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Introduction

Cannabis, also commonly known as marijuana or weed, is a controlled substance derived from the *Cannabis sativa* plant. It is consumed worldwide for medicinal (i.e., to treat medical symptoms) and recreational purposes (i.e., for pleasure or amusement, spiritual or lifestyle purposes) (Canadian Centre on Substance Use and Addiction, 2022; United Nations, 2020). Cannabis can be consumed through inhalation, oral ingestion, or topically through lotions or oils (Canadian Centre on Substance Use and Addiction, 2022). With estimates of approximately 192 million users worldwide, cannabis is reported as the most consumed drug after alcohol and tobacco (United Nations, 2020). Among respondents of the Canadian Cannabis Survey (CCS), comprised of Canadians aged 16 years or older, 25% reported consumption of cannabis in the past 12 months, with 19% of these individuals reporting daily use (Government of Canada, 2021). It is estimated that approximately 8% of individuals who consume cannabis will develop a dependence (Nordstrom & Levin, 2007). Reported rates of substance use among females are highest during the reproductive years (18 to 29) (Stinson et al., 2005).

Cannabis Use in Pregnancy

Despite warnings from governing health bodies advising against the use of cannabis products during preconception, pregnancy, and breastfeeding, cannabis continues to be commonly used by pregnant individuals (American College of Obstetricians and Gynecologists, 2017; Corsi et al., 2018; El Marroun et al., 2008; Grant et al., 2020; Luke et al., 2019). An estimate generated analysis of the United States National Survey on Drug Use and Health found that 3.9% of pregnant people used cannabis in the past month, and 18.1% met the criteria for cannabis abuse and/or dependence (Ko et al., 2015). Self-report data consistently estimates that approximately 2-5% of pregnant individuals consume cannabis during pregnancy; however, this number likely represents an underestimation (Badowski & Smith, 2020; Roncero et al., 2020). The under-reporting of cannabis use may be associated with fear of legal consequences related to the disclosure, including possible loss of child custody rights, or feelings of guilt related to the effects the use may have on their child (Roncero et al., 2020). With recent legalization in Canada, it is possible that future reporting will reflect more reliable estimates coinciding with the reduction of fear surrounding legal repercussions.

Recent estimates of prenatal cannabis use across North America suggest that prevalence of use is increasing. National reports of use among pregnant individuals residing in the United States have significantly increased, rising from 3.4% in 2002-2003 to 7.0% in 2016-2017 (Volkow et al., 2019). In 2017, 6.5% of participants in a population-based study between the ages of 15-24 reported using cannabis during their pregnancy, which marked a significant increased from the 4.9% who reported use in 2012 (Corsi et al., 2018). In their analysis of the National Survey on Drug Use and Health, Agrawal and colleagues (2018) highlight that the prevalence of alcohol and tobacco use decreased among pregnant individuals between 2002 and 2016; conversely, prenatal cannabis use had marked increases during the first trimester (Agrawal et al., 2018).

Pregnant individuals commonly report using cannabis for medical purposes, such as treating symptoms of nausea and vomiting associated with pregnancy (Badowski & Smith, 2020; Chaput et al., 2022; Mark et al., 2017; Westfall et al., 2006), with most users reporting they found cannabis “effective” or “extremely effective” for this purpose (Westfall et al., 2006). Mark et al. (2017) theorize that pregnant individuals may choose to consume cannabis as an alternative to prescription medications that treat nausea due to their associated risks and negative adverse side effects. Additional reasons for consuming cannabis during pregnancy include lack of appetite, pain, insomnia, fatigue, treatment of anxiety and depressive symptoms, and stress relief (Chaput et al., 2022; Ko et al., 2020; Westfall et al., 2006). An anonymous survey distributed to individuals receiving prenatal care revealed that 30% of respondents did not believe that consuming cannabis during pregnancy was harmful to a baby (Mark et al., 2017).

The average concentration of THC in seized cannabis samples has substantially increased over time, with lab studies confirming these increases on the market from 3% in 1983 to 13% in 2008 (Metz & Stickrath, 2015) and from 4% in 1995 to 12% in 2014 (ElSohly et al., 2016). This increase has led to speculation that a greater magnitude of difference between infants exposed and not exposed to cannabis prenatally may emerge, because of the larger amounts of THC present in the cannabis consumed in pregnancy (Badowski & Smith, 2020; Zhang et al., 2017). With the legalization of cannabis in Canada and increasing prenatal cannabis exposure, both in frequency and in potency, it is essential to understand how cannabis use during pregnancy is associated with infant developmental outcomes to provide evidence-based rationale for prevention and intervention measures.

Trends of Cannabis Use among Pregnant Individuals during the COVID-19 Pandemic

Data assessing changes in patterns of prenatal cannabis use during the COVID-19 pandemic is limited; however, research by Young-Wolff et al. (2021) suggests that an increase in prenatal cannabis use coincided with the rise of the COVID-19 pandemic. Analysis of urine toxicology screens of 95,412 women receiving prenatal care in California during the COVID-19 pandemic revealed a 25% increase in prenatal cannabis use, as compared to the 15-month period pre-pandemic (Young-Wolff et al., 2021). In earlier analysis of the Pregnancy During the Pandemic cohort utilized in the current study, 12.8% reported substance use (i.e., the consumption of alcohol, cannabis, tobacco, or illicit substances) after recognition of pregnancy, with 4.3% self-reporting the use of cannabis specifically (Kar et al., 2021). This figure represents an increase from previous Canadian estimates, in which the overall prevalence of self-reported prenatal cannabis consumption was 1.8% (Corsi et al., 2019); however, these higher rates of reporting may be in part reflective of differences in methodology. Substance use data analyzed by Kar and colleagues (2021) was collected using electronic survey data, whereas data analyzed by Corsi and colleagues (2019) was obtained from administrative data in which women had to disclose substance use to a healthcare provider during a prenatal visit.

Predictors of Cannabis Use during Pregnancy

The likelihood of using cannabis during pregnancy is associated with various sociodemographic and biopsychosocial factors. Reports of prenatal cannabis use are most common among young mothers, with North American estimates finding more than half of the individuals who reported use between the ages of 15 and 24 (Corsi et al., 2019; van Gelder et al., 2010). Higher rates of prenatal cannabis use are also more prevalent among non-Hispanic white individuals (Crume et al., 2018; Ko et al., 2015; van Gelder et al., 2010), non-married individuals (Crume et al., 2018; Ko et al., 2015), and individuals who completed only high school or less than 12 years of education (Crume et al.; Mark et al., 2017; van Gelder et al., 2010). In addition, prenatal cannabis use has been associated with lower reported household income (Corsi et al., 2019; Ko et al., 2015), where individuals who report a yearly household income of less than $50,000 USD are approximately twice as likely to report using cannabis during pregnancy when compared to their counterparts who reported yearly household incomes of more than $75,000 USD (Ko et al., 2015).

