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Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation

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Abstract

Introduction and Aims. *There is little objective market data on the price or potency of legal and illegal cannabis products following recreational cannabis legalisation.* ***Design and Methods.*** *In the 2 months post-legalisation in Canada (November–December 2018), legal and illegal cannabis retailers were identified from government lists and online directories. The store location, price and Δ9-tetrahydrocannabinol (THC) and cannabidiol levels of dried herb and cannabis cookies were collected from retailer websites or Weedmaps.* ***Results.*** *We identified 185 legal retailers (22 online stores, 163 storefronts; 65 government-run stores, 120 private stores) and 944 illegal retailers (791 delivery-only services, 157 storefronts). Relative to legal dried herb, illegal dried herb was lower in price (1 g: $10.23 vs. $11.08, 1/8 oz: $9.37/g vs. $10.88/g, ½ oz: $8.18/g vs. $8.85/g; P < 0.05 for all) and higher in potency (THC: 20.5% vs. 16.1%, cannabidiol: 2.4% vs. 1.7%; P < 0.05 for both). Legal private stores had higher prices for dried herb than government-run stores (1 g: $13.08 vs. $10.89, 1/8 oz: $12.75/g vs. $10.45/g, ½ oz: $10.85/g vs. $8.71/g, 1 oz: $8.54/g vs. $7.22/g; P < 0.05 for all). On average, one cannabis cookie in the illegal market contained 96 mg of THC and cost $1.57 per 10 mg of THC.* ***Discussion and Conclusions.*** *In the 2 months post-legalisation, illegal cannabis was less expensive, with higher labelled THC content than legal cannabis, although the scope of these differences was more modest than estimates from other crowdsourced and self-reported data. Direct monitoring of cannabis price and potency from legal and illegal retailers is needed to examine the impact of legalisation over time.* [Mahamad S, Wadsworth E, Rynard V, Goodman S, Hammond D. Availability, retail price and potency of legal and illegal cannabis in Canada after recreational cannabis legalisation. *Drug Alcohol Rev* 2020]

Key words: cannabis, health policy, legalisation, drug.

Introduction

On 17 October 2018, Canada became only the second country after Uruguay to legalise non-medical ('recreational') cannabis. The federal *Cannabis Act* regulates the manufacturing, marketing and sale of cannabis products, while provinces and territories (P/T) have primary responsibility for regulating legal cannabis retailers (LCR), including online and 'brick-and-mortar' stores [1]. One primary objective of the *Cannabis Act* is to shift existing consumers from the illegal to the regulated market [1]. Estimating the size of illicit cannabis markets is challenging due to a lack of population-level data on purchase sources. Based on self-reported data, the federal government estimated that 42% of consumers purchased cannabis from illegal sources in August 2019 [2]. Data from US states that have legalised cannabis suggest that, although the size of the illegal market has diminished following legalisation, illegal sales have persisted [3–5].

Similar to the tobacco market, price is believed to be an important factor that influences whether cannabis consumers transition from illegal to legal retail sources in a regulated market [6–13]. High cannabis prices may be desirable for discouraging consumption; however, if the legal-illegal price differential is large, demand for illegal cannabis will persist [14–16]. Canada and the 11 US states that have legalised recreational cannabis have sought to minimise the legal-illegal price differential to displace the illegal market [17]. However, there is a lack of data on the illegal cannabis market to accurately estimate the price and purchasing of illegal products. Prior to legalisation in Canada, estimates of illegal dried herb (DH) prices ranged from $6.80/g to $7.69/g from

