Marijuana Use by Breastfeeding Mothers and Cannabinoid Concentrations in Breast Milk

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abstract

BACKGROUND AND OBJECTIVE: Marijuana is the most commonly used recreational drug among breastfeeding women. With legalization of marijuana in several US states and a 1990 study in which authors documented psychomotor deficits in infants breastfed by mothers using marijuana, there is a need for information on potential exposure to the breastfed infant. Our objective with this study was to quantify cannabinoids in human milk after maternal marijuana use.

METHODS: Between 2014 and 2017, 50 breastfeeding women who reported marijuana use provided 54 breast milk samples to a research repository, Mommy's Milk. Concentrations of Δ-9-tetrahydrocannabinol (Δ9-THC), 11-hydroxy-Δ-9-tetrahydrocannabinol, cannabidiol, and cannabinol were measured by using liquid chromatography mass spectrometry electrospray ionization.

RESULTS: Δ9-THC was detectable in 34 (63%) of the 54 samples up to ∼6 days after last reported use; the median concentration of Δ9-THC was 9.47 ng/mL (range: 1.01–323.00). Five samples had detectable levels of 11-hydroxy-Δ-9-tetrahydrocannabinol (range: 1.33–12.80 ng/mL) or cannabidiol (range: 1.32–8.56 ng/mL). The sample with the highest concentration of cannabidiol (8.56 ng/mL) did not have measurable Δ9-THC. Cannabinol was not detected in any samples. The number of hours since last use was a significant predictor of log Δ9-THC concentrations (−0.03; 95% confidence interval [CI] −0.04 to −0.01; P = .005). Adjusted for time since last use, the number of daily uses and time from sample collection to analysis were also significant predictors of log Δ9-THC concentrations (0.51; 95% CI 0.03 to 0.99; P = .039; 0.08; 95% CI 0.00 to 0.15; P = .038, respectively).

CONCLUSIONS: Δ9-THC was measurable in a majority of breast milk samples up to ∼6 days after maternal marijuana use.

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Mrs Bertrand designed the data collection instruments, coordinated and supervised data collection, drafted the initial manuscript, and reviewed and revised the manuscript; Dr Chambers conceptualized and designed the study and critically reviewed and revised the manuscript; Drs Best and Hanan conducted the assay development and sample analysis and reviewed and revised the manuscript; Mr Honerkamp-Smith conducted the study analyses and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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WHAT'S KNOWN ON THIS SUBJECT: Previous data used to quantify the transfer of Δ-9-tetrahydrocannabinol and other cannabinoids into human breast milk after maternal marijuana use are limited to several case reports.

WHAT THIS STUDY ADDS: In 50 women reporting marijuana use while breastfeeding, Δ-9-tetrahydrocannabinol was measurable in 63% of milk samples, up to 6 days after last use; 11-hydroxy-Δ-9-tetrahydrocannabinol and cannabidiol were measurable in 9% of milk samples, and cannabinol was undetectable in all samples.

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Marijuana is the most commonly used recreational drug among breastfeeding women (Supplemental Fig 2).[1,2] However, potential infant exposure to marijuana through breastfeeding is poorly understood. This question is of critical importance because human milk is the normative standard for infant feeding and nutrition.[3] The World Health Organization recommends exclusive breastfeeding up to 6 months of age.[4] Being breastfed early in life has been associated with a reduction in subsequent obesity and improved performance on intelligence tests. In mothers, breastfeeding has been associated with lower risks for subsequent breast and uterine cancer and type 2 diabetes.[5,6]

