies and use intentions, following advertisement exposures, as compared to those living in urban locations 3b) ethnicity: Ethnic minorities will have a greater increase in cannabis use expectancies and use intentions, following advertisement exposures 3c) age: Compared to younger youth, older youth will have a greater increase in cannabis use expectancies and use intentions, following advertisement exposures 3d) gender: Marginalized gender groups (e.g., transgender, gender neutral, non-binary, agender, gender queer, two-spirit) and females will have a greater increase in cannabis use expectancies and use intentions following advertisement exposures, than females 3e) psychosis risk: Youth at risk of psychosis will have a greater increase in cannabis use expectancies and use intentions following advertisement exposures than those who are not at risk	**Demographics**: including age, gender identity, school grades, ethnicity, cannabis use history and location of residence assessed using select questions adapted from the Ontario Student Drug Use and Health Survey (OSDUHS) – secondary Form A at the end of baseline session through the Expiwell app. See Appendix C for a list of specified options for demographic categories **Psychosis risk (yes/no)**: assessed using the Prevention through Risk Identification, Management, and Education (PRIME; Miller, 2004) Screen Revised administered during the baseline test session **Expectancies:** aggregate measure with six questions related to cannabis expectancies during each advertising exposure labelled as "I see an ad", and during non-exposure moments captured through random study prompts. **Use intentions:** an aggregate measure of the likelihood of using cannabis with three statements during each advertising exposure labelled as "I see an ad", and during non-exposure moments captured through random study prompts	**HLM 1 (separately for each sociodemographic, psychosis risk predictor) :** (covariates: ever-cannabis use, time) **IV:** advertisement exposure, psychosis risk….. **DV:** cannabis expectancies Interaction terms: Exposure*psychosis risk… **HLM 2 (separately for each sociodemographic, psychosis risk predictor):** (covariates: ever-cannabis use) **IV:** advertisement exposure, psychosis risk… **DV:** cannabis use intentions Interaction terms: Exposure*psychosis risk…

Qualitative Analyses

Qualitative Coding of Cannabis Marketing Images

The list of exposure types we used in the current study was adapted from previous studies using EMA to monitor alcohol and tobacco advertising (Martino et al., 2012; Scharf et al., 2013; Shadel et al., 2012) and validated for use with cannabis in Noël et al. (2021). We coded the first 30 images together to refine the list of codes and create consensus. After that, teams of two researchers double-coded the remaining images. We met as a group to discuss inconsistencies which were resolved through discussion to create consensus.

Quantitative Analyses

Descriptive Statistics

I used descriptive statistics to report on the overall sample demographics and compliance rate. Further descriptive statistics were used to present advertising channel types and context and to test hypothesis 1.

Compliance

Before calculating EMA compliance, we dropped device-issued control prompts from the denominator that occurred within school hours and on school days. In other words, our calculation of compliance excluded prompts that participants could not answer due to being in school. We also assessed how app and device functionality may have impacted compliance by comparing compliance rates between individuals who reported encountering functionality issues with app, versus those who did not.

Multivariate Analyses

Due to the structure of the data, where EMA surveys are nested within participants (Raudenbush & Bryk, 2002), to determine the effects of advertising exposure(s) (independent

predictor variable) on cannabis expectancies and intentions to use (continuous outcomes/ dependent

variables), I created separate mixed effects regression models, a type of multilevel model (MLM,

also known as hierarchical linear mixed models; HLMs). This allowed for a comparison of

cannabis-related expectancies and intentions between moments of exposure to cannabis

advertisements (event reports) and non-exposure (random prompts/ control reports). Separate

HLMs allowed us to account for variability within (Level 1, advertising exposure vs. non-exposure

expectancy and intentions ratings) and between (Level 2, across occasions) individuals in the study.

These models are well suited for EMA as they can handle repeated assessments within individuals

over the study period while accounting for data dependency of observations within individuals

(Schwartz & Stone, 2007). Additionally, they allow for an unequal number of observations across

individuals, thus allowing to include subjects regardless of data 'completeness' and preventing the

aggregation of data across study days (Schwartz & Stone, 2007). To test hypotheses 2 through 3e,

all HLMs included ever-cannabis use and time as a fixed effect and were run with random

intercepts and compound symmetry. All models also included sampling event as a repeated

measure, subject and intercept as random effects, and advertising exposure as a fixed effect.

      To test hypotheses 3a to 3e, we ran two separate models for each outcome and

sociodemographic predictor, all using cross-level interactions at Level 2 to investigate the

hypothesized moderating effect of demographic factors (urbanicity, gender, ethnicity, age) and

psychosis risk (yes/no) on the relationship between advertising exposures and cannabis

expectancies and use intentions, controlling for ever-cannabis use and time.

Results

Participant Demographics and Baseline Characteristics

Participant demographics and baseline characteristics for our sample of 120 youth are presented in Table 3.

Table 3

Sample Demographics and Baseline Characteristics

Sample variable	n	%
Age		
14	38	31.67
15	19	15.83
16	18	15.00
17	11	9.17
18	34	28.83
Total	N	M(*SD*)
	120	15.87 (1.63)
	n	%
Education Level		
8th Grade	15	12.5
9th Grade	28	23.33
10th Grade	20	16.67
11th Grade	14	11.67
12th Grade	11	9.17
1st or 2nd Year University or College	32	26.67
Total	120	100.00
Gender		
Female	65	54.17
Male	50	41.67
Refused/ Prefer not to say	3	2.50
Transgender	2	1.67
Total	120	100.00
Race		
White	65	54.17
South Asian	16	13.33
Multiracial	12	10.00
All other groups n < 10	27	22.50
Total	120	100.00
Location Data Based on the First Letter of Participant's Postal Code (Statistic Canada, 2018)		
Eastern Ontario (K)	13	10.83
Central Ontario (L)	45	37.50
Metropolitan Toronto (M)	16	13.33
Southwestern Ontario (N)	13	10.83
Northern Ontario (P)	32	26.67
Not reported	1	00.83
Total	120	100.00
Urban/ Rural Residence		
Urban	101	84.17

Rural	18	15.00
Not reported	1	00.83
Total	120	100.00
Lifetime Cannabis Use History		
Never Used	79	65.83
1-5 times in the past year	18	15.00
6+ times in the past year	18	15.00
Used but not in the last 12 months	5	4.17
Total	120	100.00
Psychosis Risk		
Yes	37	30.83
No	83	69.17
Total	120	100.00

The mean age of participants was 15.87 (SD = 1.63) years of age, with more than half (n = 72; 60.00%) being 14 years of age (n = 38; 31.67%) or 18 years of age (n = 34; 28.83%). Participants were predominantly female (n = 65; 54.17%) and White (n = 65; 54.17%), residing in diverse locations throughout the province of Ontario, with most participants stating that they lived in either Central (n = 45; 37.50%) or Northern (n = 32; 26.67%) Ontario. The majority (n = 101; 84.17%), of participants reported living in urban (as opposed to rural or suburban) areas.

Baseline Measures of Cannabis Use History and Psychosis Risk

On the OSDUHS cannabis history item (Boak et al., 2017), 65.83% (n = 79) of participants reported never using cannabis in their lifetime. Of those with any cannabis use history, 15.00% (n = 18) indicated frequent use (defined as using cannabis six or more times in the past year) while 15.00% (n = 18) indicated nonproblematic (i.e., infrequent) use (defined as using cannabis less than six times within the past year). Just under 5% (4.17%; n = 5) reported a history of cannabis use but no use within the past year (n = 5). Based on the PRIME (Miller et al., 2004) psychosis risk measure and its established scoring bands, 30.83% of participants were classified as at risk of psychosis (n = 37) because they answered three or more items as 'somewhat agree' (5) *or* two or more of items as 'definitely agree' (6).

Compliance: EMA Random Prompt Completion Rates and Self-reported Compliance

Before calculating EMA compliance, we dropped device-issued control prompts from the denominator that occurred within school hours and on school days. In other words, our calculation of compliance excluded prompts that participants could not answer due to being in school. We did this because non-response at those times was outside of participants' control and not indicative of willful protocol non-adherence. Using this criterion, we dropped $M = 1.84$ ($SD = 1.52$; range $0 - 5$) device-issued control per participant. This resulted in participants' compliance rates being calculated from an average denominator of 15.16 device-issued random prompts instead of 17 device-issued random prompts.

After omitting control prompts that occurred within school hours on school days, we examined how app and device functionality may have impacted compliance since a subset of participants' responses to control prompts were impacted by the functionality issues with the app. Twenty-seven (22.50%) participants reported app problems, and among this subset, compliance was low, with a mean response rate of 43.02% ($SD = 19.71$; range $5.88 - 76.92\%$) to the 17 device-issued random prompts. For those with no reported app functional issues ($n = 93$), compliance was higher: Participants responded to an average of 66.91% ($SD = 21.26$; range $6.25 - 100\%$) of random prompts within 5 minutes of the alarm. Overall, when we included both subsets of participants (i.e., those with and without technical issues), rates of compliance were moderate (67.95%) and comparable to prior research with similar protocols and populations (Gwaltney et al., 2008; Noël et al., 2021; Scharf et al., 2013; Van Zundert et al., 2010; Watson et al., 1988).

We also conducted sensitivity analyses in which we ran Hierarchical Linear Mixed Models with a subset of the sample that had a minimum raw (i.e., uncorrected for device-issued control prompts occurring within school hours on school days) compliance rate of 50% ($n = 80$ participants). Overall, the results were essentially the same as those that follow; therefore, analyses presented here utilize the entire sample to maximize study power.

Descriptive Statistics for Real-Time Data

Overall, the final data set included 357 ad exposures and 1,161 completed random prompts from 120 participants over nine study days. Most ($n = 85$; 70.83%) participants reported at least one cannabis advertisement exposure during the 9-day study (minimum = 1, maximum = 30). On average, participants reported 4.02 ($SD = 4.70$) exposures and responded to 9.55 ($SD = 3.98$) random prompts.

Advertising Exposure Frequency by Channel Type

Table 4 presents the frequency of cannabis advertising exposures by advertising type. Participants were primarily exposed to advertisements through point of sale ($n = 142$; 40.06%), billboards and posters ($n = 53$; 14.85%), promotions through public figures ($n = 50$; 14.01%), personal items ($n = 45$; 12.61%), and the internet ($n = 29$; 8.12%). Figure 3 presents an illustrative selection of participant-submitted advertising exposures for each most frequently encountered advertising type.

Table 4

Advertising Exposure Frequency by Type

	N	**%**
Advertisement type		
Print	1	0.28
Billboard/ poster	53	14.85
Internet	29	8.12
Point of sale	143	40.06
Personal item	45	12.61
Coupon	1	0.28
Radio/Podcast	4	1.12
TV/ movie/ game	16	4.48
Promotion by public figure	50	14.01
Unknown/ Other	4	1.12
Not an advertising exposure	11	3.08
Total	357	100
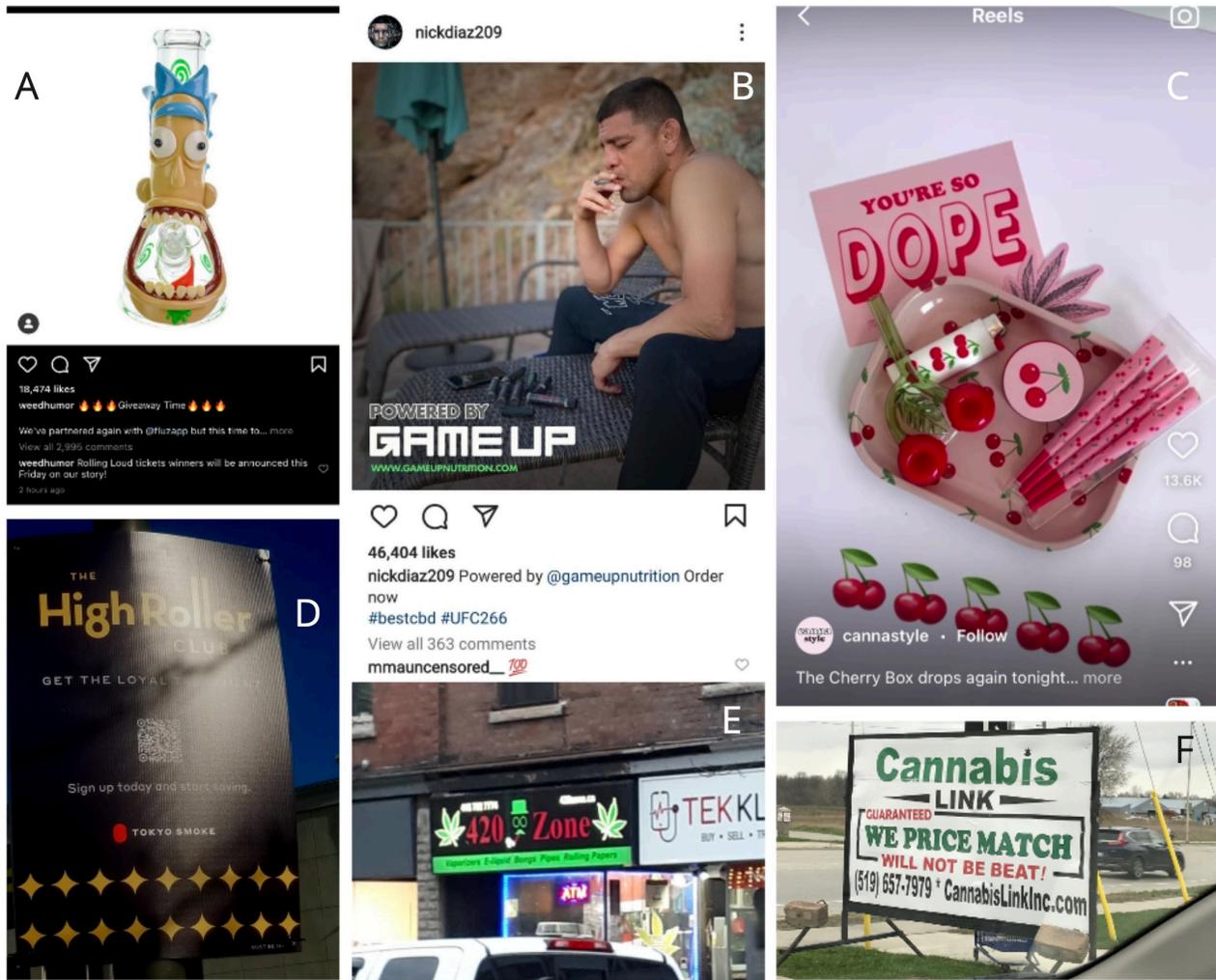
Figure 3

Participant Submissions of Cannabis Advertising Exposures

Note. This figure shows a submission of marketing exposures through the following advertisement types: A) and B)

Promotion by public figure, C) Internet advertisement, D) and F) Billboard/ Poster, and E) Point of sale.

Mean Cannabis Expectancies and Use Intentions by EMA Entry Type

We calculated within-person means for cannabis expectancies and use intentions separately

for control prompts and momentary exposure to cannabis advertisements. Mean expectancies and

use intentions for the overall sample are in Table 5, categorized by entry type (control prompt vs.

exposure to cannabis advertisement). Mean expectancies and use intentions for the overall sample,

grouped by each hypothesized moderating predictor (i.e., cannabis use history, urbanicity, ethnicity,

age, gender, and psychosis risk), and categorized by entry type (control prompt vs. exposure to

cannabis advertisement) are in Table 6.

Table 5

Within-Participant Mean Expectancies and Use Intentions by EMA Entry Type

	Outcome								
	Cannabis expectancies					Cannabis use intentions			
EMA entry type	N	*Mean*	*Min*	*Max*	*SD*	N	*Mean*	*Min*	*Max*	*SD*
Control prompt	120	1.16	0.50	4.99	1.07	120	1.35	0.50	5.00	1.26
Cannabis advertising exposure	85	1.30	0.50	5.00	1.19	85	1.51	0.50	5.00	1.39

Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with questions related to the

negative affect management from the Smoking Consequences Questionnaire (Brandon & Baker, 1991), assessing

participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1

(disagree) to 5 (agree). Cannabis use intentions were assessed through cannabis-adapted items from the Smoking

Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-

point Likert scale from 1 (definitely not) to 5 (definitely yes).