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crowdsourced studies [17,18]. Crowdsourced data from several months after legalisation suggested that the price of legal DH was 51% higher than illegal DH: $9.82/g versus $6.51/g, respectively [19]. Self-reported data from a national population-based survey conducted on behalf of the Canadian government in 2018 estimated an average price of $8.62/g but did not distinguish between legal and illegal sources [20]. One of the challenges with existing estimates in Canada is that they are based on self-reported data, and it remains unclear to what extent consumers can accurately report product amounts and purchase prices. In addition, crowdsourced data is highly sensitive to self-selection bias, with the potential to skew findings, particularly with respect to reporting illegal purchases to a government crowdsourcing website. To date, we are aware of only one study, conducted by our research group, that objectively sourced prices from illegal cannabis retailers (ICR) in the year prior to legalisation in Canada using web-based directories of online and 'brick-and-mortar' retailers. The study reported an average price of $10.02/g for DH, with substantial discounts of more than 25% for cannabis purchased in larger quantities [21].

The price of cannabis products is also believed to reflect differences in product quality and potency, including the level of Δ9-tetrahydrocannabinol (THC), the primary psychoactive cannabinoid [22,23]. Several studies suggest that the price of cannabis products increases with THC levels [24,25]. THC levels are also important to estimate changes in product potency over time, particularly with the emergence of potent cannabis extracts. The average THC levels of illegal DH have risen from <5% to almost 20% in North American markets, while the THC concentration of cannabis extracts is approximately 60% and can exceed 90% [26–28]. Cannabidiol (CBD), a non-psychoactive cannabinoid, is hypothesised to moderate the effects of THC and is often associated with therapeutic effects; however, there is little data on CBD levels of either legal or illegal DH products [29].

The current study sought to estimate the number of LCRs and ICRs, the average price, and THC and CBD levels of DH and cannabis cookies in Canada. The Canadian legal cannabis retail system varies by P/T: five P/Ts operate government-run stores and online sales [New Brunswick (NB), Nova Scotia (NS), Northwest Territories (NT), Prince Edward Island (PE), Quebec (QC)], three allow private stores and online sales [Manitoba (MB), Nunavut (NU), Saskatchewan (SK)], while five allow private stores, with government-run online sales [Alberta (AB), British Columbia (BC), Ontario (ON), Newfoundland and Labrador (NL), Yukon (YT)] [30]. Therefore, the study examined differences by legal status, P/T and private versus government-run retailers.

Methods

A scan of LCRs and ICRs in Canada was conducted in November and December 2018, over the first 2 months following recreational cannabis legalisation.

Data collected

Regardless of legal status, the price (including purchase quantity), THC levels and CBD levels of the least expensive, most expensive and up to 10 random DH strains were collected. If product information was not online, stores were contacted by phone to determine the price of the least expensive and most popular strains. Prices were collected for 1 g, 1/8 oz (approximately 3.5 g) and the largest quantity sold of each selected DH strain. In addition, the price, quantity and THC content of all cannabis cookies were collected from ICRs only, as edibles were illegal in Canada at the time.

Legal retail sources

Official P/T government websites were used to identify legal cannabis stores in Canada. For the five P/Ts with both government-run online stores and storefronts, pricing online was identical to storefronts. The data points specified above were collected from all private online stores and up to 15 random privately run storefronts in each P/T. Overall, product data were collected from all public stores and private online stores, and 65% of the private storefront sample.

Illegal retail sources

Weedmaps and Google Maps were used to identify ICRs, using an established methodology [21]. Briefly, Weedmaps was used to identify 'storefronts', 'mail order' and 'delivery' services in each P/T. Google Maps was also used to identify ICRs via the 'search nearby' function, with the following keywords: 'cannabis dispensary', 'cannabis' and 'marijuana'. The type and location of all ICRs were recorded. Duplicate businesses within the same P/T were excluded. In each P/T, the data points specified above were recorded for up to 15 random storefronts and 15 random delivery-only services. Overall, product data were collected from 81% of illegal storefronts and 97% of illegal delivery-only services identified.