An additional predictor associated with cannabis use during pregnancy is concurrent substance use. Among the 4.3% of participants in the Pregnancy During the Pandemic cohort study, approximately half were using cannabis in combination with alcohol, tobacco, or other illicit drugs (Kar et al., 2021). When compared to pregnant non-cannabis users, pregnant individuals who reported using cannabis in the past month also reported higher rates of tobacco smoking, binge drinking, and the use of other illicit drugs across the past month (Ko et al., 2015). Individuals who reported continued cannabis use throughout pregnancy were also more likely to have reported the use of cigarettes in their lifetime and were more likely to be current tobacco smokers (Mark et al., 2017; Chaput et al., 2022) and amongst those who had used illicit substances in the past (Chaput et al., 2022).

Associations between Prenatal Cannabis Use and Developmental Outcomes

Previous research on prenatal cannabis use has explored both associations with fetal outcomes at birth, and psychosocial developmental trends throughout childhood and into adolescence. Although various significant associations have been found, interpretation of these findings must be considered in their specific context. Some prior studies have failed to control for important confounders such as concurrent tobacco exposure, or socioeconomic status (Badowski & Smith, 2020; Conner et al., 2016). In addition, the ground-breaking cohort studies examining associations between child development and prenatal cannabis use were initiated in the late 1970s and early 1980s (Campolongo et al., 2009), rendering the results out of date.

Birth Outcomes

Conflicting results have arisen while assessing the association between prenatal cannabis use and birth weight; while some studies have shown no relationship (Day et al., 1991; Fried, 1980; van Gelder et al., 2010), other studies have found that prenatal cannabis use was related to lower birth weight (El Marroun et al., 2009; Rodriguez et al., 2019). This effect may also be dose dependent, with sustained cannabis use throughout pregnancy showing larger reductions in birth weight than for those who used only early in pregnancy (Badowski & Smith, 2020).

The association between prenatal cannabis use, small for gestational age (SGA; defined by birthweights falling below the 10^{th} percentile), and preterm birth (defined as birth before 37 weeks gestation) has also been explored. SGA has been repeatedly associated with prenatal cannabis exposure, with SGA births occurring in significantly higher rates for individuals who screened positively for cannabis use during pregnancy (Kharbanda et al., 2020; Luke et al., 2019; Rodriguez et al., 2019; Warshak et al., 2015). In contrast, conflicting results have arisen when considering the association between of preterm birth, associated with prenatal cannabis exposure. Preterm birth did not occur at a significantly higher rate in some studies amongst individuals who screened positive for cannabis (Baer et al., 2019; Kharbanda et al., 2020); however, others have found increased rates of preterm birth to be associated with prenatal cannabis use (Corsi et al., 2019; Luke et al., 2019).

Psychosocial Development Trends throughout Childhood

Three prospective longitudinal cohorts have followed individuals exposed to cannabis prenatally into young adulthood to assess the ongoing developmental effects associated with the exposure: (1) The Ottawa Prenatal Prospective Study (OPPS); (2) The Maternal Health Practices and Child Development Study (MHPCD); and (3) The Generation R Study (Gen R) (Jaddoe et al., 2006). At various timepoints between the ages of 4-9 years, exposed children across these cohorts showed poorer performance on verbal reasoning and short-term memory tasks, poorer academic achievement in reading and spelling, and delays in language comprehension (Badowski & Smith, 2020; McLemore & Richardson, 2016; Zhang et al., 2017).

In addition to these delays, prenatal cannabis exposure has also been associated with adverse consequences to psychological health throughout infancy and childhood. Female infants in the Gen R cohort exhibited increased rates of aggression and inattention at 18 months of age (El

Marroun et al., 2011), and increased hyperactivity and inattention across males and females at 6 years of age were reported in both the OPPS and MHPCD cohorts (Fried et al., 1992; Leech et al., 1999). Children exposed to cannabis prenatally also reported significantly higher rates of anxiety and depressive symptoms at 10 years of age (Gray et al., 2005; Leech et al., 2006).

Similar to the current study, Kharbanda et al. (2020) assessed the association between prenatal cannabis use and risk of developmental delays at 9 months of age and 12 months of age. In contrast to previous findings, prenatal cannabis exposure was not significantly associated with risk of developmental delays at 9 months. Testing at 12 months found that infants exposed to cannabis prenatally screened abnormally at significantly higher rates than those who were not exposed; however, this trend was not significant in adjusted analysis accounting for race/ethnicity, maternal age, and tobacco consumption during pregnancy.

Trends of Infant Development During the COVID-19 Pandemic

The Pregnancy During the Pandemic cohort began its data collection during the COVID-19 pandemic. Data collection remains ongoing; however, baseline measures were completed by participants beginning in April 2020, with the one-year follow up measure completed when their infant reached 12 months of age. As such, the majority of data collection was completed while participants were facing extraordinary circumstances, including social distancing and lockdown measures.

Because data collection for this study occurred during the COVID-19 pandemic, the results of this study must be considered in this context. Researchers have raised questions regarding whether the experiencing the pandemic generally may impact the regular neurodevelopment of infants. Participants in the PdP cohort completed the Ages and Stages (ASQ-3; Squires et al., 2009) questionnaire to assess developmental milestones of their infant at 12 months of age. Compared to cohorts of infants with similar sociodemographic characteristics born pre-pandemic, infants in the PdP cohort had lower mean scores on all ASQ-3 domains except for problem solving, and presented with significantly higher risk for developmental risk in the communication and personal-social domains (Giesbrecht et al., 2023). Shuffrey and colleagues (2022) similarly compared the neurodevelopment of infants born during the COVID-19 pandemic at six months of age to a historic cohort, and found that infants born during the pandemic scored significantly lower on the gross motor, fine motor, and personal-social domains of the ASQ-3. These results indicate that infants born during the pandemic may face delays in development; however, it remains unclear whether these delays are due to the virus itself or due to societal changes experienced during the pandemic (Metz, 2022).

Recent research has examined the associations between in utero exposure to COVID-19 infection contracted by the birthing parent and neurodevelopmental outcomes; however, findings vary. Some have found that in utero exposure to COVID-19 infection is not significantly associated with differences on any of the ASQ-3 domains when compared to unexposed infants at three months of age (Wu et al., 2021), six months of age (Huang et al., 2021; Shuffrey et al., 2022) and ten to twelve months of age (Ayed et al., 2022). Follow-up comparison at twelve months of age by Huang et al. (2021) revealed a higher risk of delay in the fine motor and communications domains when compared to unexposed infants; however, the communication delay was only present in first-born children. In contrast to these assessments completed with the ASQ-3 questionnaire, analysis completed by Edlow et al. (2022) of a retrospective cohort revealed a greater risk for neurodevelopmental delay amongst infants exposed to COVID-19 in utero within twelve months of birth. Diagnoses of neurodevelopmental disorders were drawn from electronic health records, and had been identified using the *International Statistical Classification of*

Diseases and Related Health Problems, Tenth Revision (ICD-10). In utero exposure to COVID-19 was associated with greater rate of neurodevelopmental diagnoses, with the most common diagnoses relating to motor function, and disorder of speech and language.

Research Aims

The current study will contribute to the existing body of literature by (1) describing differences in sociodemographic characteristics of participants who reported cannabis use during pregnancy and those who did not, (2) examining the association between cannabis use during pregnancy and birth outcomes (i.e., instance of preterm birth and differences in birth weight), and (3) providing further evidence for or against associations between prenatal cannabis use and infant developmental outcomes at 12 months of age across five domains: communication, gross motor, fine motor, problem-solving, and personal social skills. Analyses will determine if cannabis use accounts for a significant portion of variance in continuous scores on the developmental measure, and whether cannabis use is associated with lower mean continuous scores for each domain. It is hypothesized that prenatal cannabis use will significantly contributed to the predictive value of the model, and that prenatal cannabis use will be associated with lower mean scores across the five domains.