However, there is a paucity of data on the effects of maternal marijuana use among infants potentially exposed through breast milk. Authors of case reports have documented the presence of the primary psychoactive ingredient in marijuana, Δ-9-tetrahydrocannabinol (Δ9-THC), in human milk.[7] In 1 report, the level of Δ9-THC measured in a milk sample provided by a mother who smoked marijuana once daily was 105 ng/mL. The concentration in a sample from a second mother who smoked marijuana 7 times per day was 340 ng/mL. In an additional set of paired milk and maternal plasma samples obtained from one of these mothers, the Δ9-THC concentration measured in the milk sample (60.3 ng/mL) was 8 times higher than the maternal plasma concentration of 7.2 ng/mL, suggesting that Δ9-THC accumulated in breast milk.[8] Furthermore, fecal samples from that mother's infant had higher concentrations of other metabolites (11-hydroxy-Δ-9-tetrahydrocannabinol [11-OH-THC] and Δ-9-carboxy-tetrahydrocannabinol) than the mother's breast milk, suggesting the infant absorbed and metabolized the Δ9-THC after breast milk ingestion. In another case report, a single human milk sample obtained from a woman with a history of drug abuse was found to have detectable levels of both Δ9-THC (86 ng/mL) and 11-OH-THC (5 ng/mL).[9] Authors of a third published study analyzed 109 randomly collected milk samples with no accompanying information on maternal marijuana use; Δ9-THC was detected in 2 samples and cannabidiol in 1.[10]

There are limited data on the potential neurobehavioral effects of infant exposure to cannabis through breast milk. Astley and Little[11] reported psychomotor deficits in fifty five 12-month-old infants breastfed by mothers using cannabis compared with 81 unexposed infants. In contrast, Tennes et al[12] reported no differences in motor and mental development in twenty seven 12-month-old infants whose mothers used marijuana while breastfeeding compared with 35 unexposed infants.

Lacking definitive data on the risk or safety of infant exposure to cannabis through breast milk, the American Academy of Pediatrics and the American Congress of Obstetricians and Gynecologists advise that marijuana use should be discouraged while breastfeeding.[13,14] However, with current legalization of marijuana for recreational use in 9 US states, there is an urgent need for characterization of cannabinoid distribution in human milk and the corresponding potential exposure of breastfeeding infants and toddlers. The purpose of this study was to measure cannabinoid concentrations in breast milk in relation to dose and time since last maternal marijuana use.

METHODS

Study Design

In 2014, the University of California, San Diego established Mommy's Milk, the human milk biorepository (HMB) for research. Volunteers residing in the United States and Canada have been recruited into HMB through a variety of sources including social media. After providing written informed consent for future research uses of milk samples and associated data, breastfeeding mothers completed an interview providing demographics, maternal and child health history, and details regarding exposures to medications, alcohol, tobacco, and other recreational substances. Participants recalled their exposures for the 14 days before milk sample collection and provided additional information on exposure to herbal supplements, prescription medications, or recreational substances since giving birth. Women were instructed to pump and collect 50 mL of milk up to a full expression as close to the time of the scheduled interview as possible and up to 24 hours before. Any quantity of milk ≥1 mL was accepted. The HMB protocol was approved by the Institutional Review Board at the University of California, San Diego, and a National Institutes of Health Certificate of Confidentiality was obtained.

Assessment of Exposure

For HMB participants who reported marijuana use at any time since giving birth, the maternal questionnaire data included route of administration (inhaled, ingested, topical), frequency of use, dose, and time since last use before sample collection. If mothers indicated a dose unit of joints, puffs, or grams, the route of administration was classified as "inhalation only"; those who indicated a dose unit of drops, milligrams, or servings were classified as "other only." Those who reported >1 route of administration were classified as "both." The frequency of marijuana use was determined by calculating the average number of uses per day during the most recent exposure window within the 14-day recall.

Hours since last use were calculated by using the end of the exposure interval for the most recent exposure up to the time of milk sample collection.

Collection and Preparation of Human Milk Samples

Before sample collection, participants were instructed to clean the nipple and areola of the breast with an alcohol wipe. Milk sampling occurred by using 1 of the following 2 methods: (1) if at the HMB research center, participants pumped milk with a hospital grade industrial breast pump (either the Medela Symphony or the Hygeia Enjoye) using a sterile collection kit provided by study staff; or (2) if a home collection, participants pumped milk into a personal milk collection container specific to their own hand or electric breast pump. For home collections, expressed milk was refrigerated at 0 to 4°C until either transported on ice to the HMB research center or picked up by courier within 24 hours of collection and shipped overnight on ice to the HMB facility. After receipt, samples were aliquoted into 1 to 15 mL cryovials or centrifuge tubes and stored at −80°C.