THC and CBD levels

THC and CBD levels of each DH strain were recorded. When THC or CBD levels were listed as a range, the

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midpoint of the values was used. In addition, '<2%' was recorded as 1%, '>20%' was recorded as 22.5% and any value <1% was recorded as 0%. Strains were also defined as THC-dominant, balanced or CBD-dominant. Strains with a THC:CBD ratio ≥ 5:1 or strains with 0% CBD and any amount of THC were classified as THC-dominant. Balanced strains were defined as having a THC:CBD ratio >1:5 but ≤2:1, and CBD-dominant strains were defined as having a ratio ≤1:5.

Data analysis

Descriptive statistics [mean (*M*), standard deviation (SD) and percentages] are reported for all outcomes. To test the differences by legal versus illegal status, and public versus private status, generalised estimating equation modelling was used to account for repeated measurements from the same retailer across different P/Ts. Separate models were fitted for each outcome variable. All models were adjusted for P/T with the exception of public versus private comparisons. All analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA).

Results

Legal and Illegal Cannabis Retailers

Table 1 shows the number of LCRs and ICRs by retailer type. At the time of data collection, there were 185 LCRs in Canada, including 22 online stores and 163 physical storefronts. Of the 185 LCRs, 35% were publicly operated and 65% were privately operated.

A total of 944 ICRs were identified in Canada, including 791 delivery-only services and 157 physical storefronts. Of the 157 illegal storefronts, 85% were located in BC or ON, while none were identified in AB, MB, PE or the territories. In all P/Ts, delivery-only services were the most common ICR type, accounting for 84% of ICRs identified.

Price of DH cannabis

Legal stores. The average advertised prices of legal DH are shown in Table 2 (M = $11.08, SD = $2.37). Prices varied substantially by P/T. When purchasing 1 g and 1/8 oz, the price varied by >80%. For example, Newfoundland and Labrador had the lowest price for 1 g ($9.33), whereas Nunavut had the highest price ($16.99). For 1/8 oz, Quebec had the lowest price ($7.90) and Nunavut had the highest price ($14.66). At larger purchase quantities, the price variation between P/T was lower, but still substantial: there was a 48% difference for 1/4 oz and 1/2 oz, and a 44% difference for 1 oz. No single P/T had the highest or lowest average price across all purchase quantities of DH; however, the average prices were generally higher in NU and SK, and lower in BC, NL, PE and QC.

Storefronts had lower average prices than delivery-only services for all purchase quantities, except for 1/8 oz and 1 oz quantities. At most purchase quantities, pricing varied by <7% between storefronts and delivery-only retailers; however, the average price for 1 oz was 24% higher in storefronts compared to delivery-only services.

To determine if there were quantity discounts, all pricing data were converted to price-per-gram. Compared to purchasing 1 g amounts, purchasing 1/8 oz of DH led to a relatively minor discount of 2%. Larger purchase quantities led to more pronounced savings: purchasing 1/4 oz, 1/2 oz and 1 oz quantities led to discounts of 11%, 20% and 32%, respectively.

The private legal market had significantly higher advertised prices for DH than the public market for 1 g [$13.08 vs. $10.89; B = 2.20 (1.25, 3.15); P < 0.001], 1/8 oz [$12.75/g vs. $10.45/g; B = 1.93 (0.59, 3.27); P = 0.01], 1/2 oz [$10.85/g vs. $8.71/g; B = 1.89 (0.98, 2.79); P < 0.001] and 1 oz [$8.54/g vs. $7.22/g; B = 1.44 (0.14, 2.74); P = 0.03]. The average price for 1/4 oz did not differ significantly between private and public retailers [$11.44/g vs. $9.66/g; B = 1.33 (−0.37, 3.03); P = 0.13].

Illegal stores. The price of illegal DH was significantly lower than legal DH for 1 g [$10.23 vs. $11.08; B = −1.76 (−2.50, −1.02); P < 0.001], 1/8 oz [$9.37/g vs. $10.88/g; B = −2.36 (−3.17, −1.54); P < 0.001] and 1/2 oz [$8.18/g vs. $8.85/g; B = −1.16 (−2.02, −0.30); P = 0.01]. The average prices for 1/4 oz [$9.96/g vs. $9.87/g; B = −0.46 (−1.34, 0.43); P = 0.31] and 1 oz [$7.29/g vs. $7.55/g; B = −0.67 (−1.61, −0.28); P = 0.17] did not differ significantly by legal status.