Table 6

Within-Participant Mean Expectancies and Use Intentions by Hypothesized Moderating Predictors

and EMA Entry Type

	Outcome							
	Cannabis expectancies				Cannabis use intentions			
EMA entry type	Control prompt		Cannabis advertising exposure		Control prompt		Cannabis advertising exposure	
Hypothesized predictor	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Cannabis use history								
1-5 times in past year	1.18	0.76	1.14	0.85	1.48	0.94	1.57	0.98
6+ times in past year	2.63	1.47	2.98	1.46	3.38	1.53	3.75	1.53
Used but not in past 12 months	1.68	0.99	2.92	0.79	1.60	1.39	2.46	1.88
Never used	0.79	0.64	0.88	0.72	0.86	0.59	0.94	0.69
Urbanicity								
Core	1.25	1.16	1.31	1.24	1.47	1.37	1.58	1.44
Fringe	0.69	0.32	1.05	0.50	0.67	0.17	0.82	0.14
Rural area inside CMA or CA	1.12	0.83	1.40	1.02	1.38	0.98	1.59	1.27
Population centre outside CMA or CA	1.35	1.79	1.33	1.12	1.76	1.74	1.78	1.73
Rural area outside CMA or CA	0.80	0.82	0.93	0.95	1.00	0.69	0.84	0.57
Secondary core	1.07	0.71	1.63	1.10	0.89	0.54	1.48	0.57
Ethnicity								
Other	1.35	1.40	1.36	1.42	1.51	1.64	1.45	1.60
South Asian	1.23	0.98	1.11	0.94	1.20	1.10	1.01	0.67
White	1.10	1.00	1.34	1.15	1.37	1.17	1.67	1.38
Multiracial	1.05	0.64	1.09	0.49	1.29	0.81	1.54	0.93
Age								
14	0.89	0.91	0.92	1.01	0.87	0.83	0.89	0.94
15	0.94	0.75	0.91	0.61	1.28	1.02	1.19	0.86
16	1.20	1.15	1.62	1.36	1.49	1.34	2.01	1.46
17	1.30	1.11	1.37	1.12	1.30	1.24	1.48	1.33
18	1.53	1.23	1.67	1.32	1.93	1.49	2.11	1.58
Gender								
Female	1.19	1.10	1.30	1.19	1.39	1.29	1.51	1.40
Male	1.08	0.95	1.16	1.03	1.23	1.10	1.30	1.18
Other	1.68	1.67	2.34	1.78	2.39	1.73	3.51	0.99
Psychosis risk								
No	1.01	0.91	1.08	1.07	1.20	1.67	1.32	1.31
Yes	1.55	1.31	1.70	1.31	1.73	1.39	1.85	1.43

Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with questions related to the

negative affect management from the Smoking Consequences Questionnaire (Brandon & Baker, 1991), assessing

participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1

(disagree) to 5 (agree). Cannabis use intentions were assessed through cannabis-adapted items from the Smoking

Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-

point Likert scale from 1 (definitely not) to 5 (definitely yes). Geographical definitions of population centre type specified in the most recent Canadian census (Statistics Canada, 2022) are used to categorize participant "urbanicity". *CMA* = Census Metropolitan Area. *CA* = Census Agglomeration. A CMA or CA is formed by one or more adjacent municipalities centred on a population centre (known as the core). A CMA must have a total population of at least 100,000 of which 50,000 or more must live in the core. A CA must have a core population of at least 10,000. *Fringe* = small population centres with a population count of less than 10,000. All areas inside the CMA or CA that are not population centres are rural. *Secondary core* = Population centre within a CMA that has at least 10,000 persons and was the core of a CA that has been merged with an adjacent CMA.

Hierarchical Linear Mixed (HLM) Modelling

Estimation Method

By default, PROC MIXED uses restricted maximum likelihood (REML) to estimate all unknown variance-covariance parameters (Jennrich & Schluchter, 1986). As missing data is common in research involving repeated measures of assessment, multilevel modelling with maximum likelihood (ML) estimates is the preferred approach (Bryk & Raudenbush, 1992; Schwartz & Stone, 1998) because it makes use of all available data (both at the within-person and between-persons levels) to estimate the model parameters (Snijders & Bosker, 2012). Thus, this was the approach I used for all HLM analyses.

Preliminary Model Building

I used separate unconditional means models (i.e., empty, or null models containing no fixed effects, only a random intercept) to determine the Intraclass Correlation (ICC) (Hox & Maas, 2001) for the two dependent outcome variables: cannabis expectancies and use intentions. Output for the unconditional means models for both cannabis expectancies and use intentions outcome variables are presented in Tables 7-10. The ICC represents the proportion of variance in the outcome that is between (vs. within) individuals and may be thought of as a "clustering coefficient" or an average correlation between repeated observations (Raudenbush & Bryk, 2002). This ratio of between-subject error variance over the total error variance is an indicator of the amount of variance

subsequent predictors added to the models have the potential to explain (Raudenbush & Bryk, 2002). ICCs range from 0 to 1, where a high ICC value indicates that the dependent variable is highly correlated over time within subjects and that there is more potential for predictors to account for between-subject variability, whereas a low ICC value suggests there is a weak correlation of the dependent variable within-subjects, and thus there is more potential for predictors to explain variability within-subject over time (Raudenbush & Bryk, 2002).

As suggested by Raudenbush and Bryk (2002), the decision to proceed with a multilevel analysis depends partly on the extent of between-group variation versus within-group variation. As such, to determine the proportion of total variance explained by individual differences (i.e., the ICC), I tested fully unconditional models separately for each dependent outcome variable (cannabis expectancies and use intentions, respectively). With 97% of the total variance in youth cannabis expectancies residing between individuals and 3% residing within individuals, and 91% of the total variance in youth cannabis use intentions residing between individuals and 9% residing within individuals, I determined that proceeding with a multilevel HLM analysis was the appropriate analysis in comparison to traditional regression models.

Table 7

Covariance Parameter Estimates for the Cannabis Expectancies Unconditional Means Model

Covariance Parameter Estimates					
Cov Parm	Subject	*Estimate*	*SE*	Z Value	Pr > Z
Intercept	ParticipantID	1.15	0.15	7.59	<.0001
Residual	ParticipantID	0.08	0.00	25.86	<.0001

Note. Cov Parm = Covariance Parameter.

Table 8

Fixed Coefficients for the Cannabis Expectancies Unconditional Means Model

Fixed Effects Model Term					95% CI	
	Estimate	*SE*	*T*	*P*	Lower	Upper
Intercept	1.17	0.10	11.70	<.0001	0.97	1.36

Table 9

Covariance Parameter Estimates for the Cannabis Use Intentions Unconditional Means Model

Covariance Parameter Estimates					
Cov Parm	Subject	*Estimate*	*SE*	Z Value	Pr > Z
Intercept	ParticipantID	1.58	0.21	7.64	<.0001
Residual	ParticipantID	0.16	0.01	26.20	<.0001

Note. Cov Parm = Covariance Parameter.

Table 10

Fixed Coefficients for the Cannabis Use Intentions Unconditional Means Model

Fixed Effects Model Term					95% CI	
	Estimate	*SE*	*T*	*p*	Lower	Upper
Intercept	1.36	0.12	11.77	<.0001	1.14	1.59

Selection of Covariance Type

For all analyses, covariance type was selected through examination of the unconditional means (i.e., an empty or null model containing no fixed effects, only the random intercept) under different structures. Akaike information criterion (AIC) scores and Bayesian information criterion (BIC) scores were used to assess the overall fit (Aho et al., 2014; Burnham & Anderson, 2004; Kuha, 2004).

For random effects, I specified an *unstructured covariance (UN) matrix* (RANDOM statement). Because of the repeated measures design with varying time lags between individual assessments, the level-1 error terms cannot be expected to be uncorrelated (Bolger & Laurenceau, 2013).

I included a random intercept in all models after previously determining that there was variability in participants' mean scores on the dependent variable both between- and within persons (Snijders & Bosker, 2012). In both the central and exploratory analyses, I entered predictor variables at level-1 (within persons) and level-2 (between persons) as fixed effects. As predictors at both levels may influence measured outcomes, this allows me to control for possible confounding variables and other predictors of interest at both levels. To account for the presumed *autocorrelation of (level-1) error terms,* I chose a covariance structure allowing for the modeling of interdependencies among error terms as a function of temporal sequencing within a subject, [i.e. accounting for the fact that residuals from adjacent assessments in a given subject are more likely to be similar in magnitude than residuals from two assessments further apart in time], type = AR(1) or "autoregressive model of order 1" (Gunter et al., 2020).

Prior to conducting multivariate analyses, I screened the data for violations of assumptions such as potential violations of normality, linearity, and homogeneity of variance (Bell et al., 2010). Following analyses, I examined model convergence to rule out any serious violation of model assumptions. Further detail and justification related to data screening procedures and estimation of degrees of freedom for the fixed effects is in Appendix D.

Variables that were not included in the analyses and the reasons for their exclusion are listed below:

- Urbanicity (in both the model predicting expectancies and the model predicting use intentions from advertisement exposure) - limited variability and not significantly related to model fit; and

- Ethnicity (in both the model predicting expectancies and the model predicting use intentions from advertisement exposure) - limited variability and not significantly related to model fit.

Cannabis Expectancies Following Cannabis Advertisement Exposures

Tables 11 and 12 present fixed and random effects, and coefficients for the general model predicting cannabis expectancies from cannabis advertising exposure events versus random prompts. The main effect of cannabis advertising exposure on real-time expectancies was nonsignificant ($\beta = .02$, $SE = .03$; $t = 0.75$; $p = .45$; n [hereafter, number of observations] $= 1,313$) in covariate-adjusted analyses.

Table 11

Fixed Effects for Cannabis Advertising Exposure by Cannabis Expectancies Following Exposure

	F	df1	df2	p
Continuous Time	2.69	1	1,313	0.10
Cannabis Use History	22.42	3	1,313	<0.0001
Cannabis Advertising Exposure	0.56	1	1,313	0.45

Table 12

Fixed Coefficients for Cannabis Advertising Exposure by Cannabis Expectancies Following Exposure

Fixed Effects Model Term	Estimate	SE	T	p	95% CI Lower	Upper
Intercept	0.76	0.10	7.59	<.0001	0.56	0.96
Continuous Time	3.79E-6	2.31E-6	1.64	0.10	-7.45E-7	8.33E-6
Cannabis Use History[a]						
1-5 times in past year	0.41	0.23	1.79	0.07	-0.04	0.87
6+ times in past year	1.83	0.23	8.08	<.0001	1.38	2.27
Used but not in past 12 months	0.91	0.40	2.28	0.02	0.13	1.69
Cannabis Advertising Exposure[b]	0.02	0.03	0.75	0.45	-0.03	0.07

Note. [a] Never used = ref. [b] Control prompt = ref.

Figure 4 presents unadjusted mean participant expectancies by exposure conditions (i.e., mean expectancies in the presence of an *in vivo* advertisement exposure vs. during control assessments).

Figure 4

Mean Participant Cannabis Expectancies by EMA Entry Type
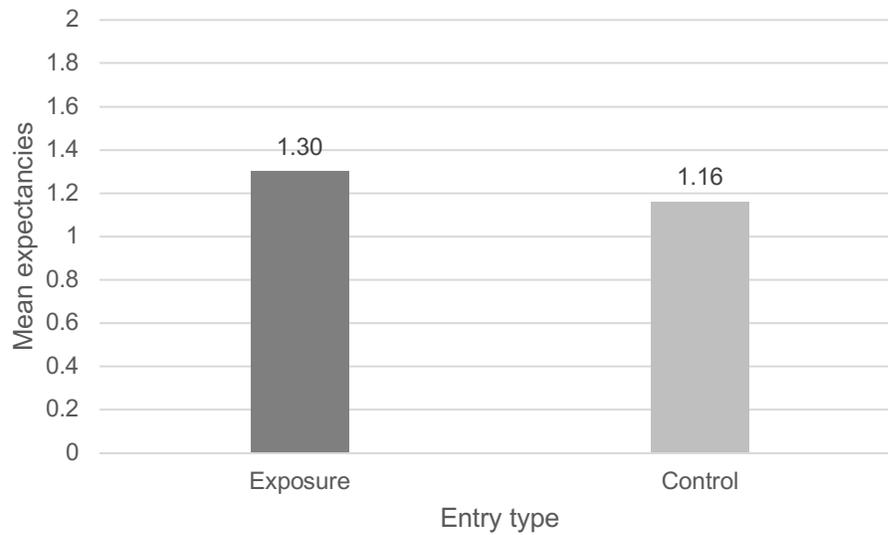
Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with cannabis-adapted negative affect management items from the Smoking Consequences Questionnaire (Brandon & Baker, 1991). Items assessed participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1 (disagree) to 5 (agree).

Cannabis Use Intentions Following Cannabis Advertisement Exposures

Tables 13 and 14 present fixed and random effects, and coefficients for the general model predicting cannabis use intentions from cannabis advertising exposure events versus random prompts. The main effect of cannabis advertising exposure on real-time cannabis use intentions was significant ($\beta = .06$, $SE = .03$; $t = 1.98$; $p = .04$; $n = 1,348$) in covariate-adjusted analyses.

Table 13

Fixed Effects for Cannabis Advertising Exposure by Cannabis Use Intentions Following Exposure

	F	df1	df2	p
Continuous Time	4.56	1	1,348	0.03
Cannabis Use History	38.07	3	1,348	<.0001
Cannabis Advertising Exposure	3.93	1	1,348	0.04

Table 14

Fixed Coefficients for Cannabis Advertising Exposure by Cannabis Use Intentions Following Exposure

Fixed Effects					95% CI	
Model Term	*Estimate*	*SE*	*T*	*p*	Lower	Upper
Intercept	0.82	0.11	7.78	<.0001	0.61	1.03
Continuous Time	6.43E-6	3.01E-6	2.14	0.03	5.26E-7	0.00
Cannabis Use History[a]						
1-5 times in past year	0.62	0.24	2.54	0.01	0.14	1.09
6+ times in past year	2.53	0.24	10.66	<.0001	2.06	2.99
Used but not in past 12 months	0.74	0.42	1.76	0.07	-0.09	1.56
Cannabis Advertising Exposure[b]	0.06	0.03	1.98	0.04	0.00	0.12

Note. [a] Never used = ref. [b] Control prompt = ref.

Figure 5 presents unadjusted mean participant use intentions in relation to exposure conditions (i.e., mean use intentions in the presence of an *in vivo* advertisement exposure vs. during control assessments).

Figure 5

Mean Participant Cannabis Use Intentions by EMA Entry Type
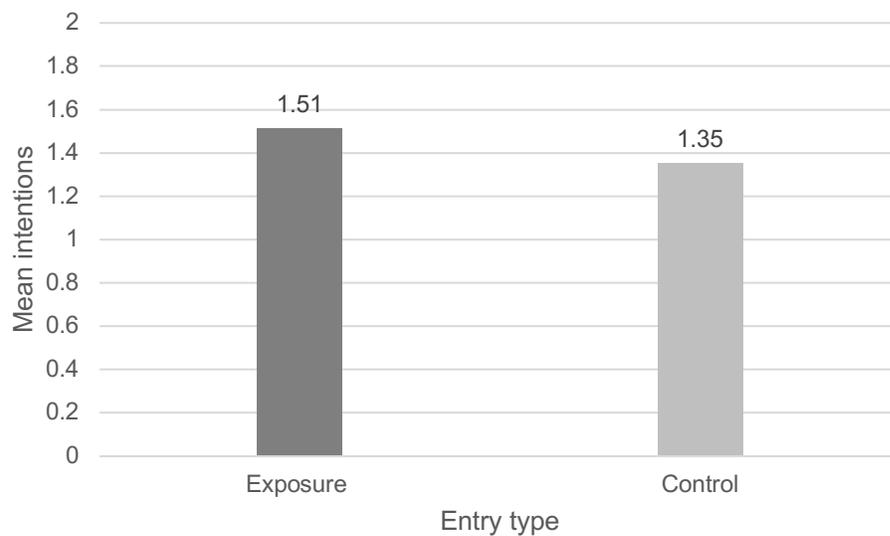
Note. EMA = Ecological Momentary Assessment. Cannabis use intentions were assessed through cannabis-adapted items from the Smoking Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-point Likert scale from 1 (definitely not) to 5 (definitely yes).

Cannabis Use History Effects on Cannabis Expectancies and Use Intentions

Although it was not the focus of my analyses, analyses (see Tables 10-13) show that the main effects of cannabis use history on both real-time cannabis expectancies and use intentions were significant. Unadjusted mean cannabis expectancies and use intentions for these model interactions are illustrated in Figures 6 and 7.

Figure 6

Mean Participant Cannabis Expectancies by EMA Entry Type and Cannabis Use History

Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with questions related to negative affect management from the Smoking Consequences Questionnaire (Brandon & Baker, 1991), assessing participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1 (disagree) to 5 (agree).