Analytical Procedure

Reference standards (Δ9-THC, 11-OH-THC, cannabidiol, and cannabinol) and isotopically labeled internal standards (THC-d3, 11-OH-THC-d3, cannabidiol-d3, cannabinol-d3) were purchased from Cerilliant (Round Rock, TX). BondElut Certify C-18 cartridges (Varian; Lake Forest, CA) were used for solid-phase extraction. High-performance liquid chromatography grade water, 0.1% formic acid in acetonitrile, and methanol were purchased from Fisher Scientific. Reagent grade ammonium formate and pure sodium hydroxide pellets were purchased from Sigma-Aldrich.

We followed the saponification–solid-phase extraction method of Wei et al[15] for sample cleanup and extraction with minor modifications.

Chromatographic separation was achieved on reverse-phase C-18 column (MAC-MOD Ace 5 C-18 15 cm × 2.1 mm). The mobile phase consisted of 5 mM ammonium formate in 0.05% formic acid (solvent A) and acetonitrile in 0.1% formic acid (solvent B). A gradient elution was performed over 15 minutes at a flow rate of 200 μL/minute. Retention times for 11-OH-THC, cannabidiol, and THC were 9.35, 10.62, and 11.70 minutes in positive ion mode, respectively. Quantitation of THC, 11-OH-THC, and cannabidiol and isotopically labeled internal standards were achieved on a triple quadrupole mass spectrometer (API-4000; AB Sciex, Framingham, MA) in positive ion mode. Cannabinol and cannabinol-d3 were detected in negative ion mode.

Statistical Analysis

Demographic and clinical variables for mothers and infants were summarized by using frequencies and percentages. For each cannabis metabolite, concentrations were categorized as either above or below the quantification limit, which was defined as 1 ng/mL. Summary statistics for those samples with concentrations above the limits of quantification for each metabolite were computed. Concentrations of Δ9-THC were log transformed. Linear regression models were used to estimate associations between the log concentrations of Δ9-THC and the time since last cannabis exposure, frequency of use, dose, and route of administration. Other covariates that were considered included maternal BMI, age and sex of the infant, time from sample collection to analysis (sample age), time of day of sample collection, time since last feed or pump, and feeding frequency. Effect estimates and 95% confidence intervals (CIs) as well as *P* values were reported.

To estimate potential infant exposure and infant plasma concentrations, we used the Δ9-THC concentrations from the linear regression models to compute the mean cumulative dose of Δ9-THC hypothetically ingested over a 24-hour period by a nursing 3-month-old infant that weighs 6.1 kg, assuming 3.1875 oz of milk was consumed at each feeding over 8 equally spaced feedings with 6% oral bioavailability.[16] All statistical analyses were performed by using R version 3.4.1 with a 2-sided *P* value <.05 judged as significant.

RESULTS

Between 2014 and 2017, 50 mothers who participated in the HMB research repository reported recent marijuana use and provided a breast milk sample. Four mothers provided 2 samples at different time points. Characteristics of the participants are shown in Table 1. Two-thirds of the women were breastfeeding a child <1 year of age. The most common route of administration was by inhalation only (64%), and most women in the sample (88%) reported at least daily marijuana use.

As shown in Table 2, Δ9-THC was detectable in 34 (63%) of 54 samples; among these, the median concentration of Δ9-THC was 9.47 ng/mL (range: 1.01–323.00). Only 5 (9%) of the 54 samples had measurable concentrations of 11-OH-THC. Similarly, 5 (9%) of the 54 samples had measurable concentrations of cannabidiol. Only 1 sample had measurable levels of all 3 cannabinoids (Δ9-THC, 11-OH-THC, and cannabidiol); in this sample, the concentration of Δ9-THC was the highest measured in the series (323 ng/mL). Similarly, only 1 other sample had measurable levels of 2 of the cannabinoids (11-OH-THC and cannabidiol but not Δ9-THC); in that sample, the concentration