The price for 1 g, 1/8 oz and 1 oz of illegal DH varied by 17% to 20% between P/Ts. However, prices varied greatly at 1/4 oz and 1/2 oz quantities, with some P/Ts having an average price more than double the average price in other P/Ts. No single P/T had the highest or lowest average price across all purchase quantities, although PE and NB generally had higher prices, while QC and MB had lower prices.

The average prices for 1 g and 1/8 oz of DH were similar between illegal storefronts and delivery-only services; however, there were notable differences at larger purchase quantities. Relative to delivery-only services, the average prices at storefronts for 1/4 oz, 1/2 oz and 1 oz were 37% lower, 19% higher and 13% higher, respectively.

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Table 1. *Number of legal and illegal cannabis retailers in each province and territory in Canada (November to December 2018)*

Province or territory	Legal retailers						Illegal retailers			
	Total no. of legal retailers	No. of people per legal storefront[a]	Storefronts		Online stores		Total no. of illegal retailers	No. of people per illegal storefront	Storefronts[b]	Delivery-only services[c]
			Public	Private	Public	Private				
AB	64	55 397	0	63	1	0	47	NA	0	47
BC	3	2 144 738	1	1	1	0	112	91 265	47	65
MB	15	99 754	0	11	0	4	33	NA	0	33
NB	21	32 975	20	0	1	0	68	73 277	9	59
NL	24	19 688	0	23	1	0	41	452 833	1	40
NS	13	68 668	12	0	1	0	77	91 557	9	68
NT	6	7168	5	0	1	0	16	NA	0	16
NU	1	NA	0	0	0	1	14	NA	0	14
ON	1	NA	0	0	1	0	384	145 233	83	301
PE	5	32 364	4	0	1	0	31	NA	0	31
QC	13	588 647	12	0	1	0	48	2 354 588	3	45
SK	17	93 542	0	10	0	7	55	935 418	1	54
YK	2	33 787	1	0	1	0	18	NA	0	18
Total	185	190 747	55	108	10	12	944	198 036	157	791

[a]The number of people per storefront was determined by dividing the number of Canadians 15 years of age and older by the number of storefronts in each province or territory. This ratio compares the number of potential clients to the number of storefronts, providing an indicator of accessibility. [b]Storefront includes physical storefronts that also have a delivery or mail-order service. [c]Delivery-only services include mail order services. AB, Alberta; BC, British Columbia; MB, Manitoba; NA, not applicable NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; NU, Nunavut; ON, Ontario; PE, Prince Edward Island; QC, Quebec; SK, Saskatchewan; YT, Yukon.

Table 2. *Average advertised prices for 1 g and other quantities of random cannabis strains converted to the unit price per gram by province and territory and legal status (November to December 2018)*[a]