Figure 7

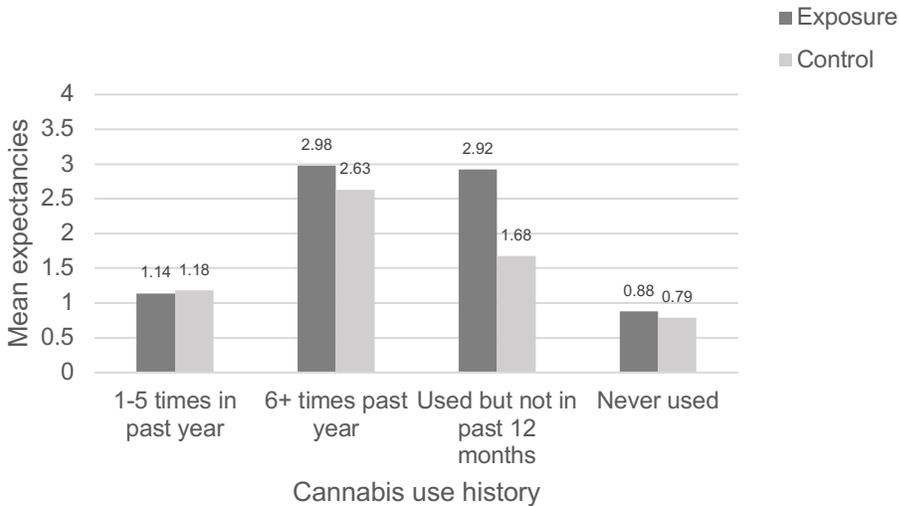*Mean Participant Cannabis Use Intentions by EMA Entry Type and Cannabis Use History*
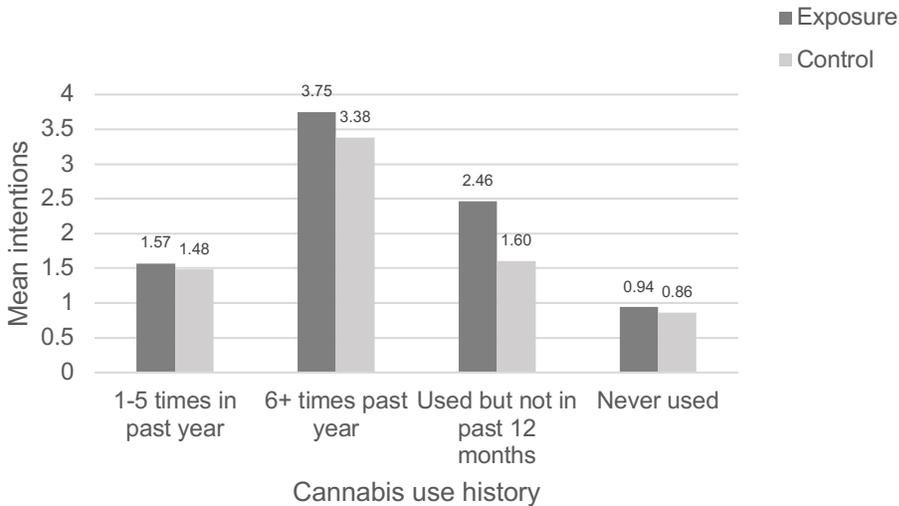
Note. EMA = Ecological Momentary Assessment. Cannabis use intentions were assessed through cannabis-adapted items from the Smoking Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-point Likert scale from 1 (definitely not) to 5 (definitely yes).

Moderating Effects of Demographic and Psychosis Risk Predictors on Cannabis Expectancies and Use Intentions Following Cannabis Advertisement Exposures

Tables 15-26 present fixed effects and fixed coefficients for models predicting cannabis expectancies from cannabis advertising exposure events (versus random prompts), demographic characteristics and psychosis risk. In other words, the purpose of this analysis was to determine if demographic and psychosis risk variables predicted youth cannabis expectancies and use intentions following ad exposures and control prompt throughout the 9-day study period. Given that urbanicity and ethnicity had limited variability, and that models including these variables were not significantly related to model fit, Hierarchical Linear Mixed Models containing these variables are not presented. Unadjusted mean cannabis expectancies and use intentions for all predicted model interactions are in Figures 8-17.

Figure 8

Mean Participant Cannabis Expectancies by EMA Entry Type and Urbanicity
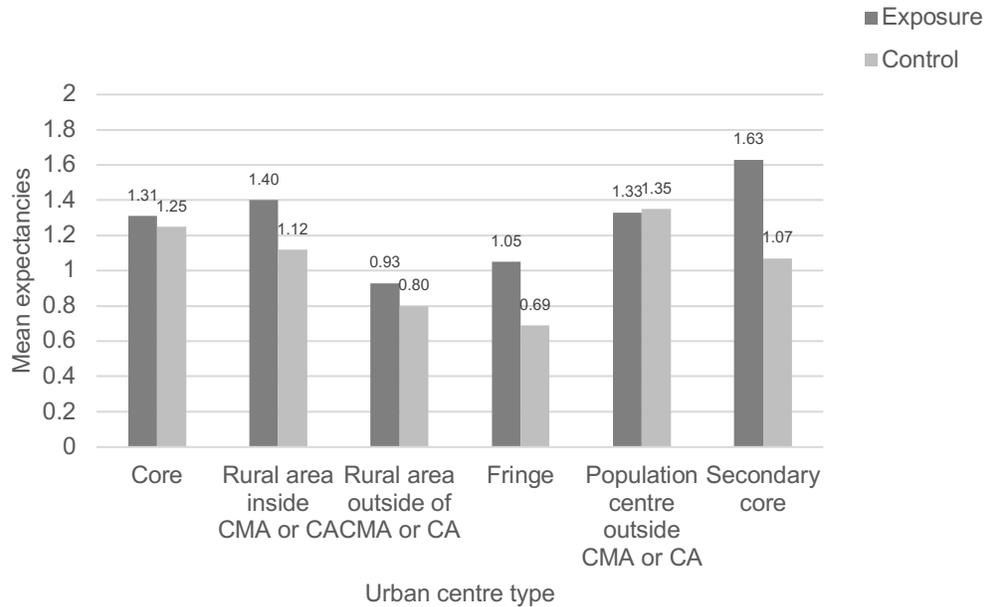
Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with questions related to negative affect management from the Smoking Consequences Questionnaire (Brandon & Baker, 1991), assessing participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1 (disagree) to 5 (agree). Geographical definitions of population centre type specified in the most recent Canadian census (Statistics Canada, 2022) are used to categorize participant "urbanicity". *CMA* = Census Metropolitan Area. *CA* = Census Agglomeration. A CMA or CA is formed by one or more adjacent municipalities centred on a population centre (known as the core). A CMA must have a total population of at least 100,000 of which 50,000 or more must live in the core. A CA must have a core population of at least 10,000. *Fringe* = small population centres with a population count of less than 10,000. All areas inside the CMA or CA that are not population centres are rural. *Secondary core* = Population centre within a CMA that has at least 10,000 persons and was the core of a CA that has been merged with an adjacent CMA.

Figure 9

*Mean Participant Intentions by EMA Entry Type and Urbanicity*

Note. EMA = Ecological Momentary Assessment. Cannabis use intentions were assessed through cannabis-adapted items from the Smoking Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-point Likert scale from 1 (definitely not) to 5 (definitely yes). Geographical definitions of population centre type specified in the most recent Canadian census (Statistics Canada, 2022) are used to categorize participant "urbanicity". *CMA* = Census Metropolitan Area. *CA* = Census Agglomeration. A CMA or CA is formed by one or more adjacent municipalities centred on a population centre (known as the core). A CMA must have a total population of at least 100,000 of which 50,000 or more must live in the core. A CA must have a core population of at least 10,000. *Fringe* = small population centres with a population count of less than 10,000. All areas inside the CMA or CA that are not population centres are rural. *Secondary core* = Population centre within a CMA that has at least 10,000 persons and was the core of a CA that has been merged with an adjacent CMA.

Figure 10

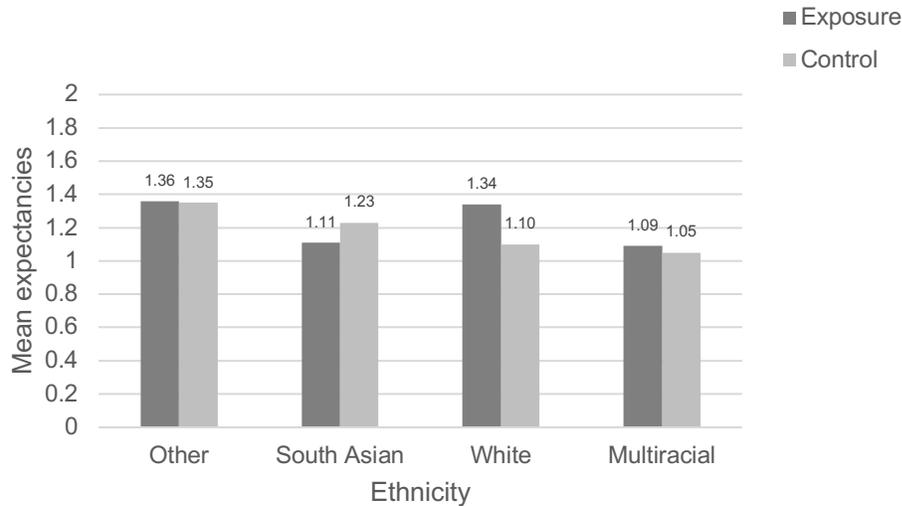*Mean Participant Cannabis Expectancies by EMA Entry Type and Ethnicity*

Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with questions related to negative affect management from the Smoking Consequences Questionnaire (Brandon & Baker, 1991), assessing participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1 (disagree) to 5 (agree).

Figure 11
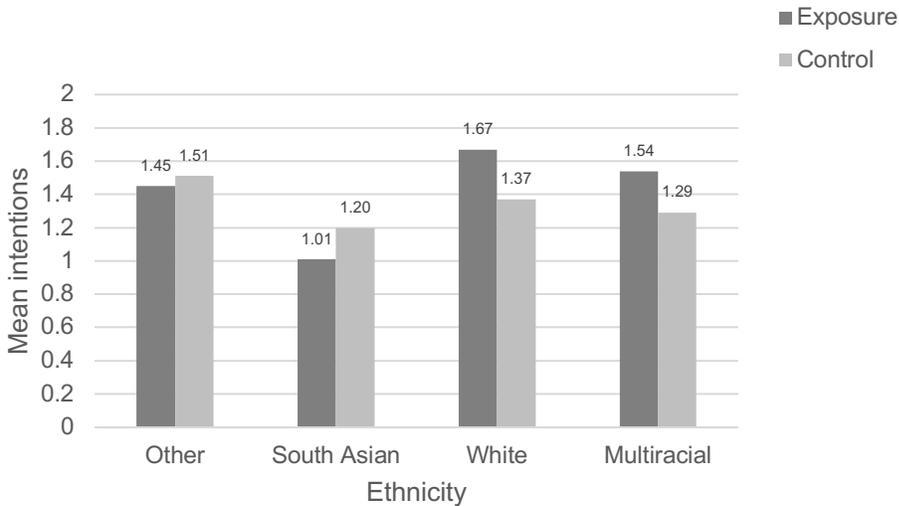
Mean Participant Cannabis Use Intentions by EMA Entry Type and Ethnicity

Note. EMA = Ecological Momentary Assessment. Cannabis use intentions were assessed through cannabis-adapted items from the Smoking Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-point Likert scale from 1 (definitely not) to 5 (definitely yes).

Age

Tables 15 and 16 present fixed and random effects, and coefficients for the general model predicting cannabis expectancies from cannabis advertising exposure events versus random prompts, and the interaction between age and cannabis advertising exposure events versus random prompts. Tables 17 and 18 present fixed and random effects, and coefficients for the general model predicting cannabis use intentions from cannabis advertising exposure events versus random prompts, and the interaction between age and cannabis advertising exposure events versus random prompts.

The main effect of age on real-time cannabis use intentions was significant ($p = .02$; $n = 1,344$) in covariate-adjusted analyses, indicating that participants' age was associated with variability in their real-time cannabis use intentions at times of cannabis advertising exposure as well as during the completion of random prompts. However, the main and interaction effects of predictors on real-time cannabis use expectancies were nonsignificant in covariate-adjusted analyses, indicating that regardless of age group, all participants experienced similar mean increases in cannabis expectancies in response to cannabis adverting exposures compared to random control times of the day. Interaction effects of predictors on real-time cannabis use intentions were also nonsignificant in covariate-adjusted analyses indicating that regardless of age group, all participants experienced similar mean increases in cannabis use intentions in response to cannabis adverting exposures compared to random control times of the day.

Table 15

Fixed Effects for Cannabis Advertising Exposure by Cannabis Expectancies Following Exposure and Age

	F	df1	df2	p
Continuous Time	2.63	1	1,309	0.10
Cannabis Use History	19.17	3	1,309	<.001
Cannabis Advertising Exposure	0.30	1	1,309	0.58
Age	1.51	4	1,309	0.22

Cannabis Advertising Exposure * Age	0.39	4	1,309	0.53

Table 16

Fixed Coefficients for Cannabis Advertising Exposure by Cannabis Expectancies Following

Exposure and Age

Fixed Effects					95% CI	
Model Term	Estimate	SE	T	p	Lower	Upper
Intercept	-0.19	0.85	-0.23	0.81	-1.87	1.48
Continuous Time	3.75E-6	2.31E-6	1.62	0.10	-7.89E-7	8.29E-6
Cannabis Use History[a]						
1-5 times in past year	0.31	0.25	1.26	0.20	-0.17	0.79
6+ times in past year	1.75	0.23	7.50	<.001	1.29	2.21
Used but not in past 12 months	0.79	0.41	1.95	.051	-0.01	1.59
Cannabis Advertising Exposure[b]	-0.14	0.25	-0.54	0.58	-0.63	0.36
Age	0.06	0.05	1.14	0.25	-0.04	0.17
Cannabis Advertising Exposure*Age[b]	0.01	0.02	0.62	0.53	-0.02	0.04

Note. [a] Never used = ref. [b] Control prompt = ref.

Figure 12

Mean Participant Cannabis Expectancies by EMA Entry Type and Age
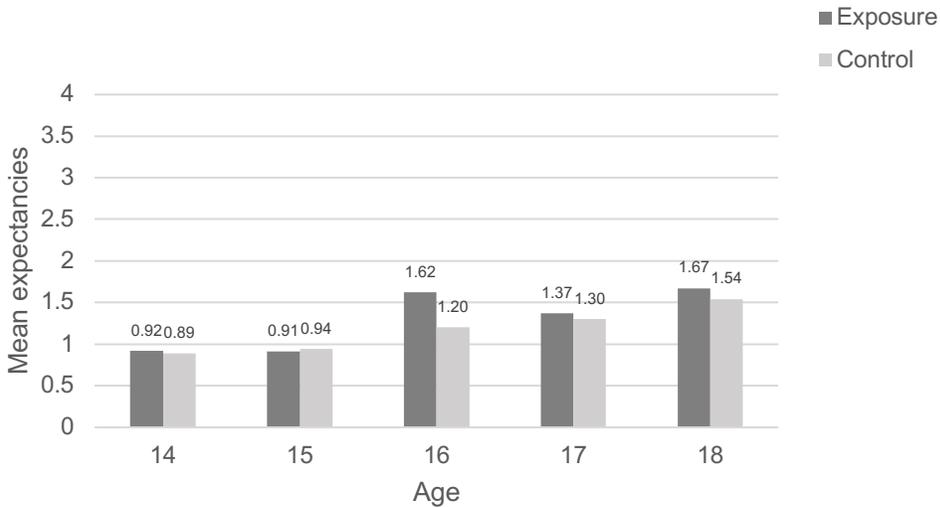
Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with questions related to negative affect management from the Smoking Consequences Questionnaire (Brandon & Baker, 1991), assessing participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1 (disagree) to 5 (agree).

Table 17

Fixed Effects for Cannabis Advertising Exposure by Cannabis Intentions Following Exposure and Age

|	F	df1	df2	p
Continuous Time	4.40	1	1,347	0.03
Cannabis Use History	32.61	3	1,347	<.0001
Cannabis Advertising Exposure	0.63	1	1,347	0.42
Age	4.88	1	1,347	0.02
Cannabis Advertising Exposure * Age	0.99	1	1,347	0.32

Table 18

Fixed Coefficients for Cannabis Advertising Exposure by Cannabis Intentions Following Exposure and Age

Fixed Effects Model Term					95% CI	
	Estimate	*SE*	*T*	*p*	Lower	Upper
Intercept	-0.97	0.88	-1.10	0.27	-2.70	0.77
Continuous Time	6.30E-6	3.00E-6	2.10	0.03	4.07E-7	0.00
Cannabis Use History[a]						
1-5 times in past year	0.42	0.26	1.62	0.10	-0.09	0.92
6+ times in past year	2.39	0.24	9.83	<.0001	1.91	2.86
Used but not in past 12 months	.52	0.43	1.23	0.22	-0.31	1.36
Cannabis Advertising Exposure[b]	-0.24	0.31	-0.79	0.42	-0.84	0.36
Age	0.12	0.06	2.06	.03	0.01	0.23
Cannabis Advertising Exposure*Age[b]	0.02	0.02	0.99	0.32	-0.02	0.06

Note. [a] Never used = ref. [b] Control prompt = ref.