Methods

Study Design

The current study utilized data collected for the Pregnancy During the Pandemic (PdP) study (Giesbrecht et al., 2021), a prospective longitudinal cohort of individuals residing in Canada who were pregnant (at time of enrolment) during the COVID-19 pandemic. Involvement in the PdP study included the completion of questionnaires distributed electronically throughout pregnancy and during the postpartum period. Participants were screened for eligibility (see

"Eligibility Criteria") and provided electronic consent prior to completing questionnaires. Participants completed a maximum of 6 surveys during pregnancy (the initial enrollment survey, and up to a maximum of 5 prenatal follow-up surveys). If the participant indicated they were no longer pregnant on a follow-up survey, they were re-directed to the delivery survey. During the postnatal period, participants have filled out surveys at 3-, 6-, and 12-months, with data collection of the cohort ongoing. The current study utilizes data from the initial baseline survey, follow-up surveys during pregnancy, and the 12-month postnatal survey.

Eligibility Criteria

To meet eligibility criteria for enrolment in the PdP study, participants had to be pregnant with a gestational age of ≤35 weeks at time of enrollment. Participants were also required to be 17 years of age or older, currently living in Canada, and able to read and write in English or French.

Recruitment

Participant recruitment for the PdP study occurred between on April 5, 2020, and April 9, 2021 (Giesbrecht et al., 2021). Social media advertising (Facebook and Instagram) was used. Advertisements were written in both English and French. Targeted social media advertisements were distributed on Facebook and Instagram in specific geographic regions and sociodemographic groups to ensure a broad and diverse sample (Giesbrecht et al., 2021). Ads utilized specific locations (e.g., individuals living within 25 miles of Abbotsford or Brampton) and key words (e.g., interests including parenting, pregnancy, or child development). Advertisements directed potential participants to a webpage to complete an eligibility survey. If eligible, participants signed an electronic consent form and were directed to fill out the enrollment survey.

Participants

In total, 11358 French and English participants consented to participate in the initial enrollment survey of the PdP study, of whom 10780 provided information on their substance using behaviours during pregnancy. As of January 2023, 3352 participants completed the 12-month postpartum survey, including the ASQ-3 to assess infant development. To note, the PdP study was originally advertised to participants as a cross-sectional study; however, it was later expanded to be a prospective longitudinal cohort. As such, there was significant attrition of participants between the baseline survey and the 12-month postpartum survey.

Procedure

All data for the PdP cohort study was collected using the web-based survey software REDCap (Research Electronic Data Capture) hosted at the University of Alberta. Online social media advertisements directed potential participants to complete an eligibility screener. If the participant was eligible, they were asked to sign an electronic consent form to complete their enrolment in the study.

Upon enrolment, participants completed the initial enrolment survey to assess various demographic and socioeconomic factors, including questionnaires to assess their substance use behaviours and current mental health symptoms. A complete list of the measures administered in the initial survey is listed in Giesbrecht et al. (2021). Follow-up surveys were sent via email to participants bi-monthly for the remainder of pregnancy. Each follow-up survey began by asking the participant to report if they were still pregnant; if yes, the participant was directed to complete a prenatal survey. If no, the participant was directed to complete a delivery survey, where birth outcome measures were collected. Reporting of substance use behaviours occurred in each prenatal follow-up survey. During the postpartum period, participants were asked to complete follow-up surveys when their infant was 3, 6, and 12 months of age. In the 12 month postpartum period, participants completed The Ages and Stages Questionnaire (ASQ-3; Squires et al., 2009) to assesses their child's progress on meeting various developmental milestones.

Measures

Main Measures

Sociodemographic Information. Demographic and socioeconomic information was collected in the enrolment survey. Participants were asked to report their race/ethnicity, highest education level they had obtained (less than high school diploma, completed high school, completed trade, technical, vocational school or business/community college, bachelor's degree, master's degree, doctorate (PhD) or professional (MD, JD, DDS, etc.)), their marital status (single, married, common-law/living with partner, divorced, widowed, separated), and their total annual household income before taxes and deductions. Maternal age was calculated from reported birth month and year.

Birth Outcomes. Gestational age and birth weight, in grams, were reported in the delivery survey participants received once indicating having given birth.

Cannabis Use. Prenatal cannabis use was measured using a self-report questionnaire. In the enrolment survey, participants were asked to report if they had ever consumed cannabis products after acknowledgment of their pregnancy (yes/no). If the participant indicated yes, they were also asked to report how many days per week on average they consumed cannabis products. In each follow-up survey prior to pregnancy, participants were asked the same self-report questions. In the current study, prenatal cannabis use will be defined as positive self-reported use (i.e., indicated "yes" to using cannabis products in the past month) of cannabis product(s) in the enrolment survey or a subsequent follow-up survey prior to birth, after acknowledgement of pregnancy.

Childhood Developmental Milestones. Analyses of infant development was assessed with the Ages and Stages Questionnaire, Third Edition (ASQ-3). The ASQ-3 is a 30-item, parent-reported measure that assesses child development across five realms: communication, gross motor, fine motor, problem-solving, and personal social skills. Parents rate their infant's current ability on a 10-point Likert scale, ranging between "Yes" (10), "Sometimes" (5), and "Not yet" (0). Table 1 reports the cut-off score for each domain at 12 months of age. Scores that fall below the cut-off indicate a risk of developmental delay and further assessment with a professional is advised (Squires et al., 2009). The ASQ-3 has strong reliability (0.93 interrater reliability; 0.92 test-retest reliability) (Rothstein et al., 2017) and is endorsed by the American Academy of Pediatrics to screen for delayed developmental milestones in children (Committee on Children with Disabilities, 2001). In the current study, continuous scores of each developmental domain was independently assessed.

Table 1

Cut-off Scores for the Ages and Stages Questionnaire (ASQ-3)

Domain	Cut-off Score
Communication	15.64
Gross Motor	21.49
Fine Motor	34.50
Problem Solving	27.32
Personal Social	21.73

Covariates

Depression and Anxiety Symptoms. Participant general anxiety symptoms were assessed in the initial questionnaire using the Patient-Reported Outcomes Measurement Information System (PROMIS) Anxiety (Adult Short Form). This self-report measure consists of 7 items that assess symptoms of general anxiety experienced in the past week (Pilkonis et al., 2011). Raw scores are converted to T-scores using the US general population norms (Giesbrecht et al., 2021). Based on the US general population norms, possible T-scores range between 36.3-82.7 (M = 50, SD = 10). Moderately elevated anxiety symptoms are represented with T-scores in the range of 60.0-69.9. Severely elevated anxiety symptoms are represented with T-scores ≥70 (Cella et al., 2010).