	Legal retailers										Illegal retailers									
	Price for 1 g		PPG for 1/8 oz		PPG for 1/4 oz		PPG for 1/2 oz		PPG for 1 oz		Price for 1 g		PPG for 1/8 oz		PPG for 1/4 oz		PPG for 1/2 oz		PPG for 1 oz	
P/T	*n*	*M* (SD)	*n*	*M* (SD)	*n*	*M* (SD)	*n*	*M* (SD)	*n*	*M* (SD)	*n*	*M* (SD)	*n*	*M* (SD)	*n*	*M* (SD)	*n*	*M* (SD)	*n*	*M* (SD)
AB	34	11.85 (1.69)	41	11.45 (1.99)	1	10.56 (0.00)	0	—	0	—	56	9.99 (2.16)	151	9.53 (2.27)	12	9.76 (1.41)	12	7.65 (1.81)	196	7.72 (2.21)
BC	95	9.75 (2.24)	119	9.28 (2.57)	75	8.55 (2.21)	22	7.58 (1.13)	0	—	151	10.28 (1.45)	89	9.52 (1.98)	0	—	4	5.98 (0.79)	96	7.06 (1.66)
MB	15	12.66 (2.01)	26	12.50 (2.29)	12	11.26 (2.73)	7	10.76 (1.97)	2	9.17 (0.00)	77	10.12 (2.50)	65	9.01 (1.47)	1	4.29 (0.00)	3	5.95 (1.09)	116	7.02 (2.22)
NB	37	12.83 (2.24)	41	12.38 (2.40)	24	11.15 (2.13)	19	11.24 (2.00)	0	—	136	10.01 (2.11)	117	10.12 (1.89)	0	—	11	10.21 (1.99)	148	7.91 (2.48)
NL	40	9.33 (2.11)	43	8.76 (1.97)	21	8.01 (1.88)	12	8.57 (1.63)	6	6.37 (0.77)	49	10.14 (1.58)	94	9.26 (2.21)	0	—	3	4.76 (1.09)	119	6.84 (1.75)
NS	57	11.53 (1.62)	79	11.73 (1.77)	24	10.85 (1.73)	13	8.94 (1.49)	6	8.07 (0.57)	128	10.19 (1.97)	107	8.75 (1.92)	1	6.00 (0.00)	1	8.57 (0.00)	122	7.04 (1.95)
NU	1	16.99 (0.00)	3	14.66 (1.47)	0	—	0	—	1	6.67 (0.00)	79	10.72 (1.39)	88	9.63 (2.03)	3	9.05 (0.82)	0	—	107	7.35 (1.46)
NT	3	13.13 (0.00)	2	12.21 (0.00)	0	—	0	—	0	—	178	10.13 (2.11)	101	9.52 (1.63)	13	9.78 (1.25)	5	9.29 (1.62)	104	7.81 (2.11)
ON	58	11.99 (2.34)	74	11.64 (2.50)	34	11.75 (2.41)	26	9.62 (1.07)	0	—	86	9.90 (1.46)	127	9.09 (1.71)	5	10.00 (0.00)	3	7.86 (0.62)	125	6.99 (1.62)
PE	30	9.91 (1.57)	53	9.40 (1.41)	20	8.26 (1.42)	14	8.15 (1.54)	0	—	81	11.57 (1.85)	99	10.26 (1.48)	10	12.36 (1.75)	4	9.64 (0.71)	112	7.02 (2.19)
SK	19	13.21 (1.29)	89	12.76 (2.53)	16	11.58 (3.52)	4	11.02 (1.02)	1	9.17 (0.00)	85	10.19 (1.85)	192	9.47 (1.69)	4	8.21 (0.41)	3	8.45 (0.41)	188	7.55 (1.69)
QC	12	9.71 (0.97)	43	7.90 (1.27)	0	—	43	7.72 (1.22)	0	—	57	9.67 (1.63)	96	8.94 (1.65)	2	9.82 (0.76)	1	6.43 (0.00)	121	6.75 (1.48)
YK	5	11.48 (1.46)	22	13.48 (2.80)	4	11.82 (1.45)	1	10.35 (0.00)	0	—	74	10.14 (1.67)	116	8.52 (1.33)	0	—	0	—	126	7.13 (1.70)
Total	406	11.08 (2.37)	635	10.88 (2.76)	231	9.87 (2.66)	161	8.85 (1.89)	16	7.55 (1.24)	1237	10.23 (1.91)	1442	9.37 (1.87)	51	9.96 (1.96)	50	8.18 (2.17)	1680	7.29 (1.96)

[a]Prices are in Canadian dollars. AB, Alberta; BC, British Columbia; CBD, cannabidiol; *M*, mean; MB, Manitoba; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; NU, Nunavut; ON, Ontario; P/T, province or territory; PE, Prince Edward Island; PPG, price-per-gram; QC, Quebec; SK, Saskatchewan; THC, Δ9-tetrahydrocannabinol; YT, Yukon.