Figure 13

Mean Participant Cannabis Use Intentions by EMA Entry Type and Age
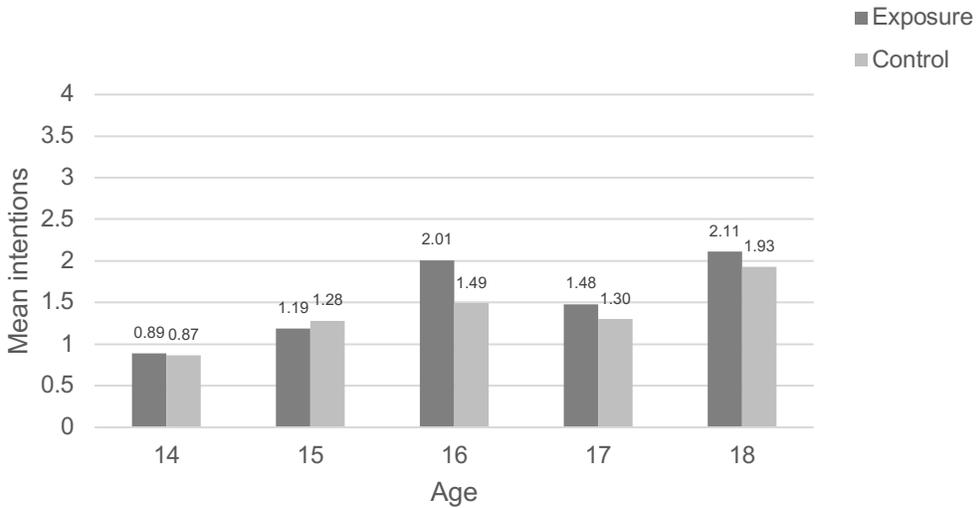
Note. EMA = Ecological Momentary Assessment. Cannabis use intentions were assessed through cannabis-adapted items from the Smoking Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-point Likert scale from 1 (definitely not) to 5 (definitely yes).

Gender

Tables 19-22 present fixed and random effects, and coefficients for the general models predicting cannabis expectancies and use intentions by advertising exposure type, and the interaction between gender and cannabis advertising exposure type. Given the small number of study participants who identified as gender minorities ($n < 10$), this subgroup of study participants was not included in models analyzing the moderating effect of gender on the relationship between cannabis advertising exposure(s) and cannabis expectancies and use intentions.

Interaction and main effects of predictors on real-time cannabis expectancies and use intentions were nonsignificant in covariate-adjusted analyses, indicating that regardless of gender group, all participants experienced similar mean increases in cannabis use intentions in response to cannabis adverting exposures compared to random, control times of the day.

Table 19

Fixed Effects for Cannabis Advertising Exposure by Cannabis Expectancies Following Exposure and Gender

	F	df1	df2	p
Continuous Time	3.36	1	1,242	0.07
Cannabis Use History	19.12	3	1,242	<.0001
Cannabis Advertising Exposure	0.44	1	1,242	0.50
Gender	0.48	1	1,242	0.48
Cannabis Advertising Exposure * Gender	0.05	1	1,242	0.08

Note. Gender minorities were not included in models analyzing the moderating effect of gender on the relationship between cannabis advertising exposure(s) and cannabis expectancies due to small cell size ($n < 10$).

Table 20

Fixed Coefficients for Cannabis Advertising Exposure by Cannabis Expectancies Following Exposure and Gender

Fixed Effects					95% CI	
Model Term	Estimate	SE	T	p	Lower	Upper
Intercept	0.70	0.14	5.01	<.0001	0.42	0.97
Continuous Time	4.37E-6	2.38E-6	1.83	0.06	-3.05E-7	9.05E-6
Cannabis Use History[a]						

1-5 times in past year	0.41	0.23	1.75	0.08	-0.05	0.87
6+ times in past year	1.69	0.23	7.42	<.0001	1.24	2.14
Used but not in past 12 months	0.91	0.39	2.33	0.02	0.14	1.68
Cannabis Advertising Exposure[b]	0.01	0.05	0.27	0.78	-0.08	0.10
Gender[c]						
Female	0.11	0.16	0.66	0.50	-0.21	0.43
Cannabis Advertising Exposure[b,c]						
Cannabis Advertising Exposure * Female	0.01	0.06	0.22	0.82	-0.10	0.12

Note. Gender minorities were not included in models analyzing the moderating effect of gender on the relationship

between cannabis advertising exposure(s) and cannabis expectancies due to small cell size ($n < 10$).

[a] Never used = ref.

[b] Control prompt = ref.

[c] Male = ref.

Figure 14

Mean Participant Cannabis Expectancies by EMA Entry Type and Gender
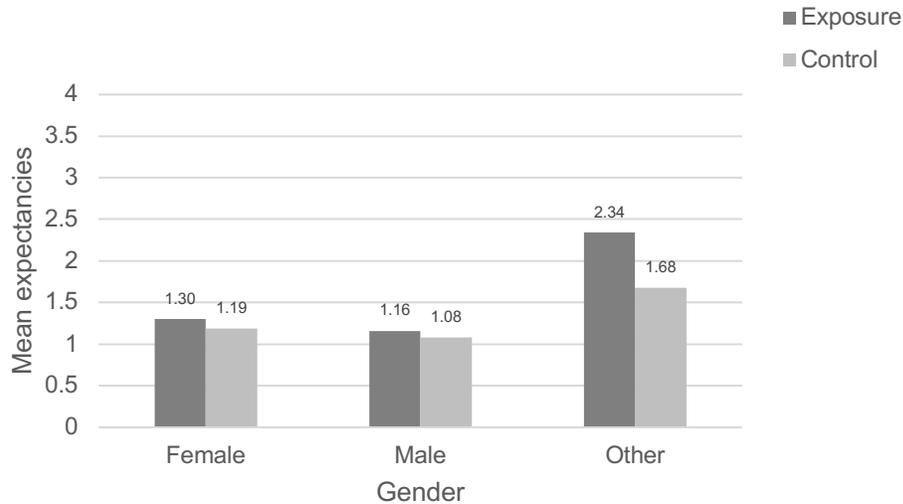
Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with questions related to negative affect management from the Smoking Consequences Questionnaire (Brandon & Baker, 1991), assessing participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1 (disagree) to 5 (agree).

Table 21

Fixed Effects for Cannabis Advertising Exposure by Cannabis Intentions Following Exposure and Gender

	F	df1	df2	p
Continuous Time	4.20	1	1,278	0.04
Cannabis Use History	36.28	3	1,278	<.0001
Cannabis Advertising Exposure	2.80	1	1,278	0.09
Gender	1.27	1	1,278	0.25
Cannabis Advertising Exposure * Gender	2.69	1	1,278	0.10

Note. Gender minorities were not included in models analyzing the moderating effect of gender on the relationship between cannabis advertising exposure(s) and cannabis use intentions due to small cell size ($n < 10$).

Table 22

Fixed Coefficients for Cannabis Advertising Exposure by Cannabis Intentions Following Exposure and Gender

Fixed Effects					95% CI	
Model Term	*Estimate*	*SE*	*T*	*p*	Lower	Upper
Intercept	0.72	0.14	5.03	<.0001	0.44	1.01
Continuous Time	6.14E-6	3.00E-6	2.05	0.04	2.64E-7	0.00
Cannabis Use History[a]						
1-5 times in past year	0.53	0.24	2.12	0.03	0.04	0.99
6+ times in past year	2.36	0.24	10.41	<.0001	1.99	2.92
Used but not in past 12 months	0.75	0.41	1.84	0.06	-0.05	1.55
Cannabis Advertising Exposure[b]	0.00	0.05	0.02	0.98	-0.10	0.11
Gender[c]						
Female	0.14	0.17	0.82	0.41	-0.19	0.47
Cannabis Advertising Exposure[b,c]						
Cannabis Advertising Exposure * Female	0.06	0.14	1.64	0.10	-0.02	0.23

Note. Gender minorities were not included in models analyzing the moderating effect of gender on the relationship between cannabis advertising exposure(s) and cannabis use intentions due to small cell size ($n < .00$).

[a] Never used = ref.

[b] Control prompt = ref.

[c] Male = ref.

Figure 15

Mean Participant Cannabis Use Intentions by EMA Entry Type and Gender
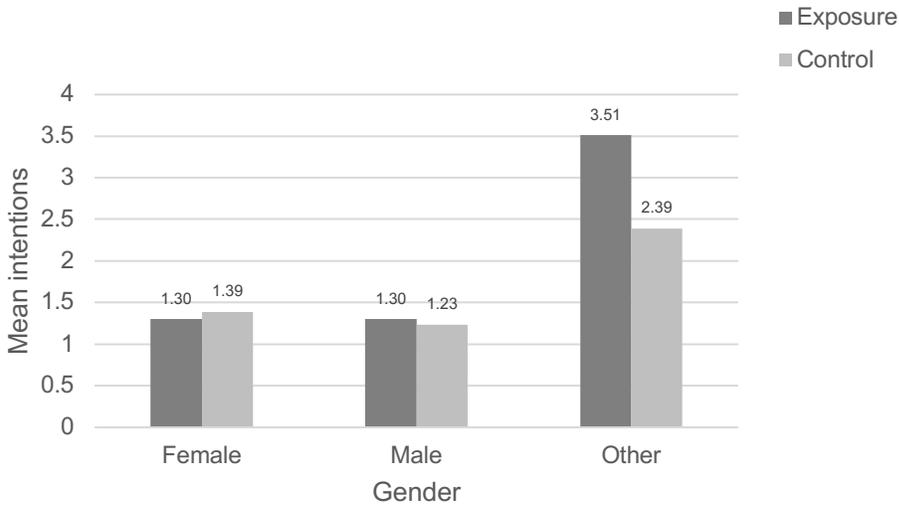
Note. EMA = Ecological Momentary Assessment. Cannabis use intentions were assessed through cannabis-adapted items from the Smoking Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-point Likert scale from 1 (definitely not) to 5 (definitely yes).

Psychosis Risk

Tables 23 and 24 present fixed and random effects, and coefficients for the general model predicting cannabis expectancies from cannabis advertising exposure events versus random prompts, and the interaction between psychosis and cannabis advertising exposure events versus random prompts. Tables 25 and 26 present fixed and random effects, and coefficients for the general model predicting cannabis use intentions from cannabis advertising exposure events versus random prompts, and the interaction between psychosis risk and cannabis advertising exposure events versus random prompts.

The main effects of psychosis risk on real-time cannabis use expectancies ($p = .004$; $n = 1,312$) and use intentions ($p = .01$; $n = 1,347$) were significant in covariate-adjusted analyses, indicating that participants' psychosis risk is associated with variability in their real-time cannabis use intentions at times of cannabis advertising exposure as well as during the completion of random prompts. However, all interaction effects of predictors on real-time cannabis use intentions and expectancies were nonsignificant in covariate-adjusted analyses indicating that regardless of psychosis risk, all participants experienced similar mean increases in cannabis expectancies and use intentions in response to cannabis adverting exposures compared to prompts completed at random, issued by the device.

Table 23

Fixed Effects for Cannabis Advertising Exposure by Cannabis Expectancies Following Exposure and Psychosis Risk

	F	df1	df2	p
Continuous Time	2.59	1	1,312	0.10
Cannabis Use History	22.88	3	1,312	<.0001
Cannabis Advertising Exposure	0.77	1	1,312	0.37
Psychosis Risk	7.98	1	1,312	0.00
Cannabis Advertising Exposure * Psychosis Risk	0.61	1	1,312	0.43

Table 24

Fixed Coefficients for Cannabis Advertising Exposure by Cannabis Expectancies Following

Exposure and Psychosis Risk

Fixed Effects					95% CI	
Model Term	*Estimate*	*SE*	*T*	*p*	Lower	Upper
Intercept	1.09	0.15	7.05	<.0001	0.7828	1.39
Continuous Time	3.72E-6	2.31E-6	1.61	0.10	-8.15E-7	8.26E-6
Cannabis Use History[a]						
1-5 times in past year	0.41	0.22	1.85	0.06	-0.03	0.85
6+ times in past year	1.78	0.22	8.12	<.0001	1.35	2.21
Used but not in past 12 months	0.95	0.39	2.47	0.01	0.20	1.71
Cannabis Advertising Exposure[b]	0.043	0.04	1.07	0.28	-0.04	0.12
Psychosis Risk[c]						
No	-0.46	0.17	-2.71	0.00	-0.79	-0.13
Cannabis Advertising Exposure[b,c]						
Cannabis Advertising Exposure * No	-0.04	0.05	-0.78	0.43	-0.14	0.06

Note. [a] Never used = ref. [b] Control prompt = ref. [c] Yes psychosis risk = ref.

Figure 16

Mean Participant Cannabis Expectancies by EMA Entry Type and Psychosis Risk
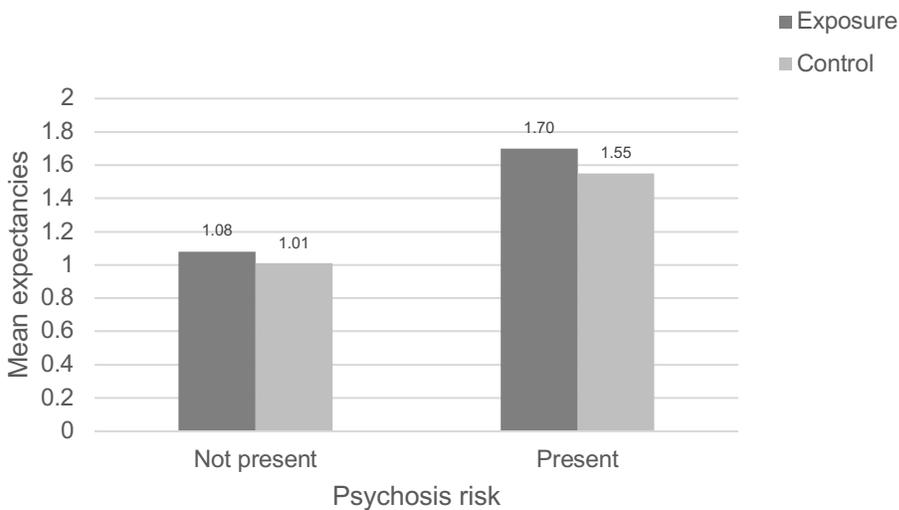
Note. EMA = Ecological Momentary Assessment. Cannabis expectancies were measured with questions related to negative affect management from the Smoking Consequences Questionnaire (Brandon & Baker, 1991), assessing participants' level of agreement with six statements on a five-point Likert scale in half-point increments from 1 (disagree) to 5 (agree).

Table 25

Fixed Effects for Cannabis Advertising Exposure by Cannabis Intentions Following Exposure and

Psychosis Risk

	F	df1	df2	p
Continuous Time	4.57	1	1,347	0.03
Cannabis Use History	38.85	3	1,347	<.0001
Cannabis Advertising Exposure	3.35	1	1,347	0.06
Psychosis Risk	5.55	1	1,347	0.01
Cannabis Advertising Exposure * Psychosis Risk	0.13	1	1,347	0.71

Table 26

Fixed Coefficients for Cannabis Advertising Exposure by Cannabis Intentions Following Exposure

and Psychosis Risk

Fixed Effects Model Term					95% CI	
	Estimate	*SE*	*T*	*p*	Lower	Upper
Intercept	1.11	0.16	6.99	<.0001	0.80	1.43
Continuous Time	6.43E-6	3.01E-6	2.14	0.03	5.30E-7	0.00
Cannabis Use History[a]						
1-5 times in past year	0.62	0.24	2.63	0.00	0.16	1.09
6+ times in past year	2.50	0.23	10.75	<.0001	2.04	2.95
Used but not in past 12 months	0.79	0.41	1.92	0.05	-0.02	1.59
Cannabis Advertising Exposure[b]	0.04	0.05	0.97	0.33	-0.06	0.13
Psychosis Risk[c]						
No	-0.43	0.18	-2.42	0.01	-0.78	-0.08
Cannabis Advertising Exposure[b,c]						
Cannabis Advertising Exposure * No	0.02	0.06	0.37	0.71	-0.10	0.14

Note. [a] Never used = ref. [b] Control prompt = ref. [c] Yes psychosis risk = ref.