TABLE 1 Selected Characteristics of Maternal and Infant Participants (2014–2017), *N* = 54

Characteristic	*N* = 50 Mothers, No. (%)	*N* = 4 Mothers Who Gave a Repeat Sample, No. (%)
Maternal age, y		
22–25	7 (14)	—
25–30	17 (34)	—
30–35	18 (36)	—
35–41	8 (16)	—
Maternal ethnicity		
Hispanic	9 (18)	—
Non-Hispanic	41 (82)	—
Maternal race		
White	44 (88)	—
African American	1 (2)	—
Asian American	2 (4)	—
Native American	3 (6)	—
Maternal education, y		
Partial high school	1 (2)	—
High school graduate or GED	4 (8)	—
Some college or specialization	27 (54)	—
College graduate	14 (28)	—
Postgraduate	4 (8)	—
Maternal BMI		
<18.5	0 (0)	—
18.5–24.99	17 (34)	—
25–29.99	17 (34)	—
>30	9 (18)	—
Parity		
1	21 (42)	—
>1	29 (58)	—
Route of marijuana exposure[a]		
Inhalation only	32 (64)	2 (50)
Other only	7 (14)	0 (0)
Both	11 (22)	2 (50)
Frequency of marijuana use		
<1 use per d	6 (12)	1 (25)
1 use per d	23 (46)	3 (75)
>1 use per d	21 (42)	0 (0)
Full expression of the breast[b]		
No	9 (18)	0 (0)
Yes	41 (82)	4 (100)
Infant age, mo[c]		
0–3	3 (6)	0 (0)
3–6	20 (40)	0 (0)
6–12	11 (22)	0 (0)
>12	16 (32)	4 (100)
Infant sex		
Girl	22 (44)	—
Boy	28 (56)	—

GED, general education diploma; —, not applicable.

[a] Inhalation only was defined as a dose unit of joints, puffs, or grams. Other only was defined as a dose unit of drops, milligrams, or servings. Both was defined as a dose unit from both the inhalation only and the other only groups.

[b] A full expression of milk was defined as emptying the breast of milk entirely during 1 pump session.

[c] If the mother of the infant was breastfeeding >1 child, only data from child 1 were included.

of cannabidiol was the highest measured in the series (8.56 ng/mL). There were no samples with detectable levels of cannabinol.

As shown in Table 3 and in Fig 1, there was a significant association between log Δ9-THC concentrations and hours since last marijuana use in the fitted regression model. On average, for each additional hour between last exposure to marijuana and the milk sample collection, there was a reduction of 0.03 in the log concentration of Δ9-THC (95% CI −0.04 to −0.01; *P* = .005). On the unlogged scale, this corresponds to a reduction in Δ9-THC concentration of 3% per hour after last exposure, which can be used to estimate a half-life of ∼27 hours for Δ9-THC in human milk. The longest duration between last use of marijuana and measurable Δ9-THC was ∼140 hours or 6 days (Fig 1).

As shown in Table 3, in each of the separate regression models (except the model for heavy use), hours since last use was a significant negative predictor of log Δ9-THC concentration. The number of uses per day was also significantly associated with increasing concentrations of log Δ9-THC (0.51; 95% CI 0.03 to 0.99; *P* = .039), as was sample age in months (0.08; 95% CI 0.00 to 0.15; *P* = .038). No other covariates among those considered were significant predictors of log Δ9-THC concentration (after adjusting for hours since last use).