Participant depression symptoms were also assessed in the initial survey, using the Edinburgh Postpartum Depression Scale (EPDS). This self-report measure consists of 10 items that assess maternal depression symptoms in the past week and has been validated for use in both the prenatal and postpartum periods (Bergink et al., 2011; Kozinszky et al., 2015). Scores on this measure may range from 0 to 30, with higher scores reflecting more severe depression symptoms (Cox et al., 1987). Participant scores of ≥ 10 indicate minor depression, and scores of ≥ 13 indicate clinically concerning symptoms of major depression (Cox et al., 1987). When validated against a diagnostic interview, sensitivity on the EPDS for a cut-off score of 10 was 79%, 70%, and 76% in the first, second, and third trimester respectively, and 38%, 39%, and 43% for a cut-off score of 13. Specificity for a cut-off score of ten was 97%, 96%, and 94%, in the first through third trimester, and 99%, 99%, and 98% for a cut-off score of 13 (Bergink et al., 2011).

Concurrent Substance Use. Prenatal substance use of alcohol and tobacco after acknowledgement of pregnancy was measured with items in the initial survey and in follow-up surveys prior to birth. Participants were asked "In the PAST MONTH, have you consumed (alcohol/tobacco products)?" and were given the option to report "yes" or "no".

Statistical Analysis

IBM SPSS (Version 27.0) software was used to complete data analysis. Descriptive analysis was completed to describe the sociodemographic composition of the sample, with means, standard deviations, and percent composition reported accordingly. To evaluate differences in sociodemographic characteristics amongst participants who reported cannabis use and those who did not, chi-square tests were used. Differences in preterm birth and birth weight were assessed respectively with a chi-square test and the Mann-Whitney U test to account for a violation of normality. To determine the proportion of variance that prenatal cannabis use accounted for in continuous ASQ-3 scores across the five domains, multiple linear regression was utilized. Prenatal cannabis use was defined as positive reported use (i.e., indicated "yes" to using cannabis products in the past month, after acknowledgement of pregnancy) in the initial survey or a subsequent follow-up prenatal survey. Unadjusted models were completed for each domain, followed up with an adjusted model that accounted for maternal age, annual household income, education level, race/ethnicity, symptoms of depression during pregnancy, positive reported use of alcohol, positive reported use of tobacco, and gestational age at birth.

Results

In total, 10,769 pregnant individuals completed the initial survey between April 5th, 2020, and June 28th, 2022. Follow-up surveys were completed during pregnancy between May 8th, 2020, and February 2nd, 2022. The twelve month follow-up survey was completed between May 28th, 2021, and February 4th, 2023, when participant's infant reached twelve months of age. Sociodemographic characteristics of the sample collected in the initial survey are reported in Table 1.

8313 participants provided information on their cannabis using behaviours on the initial survey or on a follow-up survey, with 605 (7.3%) reporting consuming cannabis after acknowledgement of their pregnancy. Of these participants, 544 reported cannabis use on the initial survey, and 61 participants (who did not report cannabis use on the initial survey) reported use on a follow-up survey. Self-reported substance use reported on the initial survey is summarized in Table 2.

Table 1.
Sociodemographic characteristics of participants in initial survey (N = 10769)

Variable (*n* reported)	*n* (Valid %)
Language (*n* = 10769)	
English	8153 (75.7)
French	2616 (24.3)
Gender Identity (*n* = 6582)	
Female	6566 (99.8)
Genderqueer/Gender non-conforming	9 (0.1)
Male	1 (.0)
Do not identify as any of the above options	1 (.0)
Prefer not to say	5 (.1)
Residing Province (*n* = 10674)	
Ontario	2955 (27.4)
Quebec	2842 (26.4)
Alberta	2250 (20.9)
British Columbia	1428 (13.3)
Manitoba	398 (3.7)
Saskatchewan	291 (2.7)
Nova Scotia	228 (2.1)
New Brunswick	164 (1.5)
Newfoundland	101 (0.9)
Prince Edward Island	44 (0.4)
Yukon	40 (0.4)
Northwest Territories	19 (0.2)
Nunavut	4 (.0)
Ethnicity (*n* = 10254)	
White	8839 (86.2)
South Asian	279 (2.7)
Biracial	255 (2.5)
East Asian (incl. Chinese, Korean)	175 (1.7)
Southeast Asian (incl. Filipino)	163 (1.6)
Metis	152 (1.5)
First Nations	142 (1.4)
Black	133 (1.3)
West Asian	113 (1.1)
Inuit	3 (.0)
Trimester at Enrolment (*n* = 10698)	
First	2517 (23.5)
Second	4975 (46.5)
Third	3206 (30.0)
Marital Status (*n* = 10593)	

Single	409 (3.9)			
Married	6539 (61.7)			
Common-law/partners living together	3578 (33.8)			
Divorced	21 (0.2)			
Separated	45 (0.4)			
Widowed	1 (.0)			
Highest Completed Level of Education (*n* = 10594)				
Less than high school	142 (1.3)			
High school diploma	901 (8.5)			
College/Trade school	2759 (26.0)			
Undergraduate degree	4117 (38.9)			
Master's degree	1889 (17.8)			
Doctorate degree	786 (7.4)			
	n reported	*M*	*SD*	Range
Age of participant at enrolment	10604	31.83	4.42	17 - 49.67
PROMIS Anxiety Score (*t*-score)	9566	58.12	8.36	36.3 - 82.7
EPDS Depression Score	9598	10.19	5.51	0 - 30

Note. PROMIS = Patient-Reported Outcomes Measurement Information System (Moderately elevated anxiety = 60.9-69.9, Severely elevated anxiety ≥ 70), EPDS = Edinburgh Postpartum Depression Scale (Minor depression ≥ 10, Clinically concerning symptoms of major depression ≥ 13)

Table 2.
Initial survey self-report substance use after acknowledgement of pregnancy of total sample and by trimester.

	Total Sample (*N* = 10769)		
Substance	Yes *n* (%)	No *n* (%)	Missing *n* (%)
Cannabis	544 (5.1)	6282 (58.3)	3943 (36.6)
Alcohol	941 (8.7)	8225 (76.4)	1603 (14.9)
Tobacco	585 (5.4)	9998 (92.8)	186 (1.7)
Illicit drugs	25 (0.2)	10540 (97.9)	204 (1.9)
	First Trimester (*n* = 2517)		
Cannabis	117 (4.6)	1485 (59.0)	915 (36.4)
Alcohol	288 (11.4)	1942 (77.2)	287 (11.4)
Tobacco	136 (5.4)	2361 (93.8)	20 (0.8)
Illicit drugs	6 (0.2)	2482 (98.6)	29 (1.2)
	Second Trimester (*n* = 4975)		
Cannabis	256 (5.1)	2920 (58.7)	1799 (36.2)
Alcohol	422 (8.5)	3829 (77.0)	724 (14.6)
Tobacco	261 (5.2)	4652 (93.5)	62 (1.2)
Illicit drugs	9 (0.2)	4897 (98.4)	69 (1.4)
	Third Trimester (*n* = 3206)		
Cannabis	171 (5.3)	1875 (58.8)	1160 (36.2)
Alcohol	231 (7.2)	2448 (76.4)	527 (16.4)
Tobacco	188 (5.9)	2978 (92.9)	40 (1.2)

Illicit drugs	10 (0.3)	3154 (98.4)	42 (1.3)
		Unknown Trimester (n = 71)	
Cannabis	0 (0.0)	2 (2.8)	69 (97.2)
Alcohol	0 (0.0)	6 (8.5)	65 (91.5)
Tobacco	0 (0.0)	7 (9.9)	64 (90.1)
Illicit drugs	0 (0.0)	7 (9.9)	64 (90.1)

Sociodemographic Characteristics of Cannabis vs. Non-Cannabis Users

Significant differences between participants who reported using cannabis during pregnancy and those who did not were identified across every sociodemographic variable. Compared to those who did not report cannabis use during pregnancy, participants who consumed cannabis were younger and endorsed more severe depression and anxiety symptoms. On average, cannabis users reported a lower annual household income, were less likely to be Caucasian, were less likely to report being married or in a common-law relationship, and were less likely to report completing a college degree or higher level of education (i.e., an undergraduate degree, a master's degree, or a doctorate degree). Finally, cannabis users were also more likely to report using one or more substances (i.e., alcohol, tobacco, or an illicit drug) in addition to cannabis. Data is presented in Table 3.