Figure 17

Mean Participant Cannabis Use Intentions by EMA Entry Type and Psychosis Risk
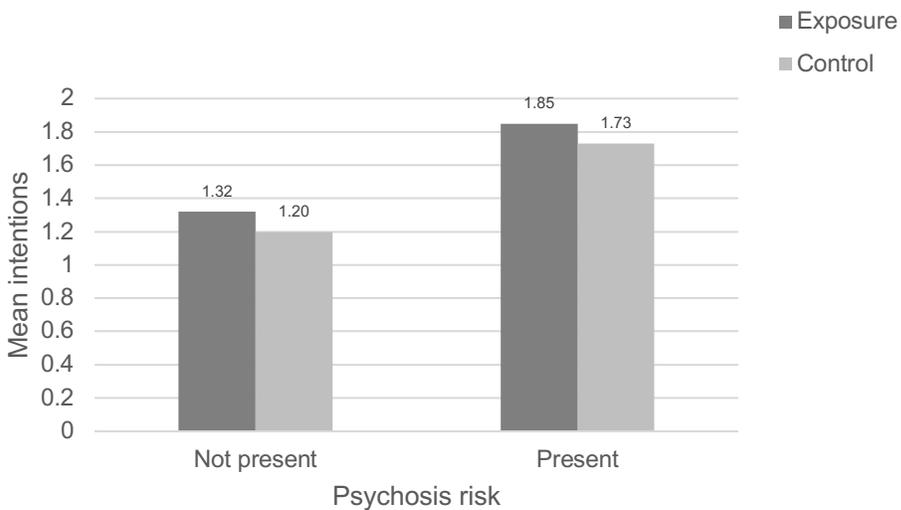
Note. EMA = Ecological Momentary Assessment. Cannabis use intentions were assessed through cannabis-adapted items from the Smoking Intentions Scale (Choi et al., 2001), assessing participants' likelihood of using cannabis with three statements on a 5-point Likert scale from 1 (definitely not) to 5 (definitely yes).

Discussion

The current study described (1) Types (e.g., billboard, internet) of advertisements that have the greatest ability to reach youth,; (2) How youth cannabis expectancies and intentions to use cannabis are impacted by exposure to cannabis advertising *in vivo*; and (3) Whether at risk (demographics, psychosis risk) youth groups' cannabis expectancies and intentions to use cannabis are differentially impacted by cannabis advertising exposures.

Specifically, using a 9-day EMA protocol, this study has: (1) Identified types (e.g., billboard, internet) of advertisements that youth in this sample encounter most frequently in their daily lives, (2) Assessed the overall impacts of cannabis advertising exposures on youth cannabis expectancies and intentions when they encounter them in real-time and in real-world settings, and (3) Investigated between-group differences in urbanicity, gender, ethnicity, age, and psychosis risk related to cannabis expectancies and use intentions following advertising exposure(s).

In the following sections, I will begin by providing an overview of the strengths of this study, followed by a discussion of findings related to my three main hypotheses, limitations through which findings should be interpreted, proposed directions for future research, and a summary of implications and conclusions.

Hypothesis 1: Cannabis Advertising Frequency and Reach by Channel Type

The first hypothesis, that cannabis companies reach Canadian youth through advertisements with a frequency that will be observable within the 9-day study observation period, was confirmed. The current study demonstrates that youth in Ontario are being exposed to cannabis advertisements in violation of existing prohibitions (Scharf et al., 2023) through various advertising channels following cannabis legalization for recreational use in Canada. In a novel contribution to the existing literature, among this sample of 120 Canadian youth, the majority ($n = 85$, 70.83%) reported exposure(s) to cannabis advertising in their everyday, natural environments via EMA through one or multiple advertising channels throughout the brief (9-day) study period.

Based on our study findings, cannabis storefronts, billboards, and posters were among the leading sources of reported advertising exposure among youth. This is not surprising, given that the province of Ontario has the highest availability (proximity, density) of cannabis retailers per capita among all Canadian provinces and territories (AGCO, 2023). As demonstrated through our study, availability of cannabis through brick-and-mortar cannabis retailers (i.e., point of sale) also resulted in youths' repeated exposure to cannabis storefronts, billboards, and posters. Of concern, such exposures may affect youth brand awareness, cannabis-related harm perceptions, use intentions, and even cannabis use rates. In a study by Rup et al. (2020) examining differences between 'illegal' and 'legal' markets in Canada and the U.S., proximity to a retail store was strongly and positively associated with brand recall, as was also the case for noticing advertisements, thus supporting our finding about the importance of the point-of-sale as a promotional setting. Recent research also demonstrates that exposure to cannabis advertisements, including exposure to cannabis retailer outlets, is associated with increased cannabis use and reduced perceptions of harm associated with cannabis (Firth et al., 2022). Given that accumulating research demonstrates that the negative effects (i.e., increased substance use intentions) of advertising appear to accumulate with repeated exposure (Setodji et al., 2014), increased cannabis retailer availability and repeated advertising exposures through storefronts, billboards and posters, structural advertisements are risk factors that should be considered in policies and public health actions related to youth cannabis-related harms.

Consistent with previous Canadian research (e.g., Asquith, 2021; Ju et al., 2021; Noël et al., 2021; Sheikhan, 2021; Wesley & Murray, 2021; Zenone et al., 2021), we also found that exposures to cannabis advertising through digital media (i.e., promotion through public figures, personal/ branded items seen through social media, and internet advertisements) and youth-appealing personal/branded items toted by peers were high, despite prohibitions on direct cannabis advertising through these channels. One possibility is that this finding may be somewhat unique to the COVID-19 context (periodic restrictions on mobility and use of public spaces) in which data were collected.

Alternatively, youth exposure to cannabis advertising via electronic channels may reflect a significant increase in youth use of social media, streaming services, gaming sites and mobile applications (Ellis et al., 2020; Fernandes et al., 2020) independent of behavioural artifacts of pandemic times. Previous research demonstrates that cannabis retailers and culture have a well-established and sophisticated online presence, with innovative online advertisements tailored to social media platforms, including Facebook, Instagram, and Snapchat, irrespective of the legal status of cannabis or policies set out by these media companies (Kelly et al., 2021). In Canada, the sale and legalization of cannabis began during the digital age, leading to a qualitative shift in advertising strategies employed by cannabis companies (Trangenstein et al., 2019) as compared to the alcohol and tobacco industries which established their advertising campaigns decades ago through traditional media channels including point of sale, print, billboards, and radio (Trangenstein et al., 2019).

Recent evidence from newly cannabis-legal markets in the U.S. demonstrates that exposure to digital advertising is particularly effective in increasing cannabis use among youth, where each additional social media platform used increased past-year cannabis use among youth by 48% (Whitehill et al., 2020), even when controlling for demographic and normative factors that may influence cannabis use. High levels of cannabis advertising exposure via digital advertising channels (e.g., social media) is particularly problematic. Social media is thought to facilitate participation in advertising through features such as liking, commenting and sharing (Whitehill et al., 2020). Moreover, similar research on alcohol and tobacco shows that youth with greater exposure to substance-related advertising have a greater risk of using or increasing their use of these products, especially if such exposures involve participation in marketing and advertising activities (Biener & Siegel, 2000; Jernigan et al., 2017). Moreover, information shared through social media and the internet may be seen as more persuasive and relevant to youth, especially when accompanied by endorsements from trusted public figures or peers (Cialdini, 2018). Indeed,

exposure to cannabis advertisements may influence youths' view of injunctive norms (i.e., perceptions of other approval of a behaviour) by suggesting high levels of peer approval for cannabis use and/or reinforcing positive expectancies regarding the outcomes associated with cannabis use (Brown & Moodie, 2009; Conner & McMillan, 1999; McClure et al., 2013). Altogether, elevated rates of cannabis advertising exposures through digital media and branded items presented or worn by peers are concerning, as an increase in the use of social media and the novel potential for social engagement and peer network integration could increase youths' vulnerability to cannabis advertising through digital advertising channels and social networks (Jernigan, 2012; Montgomery et al., 2012; Noël et al., 2021; Trangenstein et al., 2019).

In sum, our findings suggest gaps in regulation and enforcement particularly related to point-of-sale retail and digital advertising channels. Given the proliferation in cannabis retailers and accompanying storefronts, billboards, and posters following legalization and a shift toward digital advertising and the dissemination of contemporary advertising messages (e.g., through branded content, native advertising [i.e., material in an online publication resembling the publication's editorial content but paid for by an advertiser and intended to promote the advertiser's product], user-generated content, or influencer's endorsement) - which are not perceived as promotional messages by consumers and regulators (Asquith, 2021; Einstein, 2016), policies and enforcement development in these areas is needed. Although regulatory bodies prohibit the dissemination of cannabis-related promotional materials to youth, our data show that existing barriers (i.e., cannabis advertising prohibitions) are not working (or not working optimally) as intended. Further discussion surrounding cannabis advertisement exposure and illegal proximity to youth-serving facilities and violations of cannabis prohibitions is warranted, but beyond the scope of my thesis. However, additional research and commentary on these topics is available from our group in forthcoming articles by Armiento et al. (2023) and Scharf et al. (2023).

Hypothesis 2: Cannabis Expectancies and Use Intentions Following Cannabis Advertising Exposure(s)

The second main hypothesis, that exposure to cannabis advertisements will increase cannabis expectancies and use intentions via momentary exposure effects in the overall sample within the 9-day study observation period, was partially confirmed. While exposure to cannabis advertisements did not increase cannabis use expectancies via momentary exposure in the overall sample, exposure to cannabis advertisements did increase cannabis use intentions.

Cannabis Expectancies Following Cannabis Advertising Exposure(s)

Although support for the hypothesis that exposure to cannabis advertisements would increase cannabis expectancies via momentary exposure effects was not supported, methodological issues with the expectancies measure may have impacted our results. In this study, expectancies were measured with six questions specifically related to negative affect management from the SCQ (Brandon & Baker, 1999), initially validated for use among adolescent smokers (Wahl et al., 2005). These negative affect management items measured expectancy constructs related to boredom reduction, negative affect reduction and stimulation/state enhancement and were chosen because of their frequent use in previous EMA and substance use studies. Upon examination of our study results and further reflection, I propose that our measure may have missed crucial cannabis expectancy-related constructs. Specifically, youths' pro-cannabis injunctive norms, positive consequences and physiological effects of cannabis, and perceptions of symptom management related to cannabis use could have been affected by cannabis ad exposure but might have been missed by our measurement tools (Bottorff et al., 2009; Brammer et al., 2022; Brown & Moodie, 2009; McClure et al., 2013; Real & Rimal, 2007).

In adult populations, cognitive social learning and behavioural decision-making theories emphasize that being exposed to substance-related advertisements (e.g., tobacco, alcohol) increases positive substance-related expectancies and that having greater positive substance-related

expectancies increases the risk of future substance among youth (Ellickson et al., 2004; Kam et al., 2009; Malmberg et al., 2012; Skenderian et al., 2008; Stephens et al., 2009). However, limited research exists on cannabis-specific expectancies that may predict future cannabis use among youth populations. Existing research on cannabis expectancies is generally descriptive or focused on older youth (e.g., college students); little research has examined youth expectancies that are specific or unique to cannabis and how these youth cannabis expectancies are related to cannabis use intentions (Pedersen et al., 2015). More research is needed to better understand which kinds of expectancies, if any, are likely to be impacted by cannabis advertising and subsequent cannabis use risk.

In future work, researchers should consider how psychosocial development is likely to affect age-specific cannabis expectancies. For example, compared to older populations, younger youth, who generally have reduced self-efficacy and behavioural control, may be particularly attracted to positive messaging about cannabis and pro-cannabis advertising suggesting that cannabis use increases social acceptance and approval by peers (Ellickson et al., 2004; Kam et al., 2009; Malmberg et al., 2012; Skenderian et al., 2008; Stephens et al., 2009). This hypothesis is consistent with research on the Theory of Normative Social Behaviour wherein injunctive norms (i.e., perceptions of others' approval of cannabis use; Brown & Moodie, 2009; McClure et al., 2013) and outcome expectancies (i.e., beliefs about the positive and negative consequences of cannabis use; Conner & McMillan, 1999) play a central role in serving as predictors of cannabis use (TNSB; Whitehill et al., 2020). In future studies, we propose that measures of pro-cannabis injunctive norms (e.g., using cannabis will help me fit in, be more sociable, or appear to be "cool"), outcome expectancies related to positive consequences of cannabis use (i.e., positive affect management, e.g., cannabis will help me get high or help me have fun), perceived positive physiological effects of cannabis use (e.g., using cannabis will help improve my sleep, reduce physiological arousal, or reduce pain), and other negative affect/ mental health symptom

management expectancy items uniquely and commonly related to cannabis use (e.g., using cannabis will help me manage agitation, improve focus, or deal with side effects of other medications) may be sensitive to cannabis advertising exposures. Such messages are often part of cannabis advertising and are consistent with widely endorsed as motivations for cannabis use by youth who use cannabis (Bottorff et al., 2009; Brammer et al., 2022).

Alternatively, it is possible that mere exposure to cannabis advertisements may produce more favourable attitudes (i.e. positive expectancies) toward cannabis brands, products, and consumption, devoid of any intentional effort to process advertising content (Janiszewski, 1993). Said otherwise, it is possible that simple repeated exposure to cannabis advertisements may increase general positive attitudes (i.e., expectancies) towards cannabis through increased advertising familiarity.

In sum, our findings did not demonstrate that exposure to cannabis advertisements increased cannabis expectancies via momentary exposure effects. However, the expectancy measure we used may not have effectively captured the full range of cannabis expectancies influenced by advertising exposure. Development and use of an expectancy measure, including items pertaining to pro-cannabis injunctive norms, positive consequences and physiological effects of cannabis, and perceptions of symptom management related to cannabis use that is tailored to and validated among youth cannabis smokers and non-cannabis smokers may provide a more accurate understanding of the effects of cannabis advertising exposure on cannabis expectancies and cannabis-related risk.

Cannabis Use Intentions Following Cannabis Advertising Exposure(s)

One of our most important study findings was that real-world, real-time exposure to cannabis advertisements did increase youth intentions to use cannabis. This finding is consistent with the literature on alcohol and tobacco advertising (e.g., Hébert et al., 2018; Martino et al., 2018; Setodji et al., 2014; Roberts et al., 2019; Shadel et al., 2012), as well as retrospective research on the adverting exposure effects of medical cannabis (e.g., D'Amico et al., 2015, 2017, 2018; Firth et

al., 2022; Park & Holody, 2018; Rup et al., 2020; Sheikhan et al., 2021; Trangenstein et al., 2019; Whitehill et al., 2019) demonstrating that being exposed to substance-related advertisements is predictive of higher substance-related use intentions among youth. Our findings are especially concerning given the young age of our sample and that more frequent advertising exposures are linked to increases in substance use expectancies, intentions, substance use itself, and negative consequences of substance use over time (Health Canada, 2018b; 2018c; Duperrouzel et al., 2020; Levine et al., 2017; Morin et al., 2019).

To mitigate cannabis-related harms among youth, prohibitions on cannabis advertising may need to be more restrictive than advertising prohibitions on other products. This is due to the prevailing perception among youth that cannabis is safer than other recreational drugs, despite the well-documented risks of early, high potency, and high-frequency cannabis use (including impaired neurocognitive functioning and affect regulation, mental health problems including increased risk for suicidality, cannabis dependence syndrome, psychosis, and cannabis-related morbidity in later life; Health Canada, 2018b; 2018c; Duperrouzel et al., 2020; Levine et al., 2017; Morin et al., 2019). Indeed, youth regularly associate cannabis use with fewer adverse outcomes than alcohol use (D'Amico et al., 2015; D'Amico et al., 2018; Goodman et al., 2020) and other recreational drugs (e.g., lysergic acid diethylamide [LSD] or ecstasy; Hellemans et al., 2019). Moreover, in recent research, younger drivers were more likely to view driving under the influence of cannabis as socially acceptable and safe (Arnold & Tefft, 2016; Goodman et al., 2020), a significant portion of youth admitted to driving under the influence of cannabis, and some reported beliefs that cannabis enhances their driving abilities (Goodman et al., 2020; Loehrke, 2013). Given our findings highlighting the impacts of cannabis advertising on cannabis use intentions, and with emerging evidence demonstrating that cannabis use before the age of 25 may permanently impact brain development (Giedd et al., 1999; Haines-Saah & Fischer, 2021; Kelsall, 2017; Lenroot & Giedd, 2006), existing public health-oriented substance policy strategies (See Cannabis Control Act, 2017)

aiming to prevent or reduce underage cannabis use are insufficient. Further implementation and enforcement of more restrictive public health-oriented strategies to prevent underage cannabis use is crucial in mitigating the well-documented harms associated with early, frequent, and high-potency cannabis use (Carliner et al., 2017).

Our findings have immediate implications for Canadian cannabis policy, as decision-making is already underway to amend the Cannabis Act and provincial regulations in Ontario on the production, sale, and advertising of cannabis. For example, Canada's competition watchdog to Health Canada, the Competition Bureau, has recommended less restrictive rules on cannabis packaging and advertising, and increasing the limit on THC that is allowed in edible products to "stamp out the black market while maintaining public safety" (White, 2023). However, there is no evidence supporting the safety or effectiveness of these recommendations. In contrast, recent Canadian research shows that a more restrictive cannabis retail market (e.g., Québec's) does not translate into favourable perceptions of illegal cannabis and does not lead to increases in the purchase of cannabis products through the black market, compared to other provinces with looser cannabis restrictions (Wadsworth et al., 2022; Wadsworth et al., 2023). Furthermore, following recreational legalization, Québec's more restrictive cannabis market has significantly decreased cannabis use among teens from 11.8% in 2019 to 10.9% in 2020, a statistic that continues to trend downwards (Rotermann, 2020). Amendments to regulations that benefit provinces with hybrid market systems (i.e., where both government-run and privately-owned operators can sell cannabis) may hinder the effectiveness of Canadian regulations designed to limit youth access to cannabis and protect public health (Watson & Erickson, 2019). This is because these changes are primarily driven by the goal of boosting sales and, consequently, increasing cannabis consumption (Competition Bureau, 2023; Statistics Canada, 2019; Watson & Erickson, 2019). To effectively protect youth, the Canadian government must counter recommendations for loosening cannabis

restrictions with research-based complementary policies in the context of adult recreational markets in which businesses compete for and use tactics to increase sales.