Based on our assumptions regarding breastfeeding frequency, quantity of milk ingested, and 6% oral bioavailability, the estimated plasma concentration of Δ9-THC in a hypothetical 3-month-old infant weighing 6.1 kg was 0.040 ng/mL. Compared with the plasma concentration of an adult who consumed 10 mg of Δ9-THC, the estimated infant dose ingested via breast milk would be ∼1000 times lower.[17]

Δ9-THC was not detectable in 20 (37%) of 54 samples. Fewer women with undetectable levels of Δ9-THC reported more than daily use compared with women with measurable quantities (41.2% vs 21.1%). In addition, the mean number of hours since last use was higher among those women with levels below limits of detection compared with those above, with wide variability across samples (53.06 hours [SD 76.54] vs 24.48 hours [SD 32.87]). However, the only statistically significant factor differentiating the 2 groups was route of administration. The majority

TABLE 2 Concentrations of Cannabinoids in Human Milk Samples, $N = 54$

	Minimum	First Quartile	Median	Third Quartile	Maximum	AQL	BQL
Δ9-THC, ng/mL	1.01	2.29	9.47	46.78	323.00	34	20
11-OH-THC, ng/mL	1.33	1.35	2.38	5.45	12.80	5	49
Cannabidiol, ng/mL	1.32	2.92	4.99	5.97	8.56	5	49

The concentration of cannabinol was BQL in all 54 samples. AQL, above quantification limit, defined as ≥1 ng/mL; BQL, below quantification limit, defined as <1 ng/mL.

TABLE 3 Log Δ9-THC Concentration by Characteristics of Maternal Cannabis Use and Sample Collection, $n = 34$ Samples

	Estimate	95% CI	*P*
Hours[a] since last use	−0.03	(−0.04 to −0.01)	.005
Uses per d[b]	0.51	(0.03 to 0.99)	.039
Hours	−0.02	(−0.04 to 0.00)	.032
Route[c]			
Hours	−0.02	(−0.04 to −0.01)	.008
Route: other only	−0.69	(−3.06 to 1.67)	.553
Route: both	−1.11	(−2.64 to 0.41)	.146
Puffs[d]	−0.04	(−0.34 to 0.26)	.785
Hours	−0.02	(−0.04 to 0.00)	.031
Heavy use[e]	1.13	(−0.28 to 2.53)	.110
Hours	−0.02	(−0.04 to 0.00)	.062
Sample age, mo[f]	0.08	(0.00 to 0.15)	.038
Hours	−0.02	(−0.04 to 0.00)	.044
Time of sample collection (PM)[g]	0.27	(−0.97 to 1.51)	.662
Hours	−0.02	(−0.04 to −0.01)	.008
Time since last feed or pump, h[h]	−0.05	(−0.18 to 0.09)	.470
Hours	−0.03	(−0.04 to −0.01)	.005
Feeding frequency, feeds per d[i]	0.15	(−0.04 to 0.34)	.117
Hours	−0.02	(−0.04 to 0.00)	.019

Separate multivariable linear regression models were used for each covariate with log-transformed Δ9-THC as the outcome. All models include hours since last use as a predictor.

[a] Hours were defined as the number of h between the most recent exposure end date and the date of sample collection.

[b] Uses per d were defined as the average number of uses of marijuana during the most recent exposure period.

[c] Route was defined as categorical variable with the following 3 levels: inhalation, other, and both, with inhalation as the reference category. Inhalation only was defined as a dose unit of joints, puffs, or grams. Other only was defined as a dose unit of drops, milligrams, or servings. Both was defined as a dose unit from both the inhalation only and the other only groups.

[d] For the covariate puffs, the data set was restricted to samples in which the dose unit was indicated as "puffs" ($n = 27$). The covariate puffs were reported as the number of puffs taken per use of marijuana.

[e] For the covariate heavy use, the data set was restricted to samples in which the dose unit was indicated as puffs ($n = 27$). The covariate puffs were reported as the number of puffs taken per use of marijuana. Heavy use was defined as women who reported uses per d and puffs greater than the median values in the sample (1 use per d and 3 puffs per use, respectively).

[f] Sample age was defined as the length of time between the date of milk collection and the date the sample was analyzed, measured in mo.

[g] Time of collection was defined as the time of d at which the sample was expressed, measured in number of h after midnight and dichotomized into before noon (AM) and after noon (PM).

[h] Time since last feed or pump was defined as the difference between the time of the sample collection and the time of the most recent feed or pump, measured in h.