Table 3.
Characteristics of sample according to cannabis use during pregnancy.

	Cannabis Use	
	Yes	No
Variable	*M (SD)* or *n* (%)	*M (SD)* or *n* (%)
Age at baseline (years)	30.46 (4.84)**	32.24 (4.24)
Depressive symptoms	12.96 (6.13)**	9.93 (5.34)
Anxiety symptoms	61.32 (8.39)**	58.00 (8.16)
Annual income, >$100,000	199 (33.7%)**	4861(63.7%)
Race, White	498 (85.3%)*	6608 (88.0%)
Marital status, has a partner	531 (88.4%)**	7419 (96.6%)
College graduate, yes	438 (72.9%)**	7109 (92.3%)
Polysubstance use, yes	315 (54.5%)**	1243 (16.2%)

Note: M (SD) = mean (standard deviation). Significant differences between groups (e.g., participants who used cannabis during pregnancy versus those who did not) are indicated with * p <.05 and **p <.001. Depressive symptoms were assessed with the Edinburgh Postnatal Depression Scale in pregnancy at the baseline survey. Anxiety symptoms were assessed with the Patient-Reported Outcomes Measurement Information System (PROMIS) Anxiety (Adult Short Form) in pregnancy at the baseline survey. Other race categories include First Nations, Metis, Inuit, Black, West Asian, South Asian, Southeast Asian, East Asian, Hispanic/LatinX, and biracial.

Birth Outcomes

Preterm Birth

Preterm birth occurred in 2.7% (n = 151) of unexposed infants, and in 4.3% (n = 13) of infants who were exposed. A chi-square test for association was conducted between preterm birth and cannabis use during pregnancy. All assumptions were met, with all expected cell frequencies greater than five. There was no significant association between exposure to cannabis prenatally and preterm birth, $\chi 2(1) = 2.66$, $p = .103$.

Birth Weight

The mean birth weight for infants not exposed to cannabis prenatally was 3420.39 grams (SD = 535.32), and 3389.72 grams (SD = 592.24) for infants who were exposed. Birth weights were non-normally distributed across both groups, as assessed by Shapiro-Wilk's test (ps < .001). Participants who did not report cannabis use with a skewness of -.78 (SE = .03) and a kurtosis of 4.26 (SE = .07). Similarly, birth weights for participants who reported cannabis use were non-normally distributed, with a skewness of .11 (SE = .15) and a kurtosis of 1.95 (SE = .29). To account for the violation to normality of distributions, a Mann-Whitney U test was run to determine if there were differences in birth weight between exposed and unexposed infants. Median birth weight did not significantly differ between the exposed (3402.26 grams) and unexposed infants (3430.65 grams), U = 681234.50, z = -1.53, p = .125.

ASQ-3 Descriptive Statistics

Frequency of not meeting the cut-off score for each domain of the ASQ-3 (Squires et al., 2009) was measured for infants who were both exposed and unexposed to prenatal cannabis use. Differences in proportion of exposed and unexposed infants who met the cut-off scores was not statistically significant ($p > .05$). All frequencies and descriptive statistics are reported in Table 4. Mean scores and standard deviations on each domain are reported for exposed and unexposed infants in Table 5. Scores of exposed and unexposed infants did not significantly differ ($p > .05$).

Table 4.
Frequency of meeting the domain cut-off score, by exposure to cannabis during pregnancy.

	Cannabis Exposure during Pregnancy			
	Yes (N = 133)		No (N = 3426)	
ASQ-3 Domain	Meets cut-off *n* (%)	Does not meet *n* (%)	Meets cut-off *n* (%)	Does not meet *n* (%)
Communication	129 (97.7)	3 (2.3)	3373 (98.5)	53 (1.5)
Gross Motor	125 (94.0)	8 (6.0)	3101 (90.6)	323 (9.4)
Fine Motor	131 (99.2)	1 (0.8)	3361 (98.4)	55 (0.7)
Problem Solving	127 (96.2)	5 (3.8)	3259 (95.7)	146 (4.3)
Personal Social	128 (97.7)	3 (2.3)	3232 (95.0)	170 (5.0)

Table 5.
Means and standard deviations of infants on the ASQ-3 at twelve months of age, by cannabis exposure.

	Cannabis Exposure during Pregnancy					
ASQ-3 Domain		Yes			No	
	n	*M*	*SD*	*n*	*M*	*SD*
Communication	132	49.47	10.32	3426	48.06	11.25
Gross Motor	133	48.05	14.60	3424	45.93	15.81
Fine Motor	132	53.52	7.09	3416	52.99	7.46
Problem Solving	132	48.26	10.28	3405	48.30	10.30
Personal Social	131	45.57	10.39	3402	44.01	11.63

Note: *M* = Mean, *SD* = Standard deviation.

Association between Prenatal Cannabis Use and Continuous ASQ-3 Scores

Multiple linear regression was used to determine the relative contribution of cannabis use during pregnancy to variance in continuous scores on the ASQ-3 (Squires et al., 2009) across the five measured domains: communication, gross motor, fine motor, problem solving, and personal social. The first model for each domain examined cannabis use during pregnancy alone and its contribution to variance within the continuous scores. The second model incorporated annual household income, age of the pregnant person, education level, race/ethnicity, depression symptoms during pregnancy, and polysubstance use of alcohol and tobacco. In order to meet adequate sample sizes per group for analysis, race/ethnicity and education were recoded into dichotomous variables. Race/ethnicity was coded to white and non-white participants (combining participants who self-reported their race/ethnicity as south Asian, biracial, east Asian, southeast Asian, Metis, First Nations, Black, west Asian, and Inuit). Education was coded to post-secondary graduates (i.e., completed trade school/college or higher) and high school graduates and lower (i.e., completed high school or less than school). Due to high multicollinearity identified between scores on the EPDS and the PROMIS Anxiety measures during assumption testing (r > .7), PROMIS Anxiety was removed from the multiple regression models.

Communication

Model 1 examined the relative contribution of cannabis use during pregnancy on continuous scores of within the communication domain. The model was not statistically significant, $F(1,3556) = 2.01$, $p = .157$, $R^2 = .001$. Cannabis use did not significantly contribute to the prediction, $p = .157$ (see Table 6).