Evidence-based policy and public health actions to limit youth cannabis-related harms from advertising in a free market include supporting parents, educators, and others to have planned, informed conversations with youth about recreational cannabis. They should also include environmental strategies, such as policy-enforced restrictions on advertising to youth. First, compared to extreme, directive language (e.g., "People don't understand—you can't do this sort of stuff!" and "Only complete idiots would do drugs."), communicating anti-cannabis information using moderate and nondirective language ("It's your health, your body, your brain." and "When it comes right down to it, it's your decision.") is more effective in decreasing youths' intentions to use cannabis (Crano et al., 2017). Further, a "wrap-around" psychoeducational approach with information provided by parents, community leaders, and teachers is also effective (D'Amico et al., 2018). In conjunction with these efforts, evidence from the alcohol and tobacco industry emphasizes the need for a more restrictive regulatory approach (D'Amico et al., 2015b; Pacula et al., 2015). This more restrictive approach involves the enhancement and enforcement of cannabis laws and regulations related to the advertisement and sale of cannabis to reduce cannabis-related harms (D'Amico et al., 2015b; Pacula et al., 2015) among other main strategies (i.e., increasing price, creating a jurisdictional monopoly on production, distribution, and sale of cannabis, restricting and monitoring licenses and licensees, limiting the products that are sold, restricting public consumption, and measuring and preventing impaired driving; Cox, 2018; Pacula et al., 2014).

Considering evidence from the tobacco industry indicating that partial restrictions on advertising are largely ineffective in reducing tobacco use (Saffer & Chaloupka, 2001) and often result in a shift of expenditures to other advertising methods that are not banned, a comprehensive ban (e.g., WHO, 2013) on all forms of cannabis advertising has been suggested (Pacula et al.,

2014). This comprehensive ban on advertising would encompass various advertising channels (e.g., print, television, radio, transit, billboards, point of sale, internet, and social media outlets), along with promotion tactics including price discounting, coupons, free sample distribution, and other indirect forms of advertising (e.g., brand stretching [how far a business can stretch its products or services into new and unrelated markets successfully], branded merchandise). Other restrictions applied to tobacco in other countries and partially enforced in Canada, including a complete ban on retail display and continued enforcement of plain packaging policies, may also be considered in the Canadian cannabis context, especially because they are minimally invasive and easily implemented in newly legal cannabis contexts (Pacula et al., 2014). The viability associated with implementing such advertising restrictions in Canada may vary by province/ territory, and legal challenges may arise (Cox, 2018; Pacula et al., 2014). However, efforts to regulate cannabis advertising should be initiated early on in the process of cannabis legalization, as waiting until cannabis sales have become well-established could limit available options to implement effective advertising regulations.

In sum, our finding that exposure to cannabis advertisements generally increases cannabis use intentions among youth aligns with research on the advertising effects of alcohol, tobacco, and medical cannabis. Importantly, preventing underage cannabis use requires careful and evidence-based development, enhancement, and enforcement of public health-oriented strategies. These policies are especially important given youths' lower perceived risk of cannabis and the risks of early and frequent cannabis use. Evidence-based approaches to mitigating the impacts of cannabis advertising on youth include implementing comprehensive regulatory measures, such as a near or complete ban on all cannabis advertising, as our data show that current regulations and their enforcement are not having their intended effects.

Hypothesis 3: Demographic and Psychosis Risk Variables Predict Differences in Cannabis Expectancies and Use Intentions Following Cannabis Advertising Exposure(s)

The third hypothesis, that demographic and psychosis risk variables will predict differences in youth expectancies and use intentions via momentary cannabis advertising exposure effects in the overall sample within the 9-day study observation period, was not supported by our study findings.

Cannabis Use History, Cannabis Expectancies, and Use Intentions Following Cannabis Advertising Exposure(s)

Although it was not the focus of our analyses, as predicted, participants' cannabis use history was associated with variability in their real-time cannabis expectancies and use intentions, such that previous cannabis use was predictive of higher cannabis use intentions, regardless of when (control vs. ad exposure) assessments were made, especially when youth reported a higher frequency of cannabis use. This finding is intuitive and in line with previous research demonstrating that previous cannabis use, especially high-frequency cannabis use, is associated with increased positive expectancies, higher future use intentions and cannabis consumption behaviours among youth (Hawke et al., 2020; Pacek & Vandrey, 2014; Plancherel et al., 2005; Skenderian et al., 2008).

While the current study did not examine the moderating effect of cannabis use history on the relationship between cannabis advertising exposures and cannabis expectancies and use intentions, previous retrospective research in cannabis-legal states and evidence from the tobacco and alcohol industry demonstrate that exposure to cannabis-related advertisements is more harmful (i.e., more likely to increase positive expectancies, use intentions, use frequency, use mode experimentation and potency, and resulting adverse consequences) among youth who are already cannabis users themselves, especially if youth use cannabis at a high frequency (Anderson et al., 2009; Jernigan et al., 2017; Krauss et al., 2017; Lovato et al., 2011). Research also demonstrates that being a current

cannabis user is strongly associated with youths' reports of seeing cannabis advertisements one year

later (D'Amico et al., 2015). Again, the present study did not examine the interaction between

cannabis use history and advertising exposure frequency. However, the reinforcing spirals model of

media exposure and risk behaviour indicates that exposure and behaviour may be a mutually

influencing process that could increase participation in risk behaviours over time (Tucker et al.,

2013). In other words, exposure to cannabis advertisements may increase youth cannabis

expectancies and use intentions, which may increase the chances that youth seek out cannabis

advertising as it fits with their interest in the drug and perhaps validates their cannabis use

(D'Amico et al., 2015).

Overall, our results demonstrate that previous and high frequency cannabis use is predictive

of higher cannabis expectancies and use intentions, and previous research indicates that exposure to

cannabis advertisements is more harmful among youth who frequently use cannabis. Altogether,

these findings underscore the need for enhanced advertising regulations to address the potential

impact of cannabis advertising on youth (including increased frequency or openness to novel,

multimodal cannabis use leading to consequent increases in adverse cannabis-related outcomes),

particularly those with a history of cannabis use.

Age, Cannabis Expectancies, and Use Intentions Following Cannabis Advertising Exposure(s)

Contrary to our hypothesis, participants experienced similar mean increases in cannabis

expectancies and use intentions in response to cannabis adverting exposures compared to random

control times of the day, regardless of age. However, the main effect of age was associated with

variability in participants' real-time cannabis use intentions such that increasing age was predictive

of higher cannabis use intentions, regardless of when (control vs. ad exposure) assessments were

made.

One possible reason that we did not identify interaction effects of age and exposure on

cannabis use expectancies could be due to the limitations of our cannabis expectancies measure

(See previous discussion related to Hypothesis 2). Current research demonstrates that cannabis-related expectancies not measured by the SCQ (e.g., pro-cannabis injunctive norms, positive consequences and physiological effects of cannabis, and perceptions of symptom management related to cannabis use) differ based on age and associated socio-environmental context. With research demonstrating that younger youth use substances primarily for social reasons, whereas college-aged youth use are motivated socially for alcohol use and personally for the use of other substances (Haden & Edmunson, 1991), cannabis expectancies related to pro-cannabis injunctive norms may be higher among younger youth, as compared to older youth. Based on this finding, it is also possible that expectancies related to personal substance-related expectancies (i.e., perceived positive consequences, physiological effects, and perceptions of symptom reduction related to cannabis use) are higher among older youth. Accordingly, measuring these cannabis expectancies following exposure to cannabis advertising could better reflect the differential impacts of age and exposure to cannabis advertisements on cannabis expectancies.

The finding that older youth have higher cannabis use intentions, regardless of exposure to cannabis advertisements, does not support our hypothesis that exposure to cannabis advertising would predict higher cannabis use intentions among older youth. However, it is directly in line with research demonstrating that older adolescents are more likely to use cannabis than younger adolescents (Sampasa-Kanyinga et al., 2018). This finding also makes sense, given that cannabis use intentions are likely driven by perceived access to and availability of cannabis. Youth who are closer to the minimum MLA may also have peers that are at or above the MLA and thus have easier access to cannabis, as compared to youth aged further away from the MLA (Nguyen et al., 2023). In line with this, research demonstrates that cannabis use intentions and use are higher among youth who identify positive peer norms and greater peer involvement in marijuana use (Arthur et al., 2002; Beyers et al., 2004). Given that our full sample was under the MLA, differences in expectancies and use intentions may have been observed following exposure based on age if we

also surveyed youth just above the MLA, who are also at increased risk of cannabis-related harms based on age and stage of development (Giedd et al., 1999; Haines-Saah & Fischer, 2021; Kelsall, 2017; Lenroot & Giedd, 2006). Future research comparing the moderating effect of age on cannabis use intentions should compare changes in use intentions between youth under the MLA (e.g., 14-18) and young adults (e.g., youth aged 18-21) to better understand the impact of age and policy on youth cannabis risk.

Gender, Cannabis Expectancies, and Use Intentions Following Cannabis Advertising Exposure(s)

Our findings showed that regardless of gender (male, female groups only), participants had similar increases in cannabis expectancies and use intentions following advertisement exposure(s). This is our primary gender-related finding. Unfortunately, our sample included only a small proportion ($n < 10$) of study participants who identified as gender minorities (a gender other than male or female), precluding us from meaningfully analyzing this subgroup effect on the relationship between cannabis advertising exposure(s) and cannabis expectancies and use intentions. Historically, marginalized populations (e.g., gender minorities) have been shown to use tobacco and cannabis products at higher rates as compared to national averages (Barger et al., 2021; Dai & Hao, 2017; Du et al., 2019; Peters et al., 2018) and are disproportionately exposed to advertisements targeted specifically to marginalized populations (Cruz et al., 2019; Dauphinee et al., 2013; Emory et al., 2019; Higgins et al., 2019; Lienemann et al., 2019; Rising & Alexander, 2011). Future studies with larger, more representative samples are needed to test hypotheses about a gender minority effect.

Unexpectedly, our findings do not support previous research suggesting that females have stronger emotional reactions to substance-related advertising and that female youth are shown to identify more strongly with gender-targeted advertising, which may, in turn, influence advertising reactivity (i.e., expectancies, use intentions; Amos et al., 2012). On one hand, it is possible that

cannabis advertising may not specifically target women, or that cannabis advertisements that are reaching youth do not focus on portraying positive emotions. This null finding might also be attributable to the limited scope of our expectancy measure. Future studies employing positive expectancy measures related to pro-cannabis injunctive norms, positive consequences and physiological effects of cannabis, and perceptions of symptom management related to cannabis use may support previous research demonstrating that gender-based differences exist in terms of substance use expectancies and use intentions following advertisement exposures. For example, research indicates that exposure to advertisements suggesting that cannabis use will increase sexual prowess or encounters increases male but not female cannabis use expectancies (Willoughby et al., 2022). Consistent with some previous work, our data suggest that cannabis advertisements do not differentially impact male and female cannabis use intentions. This finding is also supported by Willoughby et al.'s (2022) study demonstrating similar increases in mean cannabis use intentions following exposure to pro-cannabis digital media.

In sum, given our small sample, the current study did not analyze the influence of marginalized gender groups on the association between cannabis advertising and cannabis expectancies and use intentions. This is a limitation of our research because we hypothesized a potential interaction effect of belonging to marginalized gender groups on cannabis expectancies and use intentions. More extensive research with larger samples is necessary to explore this further. Furthermore, study findings do not support prior research indicating stronger emotional reactions to substance-related advertising and possible increased reactivity (use intentions) among females. However, gender-based differences in expectancies may still exist, and future studies should incorporate measures encompassing positive expectancies related to pro-cannabis norms, symptom management, positive consequences, and physiological effects to gain a comprehensive understanding of the impact of cannabis advertising. These findings also support previous work demonstrating that cannabis advertisements do not differentially impact male and female cannabis

use intentions. Future studies investigating the moderating effect of advertising channel type and content on cannabis expectancies and use intentions tailored to youth cannabis smokers and non-smokers would be valuable. This would also help to identify gender groups at increased risk of adverse consequences related to cannabis advertising exposure(s) and allow policymakers to enhance the specificity and enforceability of cannabis advertising prohibitions.

Psychosis Risk, Cannabis Expectancies and Use Intentions Following Cannabis Advertising Exposure(s)

Lastly, all participants experienced similar mean increases in cannabis expectancies and use intentions in response to cannabis adverting exposures compared to random control times of the day, regardless of psychosis risk. However, participants' psychosis risk was associated with variability in their real-time cannabis expectancies and use intentions at times of cannabis advertising exposure as well as during the completion of random prompts. More specifically, the presence of psychosis risk was predictive of higher cannabis expectancies and use intentions, regardless of exposure to cannabis advertisements.

These findings suggest that possible impairments in cognition among youth at risk of psychosis may lead to greater baseline susceptibility to pro-cannabis expectancies and increase the likelihood of future cannabis consumption, and related adverse outcomes among this population (Davidson et al., 2018; Lake et al., 2020; MacKenzie et al., 2017; Thompson et al., 2012), regardless of exposure to cannabis advertising. In particular, given that changes in expectancies measured using the SCQ were related to negative affect management, findings demonstrating higher expectancies, regardless of exposure to cannabis advertisement, align with the self-medication hypothesis, wherein youth at risk of psychosis report using cannabis for the purpose of self-medication and/or regulation of negative symptomology (Gill et al., 2015; Hurd et al., 2014). Indeed, recent research (Gill et al., 2015) has shown that the main reason that youth at clinical high risk (CHR) of psychosis primarily use cannabis is to enhance mood (i.e., to promote negative affect

reduction and address symptoms of anhedonia and anxiety), followed by social motives. Cannabis

expectancy motivations identified by youth at risk of psychosis may also explain the lack of

interaction effect between psychosis risk and cannabis expectancies and use intentions. It is

possible that cannabis advertising channel and advertising message content did not target already

elevated cannabis expectancy motivations specific to youth at risk of psychosis (i.e., advertisements

did not target expectancies related to negative affect reduction or pro-cannabis injunctive norms)

that are shown to be most predictive of increased cannabis expectancies and use intentions among

this population.

The finding that only the main effect (and not the interaction terms) of psychosis risk on

real-time cannabis use expectancies and use intentions was significant also aligns with the unifying

hypothesis in the development of psychosis (Khokhar et al., 2018). As per the unifying hypothesis,

vulnerability to substance use (and perhaps related substance use expectancies) is innate and may

exist before the onset of psychotic symptoms regardless of whether youth are exposed to cannabis

advertisements. This could be for a myriad of reasons including neurocognitive (e.g., dysfunctional

mesocorticolimbic brain reward circuitry, alleviation of prodromal psychotic symptoms) and

socioeconomic (e.g., communities with higher rates of substance use, fewer opportunities for social

and economic rewards) risk factors. As increased substance use among youth at risk of psychosis

(as well as in non-psychotic first-degree relatives; Smith et al., 2008; Stone et al., 2001) may

concurrently enhance the risk of future substance use disorder and serve as an additional risk factor

for the onset of psychotic symptoms, collecting information related to youths' exposure to

educational cannabis-related information and anti-cannabis information, and its subsequent effect

on cannabis-related cognitions and cannabis use could be useful. More specifically, this information

may potentially inform psychoeducational interventions and support the creation and dissemination

of psychoeducational cannabis-related messaging, especially among this vulnerable population.

Policymakers should also keep total and complete advertising bans as part of the conversation given their potential benefit for high-risk, high-cost and high-need groups.

Given our small sample of youth who were found to be at risk of psychosis ($n = 37$; 30.83%) and our naturalistic, unbalanced design, it is also possible that significant changes in expectancies and use intentions were not observed following advertising exposures. This is because 1) this subset of our sample may not have experienced frequent/ repeated exposure to cannabis advertisements (shown to predict increased cannabis use expectancies and use intentions) or only a small proportion of this subset of our participants were exposed to cannabis advertisements within the 9-day study period that may lead to observable effects on these outcomes and/or 2) we did not have the power to detect such differences.

In sum, these findings align with the self-medication hypothesis and the unifying hypothesis in the development of psychosis, suggesting innate vulnerability to elevated positive cannabis expectancies and cannabis use intentions among youth at risk of psychosis. Due to the study's small sample size and naturalistic design, significant changes in expectancies and use intentions following advertising exposure may not have been observed. Future research employing a larger sample of youth at risk of psychosis and examining advertising channel type and content is needed to fully understand the relationship between psychosis risk and cannabis expectancies and use intentions.