[i] Feeding frequency was defined as the number of feedings per 24 h.

of women with quantifiable levels of Δ9-THC used marijuana exclusively via inhalation (76.5%) compared with only 36.8% in the group with levels of Δ9-THC below limits of detection ($P = .010$) (data not shown).

DISCUSSION

This is the first study used to quantify levels of specific cannabinoids detectable in human milk in a relatively large sample of mothers with detailed and varied histories of recent marijuana use of currently available products. Δ9-THC, 11-OH-THC, and cannabidiol were all detectable at 1 ng/mL or above in at least 1 human milk sample. Δ9-THC was detected in 34 (63%) of the 54 samples analyzed. This finding is consistent with the few previously published case reports in which Δ9-THC was measurable in human milk.

Cannabinoids are highly lipophilic compounds.[16,18] Therefore, it is not surprising that metabolites would be detected in human milk, which is composed of 3% to 5% fat.[19] However, the fat content of human milk is the most variable of its macronutrient components; hindmilk may contain 2 to 3 times the concentration of milk fat found in foremilk.[20,21] As a result, we might have expected that women in this study who did not provide a full expression of the breast would have lower concentrations of cannabinoids; however, 80% of the samples were collected from a full expression (Table 1), and sample collection type as a covariate was not significant in any of our models (Table 3). In addition, 11-OH-THC is less lipophilic than Δ9-THC, which might explain why only 5 of the milk samples had measurable concentrations for this cannabinoid.[16,18]

The number of times a woman used marijuana per day was a positive predictor of log Δ9-THC concentrations in milk. This finding was expected and consistent with the few previous case reports in which higher concentrations were found in 1 mother who smoked marijuana 7 times per day compared with another who smoked once per day.[8]

In our study, the sample age was also a significant predictor of log Δ9-THC concentrations in milk, which was unexpected. Cannabinoids are stable with minimal degradation long-term when frozen, and there is no evidence that more metabolites are formed

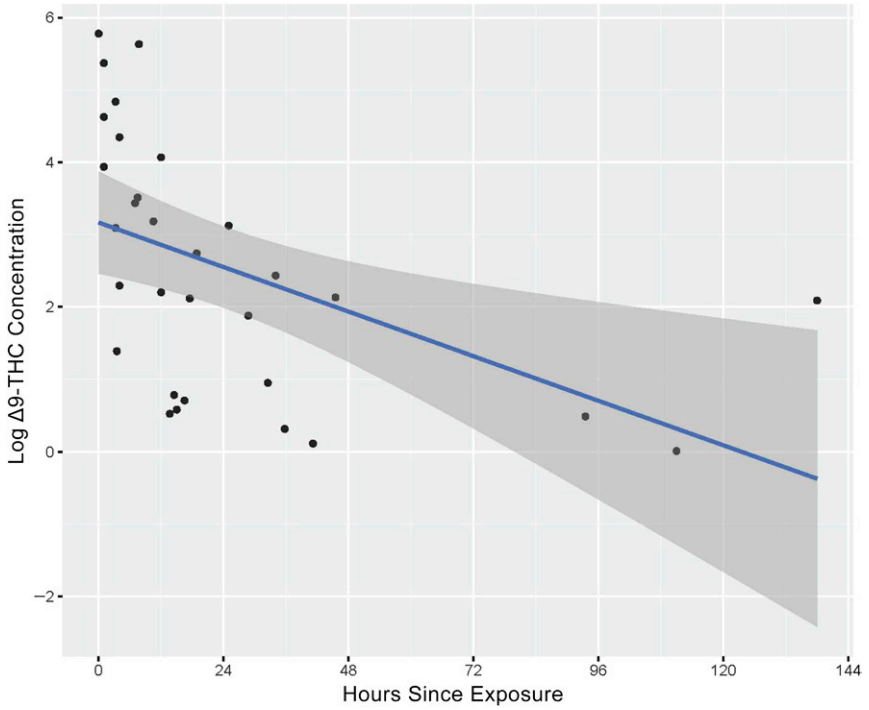

FIGURE 1
Scatterplot and fitted regression line of log concentration of Δ9-THC by hours since last use of marijuana, *n* = 34. The fitted regression line is shaded with 95% confidence limits around the regression line.

during storage.[15] However, sample age was also positively correlated with the number of times a woman used marijuana per day (ie, dose) (Supplemental Fig 3). Thus, the association between sample age and log Δ9-THC may be explained by this artifact in the data.