Model 2, which incorporated maternal age, annual household income, education obtained, race/ethnicity, depression, gestational age, alcohol use, and tobacco use, significantly predicted continuous scores on the communication domain, $F(9,3346) = 2.11$, $p = .026$, $R^2 = .006$. Gestational age added significantly to the prediction, $p = .021$; however, all other variables did not significantly contribute to the prediction. Regression coefficients and standard errors are reported in Table 6.

Table 6.
Multiple regression results for communication scores.

Communication	B	95% CI for B		$SE\ B$	β	R^2	ΔR^2
		Lower	*Upper*				
Model 1						.001	.000
Constant	48.06	47.69	48.44	.19			
Cannabis use	1.41	-.54	3.36	1.00	.02		
Model 2						.006	.003
Constant	36.39	25.67	47.12	5.47			
Cannabis use	1.65	-.47	3.76	1.08	.03		
Maternal age	-.05	-.14	.05	.05	-.02		
Annual household income	-.08	-.28	.13	.11	-.01		
Education	1.48	-.39	3.35	.95	.03		
Race/ethnicity	-.74	-2.00	.52	.64	-.02		
Depression	.03	-.04	.11	.04	.01		
Gestational age	.28	.04	.52	.12	.04*		
Alcohol use	-.76	-1.83	.31	.55	-.03		
Tobacco use	2.13	-.18	4.45	1.18	.03		

Note. B = unstandardized regression coefficient; CI = confidence interval; $SE\ B$ = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2; *$p < .05$; **$p < .01$; ***$p < .001$.

Gross Motor

Model 3 examined the relative contribution of cannabis use during pregnancy on continuous scores of within the gross motor domain. The model was not statistically significant, $F(1,3555) = 2.30$, $p = .130$, $R^2 = .001$. Cannabis use did not significantly contribute to the prediction, $p = .130$ (see Table 7).

Model 4, which incorporated maternal age, annual household income, education obtained, race/ethnicity, depression, gestational age, alcohol use, and tobacco use, significantly predicted continuous scores on the gross motor domain, $F(9,3345) = 5.00$, $p < .001$, $R^2 = .013$. Gestational age ($p < .001$), maternal age ($p = .006$), education ($p = .010$), and depression symptoms ($p = .041$) contributed significantly to the prediction; however, all other variables did not, ps > .05. Regression coefficients and standard errors are reported in Table 7.

Table 7.
Multiple regression results for gross motor scores.

Gross Motor	*B*	95% CI for *B*		*SE B*	*β*	R^2	ΔR^2
		Lower	*Upper*				
Model 3						.001	.000
Constant	45.93	45.41	46.46	.27			
Cannabis use	2.11	-.62	4.84	1.39	.03		
Model 4						.013	.011
Constant	34.75	19.73	49.77	7.66			
Cannabis use	1.74	-1.20	4.69	1.50	.02		
Maternal age	-.19	-.33	-2.73	.07	-.05**		
Annual household income	-.08	-.37	.21	.15	-.01		
Education	-3.43	-6.05	-.81	1.34	-.05*		
Race/ethnicity	.03	-1.74	1.80	.90	.00		
Depression	.11	.01	.21	.05	.04*		
Gestational age	.60	.27	.94	.17	.06***		
Alcohol use	-1.44	-2.94	.05	.76	-.03		
Tobacco use	1.27	-1.98	4.51	1.65	.01		

Note. *B* = unstandardized regression coefficient; CI = confidence interval; *SE B* = standard error of the coefficient; *β* = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2; *$p < .05$; **$p < .01$; ***$p < .001$.

Fine Motor

Model 5 examined the relative contribution of cannabis use during pregnancy on continuous scores of within the fine motor domain. The model was not statistically significant, $F(1,3546) = 0.65$, $p = .419$, $R^2 < .00001$. Cannabis use did not significantly contribute to the prediction, $p = .419$ (see Table 8).

Model 6, which incorporated maternal age, annual household income, education obtained, race/ethnicity, depression, gestational age, alcohol use, and tobacco use, significantly predicted continuous scores on the fine motor domain, $F(9,3337) = 3.48$, $p < .001$, $R^2 = .009$. Gestational age ($p < .001$) and annual household income ($p = .008$) contributed significantly to the prediction; however, all other variables did not (*p*s > .05). Regression coefficients and standard errors are reported in Table 8.

Table 8.
Multiple regression results for fine motor scores.

Fine Motor	*B*	95% CI for *B*		*SE B*	*β*	R^2	ΔR^2
		Lower	*Upper*				
Model 5						.000	.000
Constant	52.99	52.74	53.24	.13			
Cannabis use	.53	-.76	1.83	.66	.01		
Model 6						.009	.007
Constant	39.31	32.14	46.48	3.67			
Cannabis use	1.01	-.40	2.42	.72	.03		
Maternal age	-.03	-.09	.04	.03	-.01		
Annual household income	.19	.05	.33	.07	.05**		
Education	1.17	-.09	2.43	.64	.03		
Race/ethnicity	.10	-.75	.94	.43	.00		
Depression	-.03	-.08	.02	.03	-.02		
Gestational age	.29	.13	.45	.08	.06***		
Alcohol use	-.57	-1.28	.15	.37	-.03		
Tobacco use	1.05	-.50	2.60	.79	.02		

Note. *B* = unstandardized regression coefficient; CI = confidence interval; *SE B* = standard error of the coefficient; *β* = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2; *$p < .05$; **$p < .01$; ***$p < .001$.

Problem Solving

Model 7 examined the relative contribution of cannabis use during pregnancy on continuous scores of within the problem solving domain. The model was not statistically significant, $F(1,3535) = 0.03$, $p = .960$, $R^2 < .00001$. Cannabis use did not significantly contribute to the prediction, $t(3533) = -0.05$, $p = .960$ (see Table 9).

The eighth model, which incorporated maternal age, annual household income, education obtained, race/ethnicity, depression, gestational age, alcohol use, and tobacco use, significantly predicted continuous scores on the problem solving domain, $F(9, 3326) = 2.47$, $p = .008$, $R^2 = .007$. Annual household income ($p <.001$) and maternal age ($p = .035$) contributed significantly to the prediction; however, all other variables did not (*p*s > .05). Regression coefficients and standard errors are reported in Table 9.

Table 9.
Multiple regression results for problem solving scores.

Problem Solving	B	95% CI for B		$SE\ B$	β	R^2	ΔR^2
		Lower	*Upper*				
Model 7						.000	.000
Constant	48.30	47.96	48.65	.18			
Cannabis use	-.05	-1.84	1.75	.91	-.00		
Model 8						.007	.004
Constant	44.37	34.48	54.27	5.05			
Cannabis use	.50	-1.45	2.44	.99	.01		
Maternal age	-.10	-.19	-.01	.05	-.04*		
Annual household income	.37	.18	.56	.10	.07***		
Education	.59	-1.14	2.32	.88	.01		
Race/ethnicity	.96	-.20	2.12	.59	.03		
Depression	-.00	-.07	.07	.04	-.00		
Gestational age	.08	-.14	.30	.11	.01		
Alcohol use	-.66	-1.65	.33	.51	-.02		
Tobacco use	.97	-1.16	3.11	1.09	.02		

Note. B = unstandardized regression coefficient; CI = confidence interval; $SE\ B$ = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2; *$p < .05$; **$p < .01$; ***$p < .001$.