Study Strengths

We acknowledge that EMA methods, in general, are not novel and that researchers starting with Shiffman (circa 1996) and others, have made significant progress in the field of EMA for over 30 years. Nevertheless, to our knowledge, this is the first study to use EMA to capture adolescent cannabis advertising exposures and assess their overall and between-group differences in impacts on cannabis expectancies and use intentions following advertising exposure(s) in Canada or elsewhere.

A particular strength of an EMA approach is that it allows for the collection of detailed contextual information (e.g., location, timing, social context, etc.) from each advertisement exposure and its immediate impacts, unattainable with the same level of precision through retrospective self-report methods (Hébert et al., 2017; Scharf et al., 2013). As such, this study presents novel evidence related to the reach and impacts of cannabis advertising among Ontario youth, and that EMA is an effective tool that other researchers and policymakers can use to study cannabis advertising exposure characteristics (i.e., location, time, messages that exposures are reaching youth), and their consequent impacts on this vulnerable group. An additional strength of this study is that data were collected throughout Ontario, which is a large and diverse province where different cannabis businesses, retailers, advertisements, and demographic presentations exist. This stands in contrast with other studies (e.g., D'Amico et al., 2015, 2017, 2018; Rhew et al., 2022), in which data are typically collected within a single city or a more limited geographic location, thus limiting their generalizability to other youth populations and jurisdictions. This research is particularly important because it was conducted in Canada shortly after cannabis was legalized for recreational use, and very little data is available about the proliferation of advertisements and how they may be impacting youth in newly recreational, cannabis-legal environments where policy and enforcement practices are in flux.

Limitations

The results of this study have various policy implications that may help enhance protections for Canadian youth from cannabis-related harms in the current post-legalization context. At the same time, there are several limitations to this study.

First, as discussed, the expectancy measure we used may not have effectively captured the full range of cannabis expectancies influenced by advertising exposure(s). More specifically, the items we used were adapted from the SCQ tobacco expectancy measure, which is validated among adolescent tobacco smokers and focused on a narrow set of negative affect management

expectancies. Development and use of an expectancy measure, including items pertaining to pro-cannabis injunctive norms, positive consequences and physiological effects of cannabis, and perceptions of symptom management related to cannabis use that is tailored to and validated among youth cannabis smokers and non-cannabis smokers may provide a more accurate understanding of the effects of cannabis advertising exposure on cannabis expectancies and cannabis-related risk.

Second, any inferences made regarding the differential impacts of advertising features or channel type are speculative, given that the moderating effects of different advertising features (e.g., perceived saliency, presence of youth-appealing advertising content/message [e.g., communication of information related to price or distribution; reference to a person, character or animal; advertising evoking popular toys, movies, performers, or games related to young persons, sporting equipment or candies, etc.; brightly-coloured cannabis, cannabis accessories, packages, labels or promotions; flavours, scents or functions associated with products appealing to young persons]) and advertising channel type were not explicitly examined. This limits our ability to comment with certainty on advertising features/ channel types that may be most predictive of increased positive expectancies and use intentions following cannabis advertisement exposure(s). Similarly, although information related to social context was collected, the moderating effect of social context on the relationship between advertising exposure(s) and cannabis expectancies and use intentions was not examined, thus limiting our possibility to comment on its likely effect.

Third, the extent to which our findings can be generalized to the broader Canadian population is limited because we used a sample of convenience. Despite our strategic and targeted recruitment efforts, we experienced relative homogeneity in terms of demographic characteristics, including age, urbanicity and ethnicity for our sample. In particular, interpretation of the interaction effects for urbanicity and ethnicity is limited and should be made with caution. Similarly, although our sample was ethnically diverse, we needed to amalgamate several ethnic/ racial groups (e.g., see "multiracial") due to small cell sizes within groups. This limited our ability to make any

interpretations regarding the possible moderating effect of ethnicity (e.g., Black, Indigenous marginalized groups) on the relationship between advertising exposure(s) and cannabis expectancies and use intentions. Moreover, due to our limited sample size, the current study did not examine the possible moderating effect of other important demographic and psychosocial risk factors (e.g., socioeconomic status) which may have affected the relationship between advertising exposure(s) and cannabis expectancies and use intentions.

Another factor that may limit the interpretability and the generalizability of these findings is a low rate of participant compliance for a small subset of participants due to technological issues impacting the function of the study app. Despite the study team's efforts to mitigate any technological issues related to app function through baseline training sessions and mid-study interviews, a small proportion of participants reported experiencing technological issues related to software compatibility that interfered with participants receiving notifications from the study app, thus affecting overall compliance and limiting the number of control prompt surveys that these participants completed. Therefore, researchers replicating or extending this research will need to consider the benefits and disadvantages of allowing participants to use their own devices for data capture (free, convenient, possibility of increased compliance) as compared to using a study-issued device (guaranteed app compatibility, fairness in data gathering) (Fillo et al., 2016).

Furthermore, given the limited time frame (9 days) and the period in which data were collected (shortly following the onset of the COVID-19 pandemic), the temporal generalizability of these research findings is somewhat limited. First, the longitudinal effects of advertisement exposure(s) on youth cannabis expectancies and use intentions and the effects of advertisement exposure(s) on future cannabis use were not examined in our study. Thus, it is unclear whether cannabis advertisement exposure effects are cumulative and/ or persistent over time and whether changes in cannabis expectancies or use intentions are related to future cannabis use risk. Second, although the finding that many cannabis-related exposures occurred through digital media (e.g.,

promotion by public figures and through advertisements on the internet) is likely influenced by the COVID-19 context (periodic restrictions on mobility, socializing, use of public spaces) in which data were collected, this is also consistent with a significant increase among youth in the use of social media, streaming services, gaming sites and apps (Ellis et al., 2020; Fernandes et al., 2020), as well as previous research demonstrating that cannabis has an established and sophisticated presence specific to the internet based on creative advertisements designed for social media platforms (e.g., Facebook, Instagram and Snapchat; Kelly et al., 2021).

Lastly, information related to youths' exposure to educational cannabis-related information and anti-cannabis information and its subsequent effect on cannabis-related cognitions and cannabis use was not collected as part of this protocol, although this information could be collected in the future and would be informative for public health promotion efforts related to cannabis risk.

Future Research

Future research of a similar nature that examines the possible moderating effects of different advertising features (e.g., perceived saliency, presence of youth-appealing advertising content/message [e.g., communication of information related to price or distribution; reference to a person, character or animal; advertising evoking popular toys, movies, performers, or games related to young persons, sporting equipment or candies, etc.; brightly-coloured cannabis, cannabis accessories, packages, labels or promotions; flavours, scents or functions associated with products appealing to young persons]) and advertising channel type on cannabis expectancies, use intentions, and future cannabis use risk could be useful for informing science and policy. Identifying specific advertising channel types and features leading to significant effects on cannabis-related cognitions and use may enhance the specificity and enforceability of cannabis advertising prohibitions through enhanced cannabis advertising prohibitions, along with enhanced resource allocation allowing for effective monitoring of such prohibitions.

Future research involving a larger, more representative, and diverse sample or using other informative and useful demographic measures of urbanicity and ethnicity allowing for more heterogeneity and more participant sub-groups within a Canadian youth sample would enable researchers to determine whether moderating effects of urbanicity, ethnicity, and age and their influence the relationship between cannabis advertising exposure(s) and cannabis use expectancies and use intentions. Determining whether demographic factors are related to cannabis expectancies and use intentions following advertising exposure(s) may enhance the specificity and enforceability of cannabis advertising prohibitions. Through enhanced cannabis advertising prohibitions designed to protect youth who are most at risk of cannabis-related harms, enhanced resource allocation will also allow for effective monitoring of such prohibitions.

Further additions to this body of work could include longer-term follow-up assessments to determine whether cannabis advertisement exposure effects are cumulative and/ or persistent over time and whether changes in cannabis expectancies or use intentions are related to future cannabis use risk. Support for cumulative and persistent exposure to cannabis advertisements and increased future cannabis use risk may provide impetus to enhance and monitor current Canadian prohibitions on cannabis advertising. Lastly, collecting information related to youths' exposure to educational cannabis-related information and anti-cannabis information and its subsequent effect on cannabis-related cognitions and cannabis use may have the potential to inform psychoeducational interventions and provide support for the creation and dissemination of psychoeducational cannabis-related messaging.

Implications

This study presents some of the very first data that demonstrate that cannabis advertising to youth is actively occurring in Canada's recreational post-legalization context and that exposure to this advertising is predictive of cannabis use intentions among youth via momentary exposure effects. These findings also demonstrate that researchers and policymakers must begin to take

action to prevent underage cannabis use through the development, enhancement, and enforcement of public health-oriented strategies, particularly considering the risks of early, frequent, and high-potency cannabis use. Additionally, these findings demonstrate that the evolving post-legalization landscape and potential loosening of advertising restrictions necessitate careful consideration of risks. Given our findings, future research is also needed to determine youth cannabis expectancies associated with increased cannabis use intentions and future cannabis use risk and cannabis use-related consequences.

Conclusion

This study provides valuable insights into the reach and impact of cannabis advertising on youth in Ontario, Canada. The strengths of the study lie in its use of an EMA protocol, which allowed for the collection of detailed contextual information about cannabis advertising exposures. This study is also the first of its kind to use EMA to capture youth cannabis advertising exposures and assess their impacts on cannabis expectancies and use intentions.

Altogether, our findings support the hypothesis that cannabis companies are reaching Canadian youth through various advertising channels, including cannabis storefronts, billboards, posters, and digital media. The increased availability of cannabis retailers in Ontario has resulted in repeated exposure to these advertisements, which may influence youth's brand awareness, harm perceptions, use intentions, and actual cannabis use. This study also highlights the concerning exposure to cannabis advertising through digital media and personal/branded items seen on social media, indicating the need for additional regulations to protect youth from such advertising. Regarding the measured impact of cannabis advertising on youth, the hypothesis that exposure to cannabis advertisements increases cannabis use intentions was supported. However, the hypothesis that exposure to cannabis advertisements increases cannabis expectancies was not supported. It is suggested that the expectancy measure used in the study may not have captured crucial cannabis-

related constructs affected by advertising exposure, and a more comprehensive measure tailored to youth cannabis smokers and non-smokers is needed.

Overall, the current study underscores the incompatibilities in the regulation and enforcement of cannabis advertising, particularly with the proliferation of cannabis retailers and a shift toward digital advertising in Canada. These findings also call for additional or enhanced cannabis promotion prohibitions to protect youth from the potential harms associated with increased exposure to cannabis advertisements. Ultimately, the study's findings have important implications for policymakers and researchers aiming to address the potential adverse effects of cannabis advertising on youth.

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Appendix A: Consent and Assent Forms
Adolescent exposure to cannabis marketing: Phase III
(Field Study): Parent consent

Study Investigators: Deborah Scharf, PhD, Anna Koné, PhD,
Rupert Klein, PhD

CONSENT:

I agree to the following:

✔ I have read and understand the information contained in the Information Letter

✔ I agree that my teen can take part

✔ I understand the risks and benefits of the study

✔ My teen is a volunteer and he/she can withdraw from the study at any time. My teen can choose not to answer any question

✔ My teen can choose to withdraw data up until the point it is submitted (since it is anonymous)

✔ That the data will be securely stored in the office of the lead researcher for a minimum period of 5 years following completion of the research project

✔ I will not have access to any information that my teen submits as part of this study

✔ My teen will remain anonymous; my name and my teen's name won't be linked to any study data

✔ All of my questions have been answered; all of my teen's questions have been answered

✔ Though we ask participants to keep everything they hear in the sessions private, we **cannot** promise that other members of the group will keep your teen's information private.

By consenting to participate, I have not waived any rights to legal recourse in the event of research related harm.

BY SIGNING THIS FORM, I WILLINGLY AGREE THAT I UNDERSTAND THE INFORMATION ABOVE, AND THAT MY TEEN CAN PARTICIPATE IN THE RESEARCH IT DESCRIBES.

_____   _____

Name of Research Participant – Parent (Print) Name of Research Participant – Teen (Print)

_____   _____

Signature of Research participant – Parent   Date

_____   _____
        Signature of Researcher   **Name of Researcher**

I agree that Dr. Scharf's research team can contact me after the end of this study with information about new opportunities to take part in research. Yes ☐ No☐

Adolescent exposure to cannabis marketing: Phase III
(Field Study): 18 year-old consent

Study Investigators: Deborah Scharf, PhD, Anna Koné, PhD,
Rupert Klein, PhD

CONSENT:

I agree to the following:

✔ I have read and understand the information contained in the Information Letter

✔ I agree to take part

✔ I understand the risks and benefits of the study

✔ I am a volunteer and I can withdraw from the study at any time. I can choose not to answer any question

✔ I can choose to withdraw data up until the point it is submitted (since it is anonymous)

✔ That the data will be securely stored in the office of the lead researcher for a minimum period of 5 years following completion of the research project

✔ I will remain anonymous; my name won't be linked to any study data

✔ All of my questions have been answered

✔ Though we ask participants to keep everything they hear in the sessions private, we **cannot**
        promise that other members of the group will keep your information private.

By consenting to participate, I have not waived any rights to legal recourse in the event of research related harm.

BY SIGNING THIS FORM, I WILLINGLY AGREE THAT I UNDERSTAND THE INFORMATION ABOVE, AND THAT I CAN PARTICIPATE IN THE RESEARCH IT DESCRIBES.

_____

Name of Research Participant

_____   _____

Signature of Research Participant   **Date**

_____   _____

Signature of Researcher   **Name of Researcher**

I agree that Dr. Scharf's research team can contact me after the end of this study with information about new opportunities to take part in research. Yes ☐ No☐

Appendix B: Participant Information Letters
Adolescent exposure to cannabis marketing: Phase III
(Field Study): Information for Parents

Dear Potential Participant:

The title of this project is **Adolescent exposure to cannabis marketing**. Through this research, Drs. Deborah Scharf, Anna Kone and Rupert Klein at Lakehead University are attempting to answer the following questions: How can we use cell phones to study how teens are exposed to cannabis (also called "marijuana", "weed" or "pot") advertising? and how does that exposure affect teens' thoughts and feelings about using cannabis in the future? Your teen's participation today will help us to answer these questions and to improve our study design.

BEFORE BEGINNING

In order for your teen to be in the study, you and your teen have to agree that he/she can take part. Your teen has been invited to take part in the study because your teen is between the ages of 14 and 18 years old, has his/her own cell phone, and can understand and speak English. Please take time to make your decision about whether you want your teen to take part. Ask questions about anything you don't understand.

WHAT IS REQUESTED OF MY TEEN IF I ALLOW THEM TO TAKE PART?

Teens who take part in this study will be asked to do the following tasks over the 9-day study period:
1. Attend a 1-hour training session at Lakehead or through a video conference on the first day of the study to learn about the study tasks.
2. Download a study app.
3. Using the study app, your teen will be asked to take photos and respond to a short questionnaire whenever they are exposed to cannabis advertising.
4. Using the study app, your teen will be asked to respond to a short survey twice per day.
5. Participate in a 10 minute telephone interview on the 4th day of the study to let us know if they're having any problems with the app.
6. Either return to the study site or complete a video conference on the 9th day of the study to tell us about their experiences in the study, transfer study data to the research team, and receive compensation for their time.

Your teen will receive 1 SONA credit for completing the study. If they respond to 70% or more of the required surveys on time, they will receive an additional $25 gift card or 1 SONA credit for a total of a 75$ gift card or 2 SONA credits in exchange for their time.

WHAT INFORMATION WILL BE COLLECTED?

Questionnaire Information
As part of the study training session, your teen will complete a brief questionnaire about themselves (age, gender), a questionnaire to screen for thought disorders in youth, provide some

rough location data (first 3 digits of their postal code) and their cannabis use history.

Throughout the 9-day study, using the study app, we will also ask your teen questions about the ads that they see and their expectancies and feelings surrounding cannabis through questionnaires hosted by the study app. This will include questions such as "what kind of cannabis ad did you see?
Billboard/print ad/ ad in movie/ internet ad", "who are you with (family, friends, co-workers)?"and "how likely are you to use cannabis right now?".

In addition, the questionnaires will also collect your teen's GPS location when they see an ad. These questions will help us better understand the way ads are reaching teens and the impact that ads have on teens' intentions to use cannabis in the future.

Image Data
Teens will take picture of cannabis ads that they see in their natural environments. Teens will only take pictures of cannabis ads when it is safe for them to do so. Teens will be trained to only take pictures of study ads, as well as to not take pictures of people (including themselves). On the last day of the study, we will remind teens that we only want to see pictures of cannabis ads. Teens will then have the opportunity to review their photos and delete any images from the app that include content other than cannabis ads before they are seen by study staff.

Day 4 and Exit Interviews
On study day 4 and on the last day of the study, we will ask your teen some questions about their experience with the study, whether the app worked well for them, and if they have any suggestions about how to improve our study design. This information will be used to help us shape the study going forward.