In this study, we did not measure infant plasma concentrations. However, on the basis of our assumptions, we estimated the mean infant plasma concentration of Δ9-THC obtained from breastfeeding to be ~1000 times lower than the concentration in an adult after a single dose of 10 mg of Δ9-THC.[22] A previous case report revealed that a nursing infant exposed to marijuana via breast milk had high concentrations of Δ9-THC, 11-OH-THC, and Δ-9-carboxy-tetrahydrocannabinol in feces indicating that the child absorbed, metabolized, and excreted marijuana metabolites despite the lower Δ9-THC levels present in the mother's milk.[8] If a child is exposed to low levels of Δ9-THC in milk daily, there is a concern for accumulation of the various cannabinoids in the nursing infant because of slow elimination from body fat stores and continuous daily exposure.[16]

Because the brain rapidly develops during the time period when, ideally, a child's main source of nutrition is human milk, brain development may be altered by Δ9-THC exposure. Authors of previous studies have suggested that prenatal exposure to cannabis may interfere with brain development resulting in deficits in cognitive and behavioral function.[23–25] It is reasonable to speculate that Δ9-THC, 11-OH-THC, or cannabidiol exposure during breastfeeding, depending on the dose and timing, could influence normal brain development of a child.

This study had several limitations as well as strengths. Samples were collected under different conditions, not all breast milk collections were directly observed, and we relied on maternal report of marijuana exposure. However, all participants completed a 14-day recall guided by trained study staff who prompted for specific daily use with the aid of a calendar. We had detailed information on timing and dose as well as information on a wide variety of other relevant covariates. Furthermore, the samples were collected from mothers who were using currently available cannabis products. In contrast, previously published data were collected at a time when Δ9-THC concentrations in marijuana were far less than is typical today.[17]

We did not have infant plasma samples; instead, we estimated potential infant Δ9-THC exposure on the basis of several assumptions. Our infant exposure estimates may be an under- or overestimation depending on infant age and other factors. Authors of future studies are required to better characterize the distribution of cannabinoids in human milk through more intensive and paired (milk and plasma) sampling, with more detailed data about the cannabinoid content of the product and exact route used by the mothers. In addition, longitudinal sampling of plasma of breastfeeding infants with either single-dose exposure (mothers who are occasional users) or steady-state exposure (mothers who are frequent users) is needed to determine the extent to which cannabinoids accumulate in the breastfeeding infant.

With our findings, we also highlight a critical need for further research on neurodevelopmental outcomes in infants breastfed by mothers using marijuana. The 1 previous study in which authors found psychomotor deficits in 12-month-old infants breastfed by mothers using cannabis was conducted in an era when Δ9-THC concentrations in marijuana were estimated to be one-third of what they are today.[11,17]

CONCLUSIONS

Δ9-THC was measurable in highly variable concentrations in the breast milk of approximately two-thirds of samples from women who reported marijuana use during breastfeeding and up to ∼6 days since last reported dose. Although the estimated median daily dose of Δ9-THC ingested by the infant is low compared with adult doses, the high variability in breast milk concentrations means that some infants may be exposed to daily amounts of cannabinoids closer to (but still lower than) typical adult amounts. Furthermore, the extent of oral absorption in breastfeeding infants, metabolism and accumulation patterns, and pharmacologic effects of even low levels of cannabinoids on neurodevelopment in infants are unknown and require further study. Because marijuana is the most commonly used recreational drug among breastfeeding women, information regarding risks to breastfeeding infants is urgently needed.

ABBREVIATIONS

11-OH-THC: 11-hydroxy-Δ-9-tetrahydrocannabinol
CI: confidence interval
HMB: human milk biorepository
Δ9-THC: Δ-9-tetrahydrocannabinol

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