Personal Social

Model 9 examined the relative contribution of cannabis use during pregnancy on continuous scores of within personal social domain. The model was not statistically significant, $F(1,3531) = 2.29$, $p = .130$, $R^2 = 001$. Cannabis use did not significantly contribute to the prediction, $t(3529) = 1.51$, $p = .130$ (see Table 10).

The tenth model, which incorporated maternal age, annual household income, education obtained, race/ethnicity, depression, gestational age, alcohol use, and tobacco use, significantly predicted continuous scores on the personal social domain, $F(9,3326) = 2.08$, $p = .028$, $R^2 = .006$. Annual household income ($p = .023$) and tobacco use ($p = .006$) contributed significantly to the prediction; however, all other variables did not (ps > .05). Regression coefficients and standard errors are reported in Table 10.

Table 10.
Multiple regression results personal social scores.

Personal Social	B	95% CI for B		$SE\ B$	β	R^2	ΔR^2
		Lower	*Upper*				
Model 9						.001	.000
Constant	44.01	43.62	44.40	.20			
Cannabis use	1.56	-.46	3.58	1.03	.03		
Model 10						.006	.003
Constant	40.63	29.53	51.73	5.66			
Cannabis use	1.58	-.60	3.76	1.11	.03		
Maternal age	-.08	-.18	.03	.05	-.03		
Annual household income	.25	.03	.46	.11	.04*		
Education	-.13	-2.08	1.81	.99	-.00		
Race/ethnicity	.42	-.88	1.73	.67	.01		
Depression	.02	-.06	.09	.04	.01		
Gestational age	.11	-.14	.36	.13	.02		
Alcohol use	-.76	-1.87	.35	.57	-.02		
Tobacco use	3.39	1.00	5.79	1.22	.05**		

Note. B = unstandardized regression coefficient; CI = confidence interval; $SE\ B$ = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2; *p < .05; **p < .01; ***p < .001.

Discussion

The current study analyzed data from a prospective, longitudinal cohort to further understand sociodemographic differences between cannabis users and nonusers, and the impact of prenatal cannabis use on birth outcomes and child development. Several clinically relevant sociodemographic predictors of cannabis use during pregnancy were identified. Many of these predictors were consistent with previous findings that individuals who consumed cannabis during pregnancy were more likely to be young (Corsi et al., 2019; van Gelder et al., 2010), non-married (Crume et al., 2018; Mark et al., 2017; van Gelder et al., 2010), of lower reported household income (Corsi et al., 2019; Ko et al., 2015) and report concurrent substance use (Ko et al., 2015; Mark et al., 2017). Participants who reported prenatal cannabis use in the current study also reported more severe symptoms of anxiety and depression symptoms at baseline. Differences in mental health symptoms and diagnoses have been less commonly explored amongst predictors of use; however, previous literature has found that pregnant individuals report using cannabis products to aid in the treatment of depression (Westfall et al., 2009) and anxiety symptoms (Chaput et al., 2022; Westfall et al., 2019). Although the current study did not ask participants to provide insight into why they consumed cannabis during their pregnancy, these findings show that cannabis users experienced more severe mental health symptoms than their non-using counterparts. It could be hypothesized that some individuals were using cannabis to manage anxiety and depression symptoms.

Consistent with findings by Baer et al. (2019) and Kharbanda et al. (2020), prenatal cannabis use was not significantly associated with increased rates of preterm birth (defined as <37 weeks gestation). In addition, median birth weight did not significantly differ between exposed and unexposed infants, consistent with findings by Day et al. (1991) and Fried et al. (1980). Low birth weight has been defined as <2500 grams (Corsi et al., 2019), and both exposed and unexposed infants median birth weight fell above this cut off. Previous examinations of the association between prenatal cannabis use and its association with birth outcomes (e.g., preterm birth, birth weight) has repeatedly garnered conflicting results. Although significant associations between preterm birth and prenatal cannabis use (Corsi et al., 2019; Luke et al., 2019), and lower birth weight and prenatal cannabis use (El Marroun et al., 2009; Rodriguez et al., 2019) have been identified, it is imperative to examine the clinical significance and methodological considerations of these findings. In a meta-analysis assessing the relationship between prenatal cannabis use and birth weight, a statistically significant mean difference of approximately 100 grams between exposed and unexposed infants was identified (Gunn et al., 2016); however, the clinical implications of this difference remain unclear. As highlighted by Corsi et al. (2019), associations between prenatal cannabis use, low birth weight, and preterm birth are often not significant in analyses that properly adjust for confounding factors. For example, in a similar meta-analysis, after adjusting for tobacco exposure, prenatal cannabis use was not significantly associated with low birth weight (Conner et al., 2016).

Exposure to cannabis use prenatally did not significantly contribute to variance in the continuous scores on any of the five domains measured by the ASQ-3 in unadjusted or adjusted models (*p*s > .05). Amongst the covariate variables, gestational age, annual household income, maternal age, education level, and tobacco use all significantly contributed to at least one model. In comparison, race/ethnicity, symptoms of depression during pregnancy, and alcohol use did not significantly contribute to variance in continuous scores in any adjusted models.

The publication of studies examining the association of prenatal cannabis use and infant development at or before 12 months of age has been limited, with little conclusive evidence that prenatal cannabis use adversely impacts development within this age range. Three previous studies aligned with examining development and its association with prenatal cannabis use were identified: Fried and Watkinson (1988), Kharbanda et al. (2020) and Richardson et al. (1995). Assessment of infants from the OPPS cohort revealed no significant relationship between prenatal cannabis use and infant development as assessed by the Bayley Scales of Infant Development (BSID) at 12 or 24 months of age (Fried and Watkinson, 1988). Similarly, data collected from the MHPCD cohort revealed that consumption of one or more joints per day during the third trimester was associated with lower scores on the mental development index of the BSID at 9 months of age; however, these findings were not significant when infants were reassessed at 19 months. Finally, in analyses completed by Kharbanda et al. (2020), prenatal cannabis use was not associated with scoring below the published threshold cut off scores for the ASQ-3 at 9 months of age, or the ASQ-SE at 12 months of age. These previous findings are mainly in line with the current study, in which prenatal cannabis use was not significantly associated with adverse outcomes on any of the five domains as measured by the ASQ-3. Published findings from past cohort studies have largely identified deficits in regular development at later ages throughout childhood, with differences in verbal reasoning, memory tasks, language comprehension emerging as early as three years of age (e.g., Day et al., 1994), and increased inattentive and hyperactive behaviour at as early as six years of age (e.g., Goldschmidt et al., 2000). It is difficult to determine if gaps in the literature assessing development in infancy associated with prenatal cannabis use are due to a lack of exploration into this area, or due to a publication bias in which null results were not published.