WHAT ARE MY TEEN'S RIGHTS AS A PARTICIPANT?

KNOW THAT AS A PARENT OR GUARDIAN OF A TEEN IN THIS STUDY THAT:

- Your teen doesn't have to finish the study after he/she has started. They can leave any time without penalty.
- Your decision to let your teen participate will not affect his/her school or work status, or his/her relationship with Lakehead University in any way.
- You and your teen will be given, in a timely manner throughout the course of the research project, information that is relevant to their decision to continue or withdraw from participation.
- You and your teen will be given information on the participant right to request the withdrawal of data (see **"what if my teen wants to withdraw from the study"**).
- **You will not have access to the information your teen provides to the study**

WHAT ARE THE RISKS AND BENEFITS?

Risks. We anticipate that there are three risks to teens that take part in this study.

Embarrassment / Feeling Uncomfortable. Participating teens will be asked questions about their cannabis use history and expectations and intentions to use cannabis. This may make some teens feel embarrassed or uncomfortable. Teens will know ahead of time, before starting the study, that we will ask them these questions. They can choose not to answer any questions or they can with draw from the study at any time.

Photos of Non-Study Content. Some teens may take pictures of non-study content, including personal matter that should not be submitted to the study. To reduce this risk, participating teens will be trained to take photos only of cannabis advertising. They will also be instructed, at the beginning and end of the study, not to submit any photos of content other than cannabis advertising. Teens will have the opportunity to delete any photos that include content other than cannabis advertising before submitting photos to the study. We have used this protocol to protect teens from submitting non-study content to our laboratory successfully in past research projects.

Breach of privacy and discrimination. Teens that participate in this study will be asked to complete questions about their cannabis use history and intentions to use cannabis in the future. This information could be used by educators or employers to discriminate against them if their privacy was breached and this information became known. Your teen's privacy is a top priority of our research team and we have several protections in place to reduce this risk. First, no study data will be associated with your teen's name, birthdate, or other identifying information. We will use alpha-numeric identifiers to label study data. Second, the study app is password-protected and it will exist on participants' password-protected phones. Study data will be stored on password-protected, Lakehead University servers. Third, teens will be instructed to not share their phone with anyone during the study period so that their study data remain private and safe. Fourth, the online platform Zoom that we use for on-line training and data collection sessions is encrypted (scrambled, and unscrambled only with a password). This decreases the risk that anyone can access your teen's information during internet-based study sessions.
In short, only researchers associated with this study will have access to the data that your teen provides. More information about how we maintain your teen's confidentiality is described below under "CONFIDENTIALITY".

Benefits. Taking part in this study will not help you or your teen in any way. The results of this study will help Lakehead University researchers to improve the design of their research study and to ultimately understand the impacts of cannabis advertising on youth.

HOW WILL MY TEEN'S CONFIDENTIALITY BE MAINTAINED?

Teens will be trained in the protocol on their own or in groups of two, in which case we will ask that participants identify themselves using first names only and that they keep private anything that others say in the training group.

During the 9-day study period, teens' data will exist on their password-protected smartphone in a password-protected app. All data provided by teens to this study will be labeled with alpha-numeric identifiers, and no personally identifying information such as name or date or birth.

Any data provided by your teen will be stored safely on Lakehead University servers, and it will be stored separately from their name and other identifying information. Only researchers working on this project, who have been trained in the safe and private storage of research data, will have access to the data provided.

Zoom usage is encrypted so video calls and any information transmitted through the application will remain private. In the video format we ask that participants complete the session in a private space where they cannot be overheard by others around them.

WHAT WILL MY TEEN'S DATA BE USED FOR?

Your teen's data will be used to help us improve our research design and to help us describe the effects of cannabis advertising on youth. Your teen's data will only be accessible by the Lakehead University research team.

WHERE WILL MY DATA BE STORED?

Any data provided will be stored safely and without connection to you or your teen. Data will be kept in a locked cabinet in the lead researchers' (Dr. Scharf's) laboratory. Electronic files will be stored on Lakehead University password-protected research servers. Data will be securely stored for a minimum period of 5 years.

HOW CAN MY TEEN OR I RECEIVE A COPY OF THE RESEARCH RESULTS?

If you or your teen would like to learn about the results of this study, you can leave us your name and
email address and we can send you a copy of the results when we're done.

WHAT IF MY TEEN WANTS TO WITHDRAW FROM THE STUDY?

Your teen doesn't have to be in this study. Your teen can stop taking part at any time. You can request that your teen stops taking part at any time. You can ask to have your teen's data removed from the study up until the point where it is submitted.

RESEARCHER CONTACT INFORMATION:

For any further questions you may have about the study contact advertstudy.psyc@lakeheadu.ca or call 807-343 – 8563. To speak with the lead researcher on the study call Deborah Scharf, PhD, CPsych at 807-343-8773.

RESEARCH ETHICS BOARD REVIEW AND APPROVAL:

This research study has been reviewed and approved by the Lakehead University Research Ethics Board. If you have any questions related to the ethics of the research and would like to speak to someone outside of the research team, please contact Sue Wright at the Research Ethics Board at 807- 343-8283 or research@lakeheadu.ca.

Adolescent exposure to cannabis marketing: Phase III
(Field Study): Information for Consenting Teens
(18 years old)

Dear Potential Participant:

The title of this project is **Adolescent exposure to cannabis marketing**. Through this research, Drs. Deborah Scharf, Anna Kone and Rupert Klein at Lakehead University are attempting to answer the following questions: How can we use cell phones to study how teens are exposed to cannabis (also called "marijuana", "weed" or "pot") advertising? and how does that exposure affect teens' thoughts and feelings about using cannabis in the future? Your participation today will help us to answer these questions and to improve our study design.

BEFORE BEGINNING

In order for you to be in the study, you have to agree to take part. You have been invited to take part in the study because you are between 14-18 years of age, because you have your own cell phone, and because you can understand and speak English. Please take time to make your decision about whether you want to take part. Ask questions to the researcher about anything you don't understand.

WHAT IS REQUESTED OF ME IF I DECIDE TO TAKE PART?

Teens who take part in this study will be asked to do the following tasks over the 9-day study period:
1. Attend a 1-hour training session at Lakehead or through a video conference on the first day of the study to learn about the study tasks.
2. Download a study app.
3. Using the study app, you will be asked to take photos and respond to a short questionnaire whenever you are exposed to cannabis advertising.
4. Using the study app, you will be asked to respond to a short survey twice per day.
5. You will participate in a 10 minute telephone interview on the 4th day of the study to let us know if you're having any problems with the app.
6. Return to the study site or complete a video conference on the 9th day of the study to tell us about your experiences in the study, transfer study data to the research team, and receive compensation for your time.

You will receive a $50 gift card or 1 SONA credit for completing the study. If you respond to 70% or more of the required surveys on time, you will receive an additional $25 gift card or 1 SONA credit for a total of a $75 gift card or 2 SONA credits in exchange for your time.

WHAT INFORMATION WILL BE COLLECTED?

Questionnaire Information
As part of the study training session, you will complete a brief questionnaire about yourself (age, gender), a questionnaire to screen for thought disorders in youth, provide some rough location information (first three digits of your postal code) and your cannabis use history.

Throughout the 9-day study, using the study app, we will also ask you questions about the ads that you see and your expectancies and feelings surrounding cannabis through questionnaires hosted by the study app. This will include questions such as "what kind of cannabis ad did you see? Billboard/print ad/ ad in movie/ internet ad", "who are you with (family, friends, co-workers)?"and "how likely are you to use cannabis right now?".

In addition, the questionnaires will also collect your GPS location when you see an ad. These questions will help us better understand the way ads are reaching teens and the impact that ads have on teens' intentions to use cannabis in the future.

Image Data
You will take pictures of cannabis ads that you see in your natural environments. You will only take pictures of cannabis ads when it is safe to do so. You will be trained to only take pictures of study ads, as well as to not take pictures of people (including yourself). On the last day of the study, we will remind you that we only want to see pictures of cannabis ads. You will then have the opportunity to review your photos and delete any images from the app that include content other than cannabis ads before your photos are seen by study staff.

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On study day 4 and on the last day of the study, we will ask you some questions about your experience with the study, whether the app worked well for you, and if you have any suggestions about how to improve our study design. This information will be used to help us shape the study going forward.

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KNOW THAT AS A PARTICIPANT IN THIS STUDY THAT:

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- You will be given information on the right to request the withdrawal of data (see **"what if I want to withdraw from the study"**).
- Your parents/guardians will not have access to any of the information that you provide to the study staff.

WHAT ARE THE RISKS AND BENEFITS?

Risks. We anticipate that there are three risks to teens that take part in this study.

Embarrassment / Feeling Uncomfortable. Participating teens will be asked questions about their cannabis use history and expectations and intentions to use cannabis. This may make some teens feel embarrassed or uncomfortable. Teens will know ahead of time, before starting the study, that we will ask them these questions. You can choose not to answer any questions or they can withdraw from the study at any time.

Photos of Non-Study Content. Some teens may take pictures of non-study content, including personal matters that should not be submitted to the study. To reduce this risk, participating teens will be trained to take photos only of cannabis advertising. Teens will also be instructed, at the beginning and end of the study, not to submit any photos of content other than cannabis advertising. Teens will have the opportunity to delete any photos that include content other than cannabis advertising before submitting photos to the study. We have used this protocol to protect teens from submitting non-study content to our laboratory successfully in past research projects.

Breach of privacy and discrimination. Teens that participate in this study will be asked to complete questions about their cannabis use history and intentions to use cannabis in the future. This information could be used by educators or employers to discriminate against them if their privacy was breached and this information became known. Your privacy is a top priority of our research team and we have several protections in place to reduce this risk. First, no study data will be associated with your name, birthdate, or other identifying information. We will use alpha-numeric identifiers to label study data. Second, the study app is password-protected and it will exist on participants' password-protected phones. Study data will be stored on password-protected, Lakehead University servers. Third, you will be instructed to not share your phone with anyone during the study period so that your study data remains private and safe. Fourth, the online platform Zoom that we use for on-line training and data collection sessions is encrypted (scrambled, and unscrambled only with a password). This decreases the risk that anyone can access your information during internet-based study sessions. In short, only researchers associated with this study will have access to the data that you provide. More information about how we maintain your confidentiality is described below under "CONFIDENTIALITY".

Benefits. Taking part in this study will not help you in any way. The results of this study will help Lakehead University researchers to improve the design of their research study and to ultimately understand the impacts of cannabis advertising on youth.

HOW WILL MY CONFIDENTIALITY BE MAINTAINED?

You will be trained in the protocol on your own or in groups of two, in which case we will ask that participants identify themselves using first names only and that they keep private anything that others say in the training group.

During the 9-day study period, your data will exist on password-protected smartphone in a password- protected app. All data that you provide will be labeled with alpha-numeric identifiers, and no personally identifying information such as name or date or birth.

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Zoom usage is encrypted so video calls and any information transmitted through the application will remain private. In the video format we ask that participants complete the session in a private space where they cannot be overheard by others around them.

WHAT WILL MY DATA BE USED FOR?

Your data will be used to help us improve our research design and to help us describe the effects of cannabis advertising on youth. Your data will only be accessible by the Lakehead University research team.

WHERE WILL MY DATA BE STORED?

Any data provided will be stored safely and without connection to you. Data will be kept in a locked cabinet in the lead researchers' (Dr. Scharf's) laboratory. Electronic files will be stored on Lakehead University password-protected research servers. Data will be securely stored for a minimum period of 5 years.

HOW CAN I RECEIVE A COPY OF THE RESEARCH RESULTS?

If you would like to learn about the results of this study, you can leave us your name and email address
and we can send you a copy of the results when we're done.

WHAT IF I WANT TO WITHDRAW FROM THE STUDY?

You don't have to be in this study. You can stop taking part at any time. You can ask to have your data removed from the study up until the point where it is submitted.

RESEARCHER CONTACT INFORMATION:

For any further questions you may have about the study contact advertstudy.psyc@lakeheadu.ca or call 807-343-8563. To speak with the lead researcher on the study call Deborah Scharf, PhD, CPsych at 807- 343-8773.

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Adolescent exposure to cannabis marketing: Phase III
(Field Study): Information for Assenting Teens
(Ages 14-17 Years)

Dear Potential Participant:

The title of this project is **Adolescent exposure to cannabis marketing**. Through this research, Drs. Deborah Scharf, Anna Kone and Rupert Klein at Lakehead University are attempting to answer the following questions: How can we use cell phones to study how teens are exposed to cannabis (also called "marijuana", "weed" or "pot") advertising? and how does that exposure affect teens' thoughts and feelings about using cannabis in the future? Your participation today will help us to answer these questions and to improve our study design.

BEFORE BEGINNING

In order for you to be in the study, you have to agree to take part. You have been invited to take part in the study because you are between 14-18 years of age, because you have your own cell phone, and because you can understand and speak English. Please take time to make your decision about whether you want to take part. Teens who are under age 18 years of age have to agree to take part, and a parent/guardian also has to give their permission for you to take part. Ask questions to the researcher or to your parent/guardian about anything you don't understand.

WHAT IS REQUESTED OF ME IF I DECIDE TO TAKE PART?

Teens who take part in this study will be asked to do the following tasks over the 9-day study period:
1. Attend a 1-hour training session at Lakehead or through a video conference on the first day of the study to learn about the study tasks.
2. Download a study app.
3. Using the study app, you will be asked to take photos and respond to a short questionnaire whenever you are exposed to cannabis advertising.
4. Using the study app, you will be asked to respond to a short survey twice per day.
5. You will participate in a 10 minute telephone interview on the 4th day of the study to let us know if you're having any problems with the app.
6. Return to the study site or complete a video conference on the 9th day of the study to tell us about your experiences in the study, transfer study data to the research team, and receive compensation for your time.

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Appendix C: Demographic Questionnaire
Teen Advertising Study
Demographics Survey

1. **What are the first three digits of your postal code? [print]**

_____

2. **How old are you? [print]**

_____

3. **What year were you born? [check one]**

□ 2000	□ 2001	□ 2002	□2003
□ 2004	□ 2005	□ 2006	

4. **What month were you born? [check one]**

□January	□May	□September
□February	□June	□October
□March	□July	□November
□April	□August	□December

5. **What is your gender? [check one]**

□Male	□Transgender	□Prefer not to say
□Female	□Two spirited	□Refused

6. **Do you go to school now? [check one]**

□Yes	□Yes, home-schooled	□No

5a. **If you are in school, what grade are you in? [check one]**

□7th	□9th	□11th
□8th	□10th	□12th

7. **What race do you consider yourself to be? [check all that apply]**

□**Indigenous** (First Nations/Inuit/Métis) □**Latin American, Central American, South American** (Ex. Mexican, Brazilian, Chilean, Venezuelan, Colombian, Argentinian, Costa Rican)	□**Korean** □**Filipino** □**South-east Asian** (Vietnam, Cambodian, Indonesian, Malaysian, Laotian) □**South Asian** (East Indian, Pakistani, Bangladeshi, Sri Lankan)	□**West Asian or Arab** (Ex. Egyptian, Saudi Arabian, Syrian, Iranian, Iraqi, Afghan, Lebanese, Palestinian) □**Korean** □**Don't know** □**Refused**
□**Chinese**	□**White** (Ex. British, Italian, Finnish)	

□**Black** (African, Caribbean, North American)	□**Japanese**	

8. **In the last 12 months, how often did you use cannabis (also known as marijuana, "weed", "pot", "grass", hashish, "hash", hash oil, etc.)? [Check one]**

□1-2 times	□6-9 times	□20-39 times	□Used but not in the last 12 months	□Don't know what cannabis is
□3-5 times	□10-19 times	□40 or more times	□Never used in lifetime	

Appendix D: Justification for Data Screening Procedures and Estimation of Degrees of

Freedom for the Fixed Effects

For all multilevel models, the degrees of freedom for the fixed effects were estimated using the 'between-within' option (i.e., betwithin; bw) in SAS 9.4. This estimation procedure separates the residual degrees of freedom into both within-persons and between-persons components (SAS Institute Inc., 2016) and is deemed suitable for analyses involving longitudinal data (Der & Everitt, 2005).

Prior to conducting multivariate analyses, data were screened for violations of assumptions often associated with multilevel models (normality, linearity, and homogeneity of variance; Bell et al., 2010). More specifically, Level-1 and Level-2 residuals were examined for potential violations of normality, linearity, and homogeneity of variance. For residuals at both levels, box-and-whisker plots and histograms of residuals were analyzed. Examination of the box-and-whisker plots and histograms did not suggest serious violation of normality assumptions. Residuals for all analyses displayed sufficient normality to support model selection. Normality, linearity, and heteroscedasticity were also examined by plotting Level-2 residuals against predicted values for aggregate values of expectancies and intentions, respectively. The resulting scatterplots demonstrated no evidence of heteroscedasticity.

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