Strengths

This study offers a milieu of strengths and contributions to the current body of literature examining cannabis use during pregnancy. To our knowledge, no studies have been completed with a cross-Canada cohort examining the association between prenatal cannabis use and developmental outcomes at 12 months of age in a post-legalization context. Assessment of developmental outcomes and their association with cannabis use during pregnancy are extremely limited in the current body of literature, with the majority of the available data published prior to the 21st century, and thus, may be becoming outdated. The current study provides information on this association from a large, cross-Canada cohort. Our study design, a prospective, longitudinal cohort, will allow for continued follow-up over time to determine if associations between prenatal cannabis use and adverse development occur beyond infancy. Previous Canadian studies have been limited in their geographical composition, and often sample individuals from a single province only (e.g., Corsi et al., 2019; Luke et al., 2019; Myran et al., 2023). Because the PdP cohort provides representation from every province and territory, a more holistic view of trends surrounding cannabis use nationally is captured.

The majority of data available on outcomes related to cannabis use during pregnancy has been collected in the United States of America, where the use of cannabis is prohibited federally. Because of differences in federal law, acceptability and commonality of use may differ between the two countries; therefore, it is important to prioritize the analysis of Canadian data as it relates to prenatal cannabis use and childhood development outcomes. Limited research has suggested that cannabis usage amongst pregnant individuals has not significantly increased post-legalization (Bayrampour & Asim, 2021; Drabkin et al., 2022). Despite this, recent analysis completed by Myran et al. (2023) found notable changes to acute care for cannabis during pregnancy post-legalization, with the mean quarterly rate increasing from 11.0 per 100,000 pregnancies pre-legalization to 20.0 per 100,000 pregnancies post-legalization. With this trend in increased rates of acute care, it is imperative to continue to monitor trends related to cannabis use during pregnancy, and remain diligent in analyzing how this usage impacts child development.

Finally, the methodology employed in this paper allowed for specific insight on delays by examining each domain of the ASQ-3 individually. Although no significant associations were observed, such methodology would have allowed for targeted interventions to be created to help mitigate the impact of these delays. Future studies may benefit by utilizing a similar methodological strategy in order to facilitate the creation of targeted interventions for older age groups, as required.

Limitations and Methodological Considerations

The findings must be interpreted in light of several limitations. To begin, the substance use measure utilized did not capture the quantity of cannabis used in grams or potency; therefore, direct comparison of the effects and their association with dosage could not be completed. Cannabis products (e.g., joints, edibles) can vary widely in potency (i.e., the percentage of THC composition) and quantity (i.e., grams of cannabis present in the product consumed). Future studies should consider collecting information on amount and potency of products used to allow for more direct comparison of use between participants, and to determine if an effect exists between the quantity and potency of cannabis products used and risk of developmental delays. Consistent use of cannabis may affect development differently than occasional use, and this potential association should be explored in future studies. Additionally, replication of the current study could be strengthened by using a more robust measure of infant development. As highlighted by Kharbanda et al. (2020), although the ASQ-3 is frequently used to identify infants at risk for developmental delays, it is not a diagnostic tool, and therefore may not be optimally sensitive in comparison to formal neurocognitive assessments.

Data was collected using self-report, online surveys, a methodology which has various strengths and weaknesses. The use of online surveys allows for the rapid distribution of measures to a wide sample of participants, for relatively low cost. Self-report measures for substance use are considered to be less invasive, and allow for reporting substance using behaviours across a broader period of time than may be captured by biochemical sampling (El Marroun et al., 2011); however, self-reports may not capture substance use as accurately as biochemical sampling. In a comparison of urinary analysis and self-report measures of cannabis use during pregnancy, El Marroun and colleagues (2011) frequently found positive urine screens in pregnant individuals with missing self-report measures for cannabis use. Considering these findings, reports of cannabis use in the current study may be underestimated. To increase rates and accuracy of reporting, future studies may consider collecting data anonymously to remove fear of reporting, or by completing analysis of biochemical samples to provide objective results. To note, the proportionally high rates of missing data for cannabis use (36.6%) were attributed to a coding error after anaylsis, in which some participants who reported “No” to ever consuming cannabis in their lifetime were marked as missing. This coding error will be corrected for publication.

As previously mentioned, the PdP study was initially advertised to potential participants as a cross-sectional study (i.e., completion of one survey, at a single point in time); however, the study was continued as a prospective longitudinal cohort study. Upon initial consent, many participants were under the impression they would only be required to complete a single survey, but were later invitied to continue their participation in the ongoing longitudinal study. Due to this change in methodology, the study experienced attrition between the initial baseline survey and the tweleve month follow-up survey, in which only approximately 25% of participants continued to participate in the longitudinal portion of the PdP study. Due to this attrition, it is possible that the results observed in the current study may have a level of attrition bias, in which the results may have underestimated or overestimated the associations observed.

Finally, data used in analysis was collected during the COVID-19 pandemic, in which substance use may have been more prevalent (Young-Wolff et al., 2021), and societal measures (e.g., social distancing, quarantining) may have impacted develop of infants born during this time generally (Metz, 2022). Although COVID-19 infection during pregnancy does not appear to have a clear link to infant development assessed using the ASQ-3 at and before 12 months of age (Ayed et al., 2022; Huang et al., 2021; Wu et al., 2021), emerging analysis of the development of infants born during the COVID-19 pandemic indicates that infants may be lagging behind developmentally when compared to historical cohorts. As previously stated, analysis of the PdP cohort revealed that, in comparison to infants born pre-pandemic, infants born during the COVID-19 pandemic scored significantly lower on all domains of the ASQ-3 at 12 months of age, except for problem solving (Giesbrecht et al., 2023). Similar results were found by Shuffrey and colleagues (2022). As such, the specific mean scores of infants in the current study may not be directly comparable to non-pandemic times.

Conclusion and Future Directions

Although the current study did not find significant associations between prenatal cannabis use and risk of developmental delays at 12 months of age, these findings should not be conflated to suggest that consuming cannabis products during pregnancy is safe or recommended. As previously mentioned, deficits in regular development seem to emerge later in childhood, and lack of adverse outcomes at 12 months of age does not negate these findings. Because risk of developmental delays associated with cannabis use seem to emerge after infancy in toddlerhood (e.g., El Marroun et al., 2011) and throughout childhood (e.g., Goldschmidt et al., 2000), it is imperative that studies assessing delays in development in infancy are followed up longitudinally to determine if these measures change over time. Public health messaging should continue to be rooted in evidence-based literature, and may emphasize the developmental risks that occur later in childhood.

Continued monitoring of trends related to sociodemographic predictors of cannabis use during pregnancy is important for the ongoing creation of public health literature surrounding cannabis use during pregnancy. By identifying risk factors associated with cannabis use during pregnancy, healthcare researchers and practitioners can more effectively create and distribute educational materials related to cannabis use during pregnancy to high risk groups. Providing accessible materials surrounding the risks related to cannabis use during pregnancy may ultimate help mitigate risks to child development later in life.

Finally, future studies may benefit from using a detailed measure of cannabis use that captures information such as the questions that capture the potency and/or quantity (i.e., grams) of cannabis in products being consumed. Collection of such information would allow for analysis on the impact of dosage and its association with childhood developmental outcomes. A bimodal distribution was observed in the current study, with the majority of participants who reported cannabis use using either one day or seven days a week. Although days per week was used as a proxy for dosage in the current study, specific information on differences in potency and quantity between participants who used one day per week versus seven days per week would have allowed for more accurate analysis between "low use" participants and "high use" participants.

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