Table 3. *Average advertised Δ9-tetrahydrocannabinol (THC) and cannabidiol (CBD) levels of cannabis dried herb strains by province and territory and legal status (November to December 2018)*

	Legal retailers						Illegal retailers					
	THC (%)			CBD (%)			THC (%)			CBD (%)		
Province or territory	*n*	*M* (SD)	Med	*n*	*M* (SD)	Med	*n*	*M* (SD)	Med	*n*	*M* (SD)	Med
AB	56	16.4 (5.4)	17.5	56	1.8 (4.1)	0.3	31	21.3 (3.3)	20.5	3	0.7 (0.6)	1.0
BC	120	16.5 (5.4)	18.0	120	1.9 (3.6)	0.5	22	22.0 (4.5)	21.5	22	0.3 (0.4)	0.1
MB	39	16.3 (4.9)	17.5	39	1.3 (2.9)	0.4	25	18.0 (7.7)	20.0	14	6.5 (10.4)	1.0
NB	44	16.6 (5.5)	18.0	44	1.8 (4.5)	0.0	76	20.8 (4.1)	21.0	43	2.0 (4.1)	0.8
NL	48	16.9 (5.9)	19.0	48	2.0 (4.1)	0.1	50	19.8 (5.6)	20.8	19	3.7 (4.8)	1.1
NS	84	16.0 (5.1)	17.5	84	1.8 (3.5)	0.3	44	19.7 (5.4)	20.0	16	2.6 (4.2)	1.1
NT	3	14.6 (1.5)	15.0	3	0.0 (0.0)	0.0	38	19.9 (4.5)	20.0	6	4.1 (6.8)	1.9
NU	3	15.7 (7.1)	17.0	3	2.7 (4.6)	0.0	38	21.0 (3.3)	21.0	4	0.8 (0.9)	0.6
ON	75	15.9 (5.1)	17.0	72	1.8 (3.2)	0.5	71	21.1 (4.9)	21.5	18	0.9 (0.4)	1.0
PE	57	14.4 (5.0)	15.5	57	1.8 (2.3)	1.0	60	20.3 (5.1)	21.0	28	2.1 (3.9)	0.2
QC	43	15.5 (6.4)	17.5	42	2.0 (4.3)	0.0	45	20.5 (5.0)	21.5	33	1.7 (4.6)	0.4
SK	100	15.6 (5.2)	16.0	95	1.5 (3.0)	0.1	34	20.9 (5.8)	22.0	15	4.2 (5.7)	1.8
YK	23	18.2 (5.2)	19.0	23	0.8 (2.7)	0.0	35	20.0 (5.1)	21.0	8	4.3 (6.4)	1.9
Total	695	16.1 (5.3)	17.5	686	1.7 (3.4)	0.5	569	20.5 (5.0)	21.0	229	2.4 (4.9)	1.0

AB, Alberta; BC, British Columbia; *M*, mean; MB, Manitoba; Med, median; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; NU, Nunavut; ON, Ontario; PE, Prince Edward Island; QC, Quebec; SK, Saskatchewan; YT, Yukon.

There were quantity discounts in the illegal market as well. Compared to purchasing 1 g amounts of DH, purchasing ⅛ oz and ¼ oz led to modest savings of 8% and 3%, respectively. Purchasing ½ oz and 1 oz led to larger savings of 20% and 29%, respectively.

THC and CBD levels of DH cannabis

Legal stores. Average THC and CBD levels of legal DH were 16.1% and 1.7%, respectively (Table 3). There was little variation in THC and CBD levels between storefronts and delivery-only retailers; however, average THC levels ranged from 14.4% to 18.2%

Table 4. *Percentage of Δ9-tetrahydrocannabinol (THC)-dominant, balanced and cannabidiol (CBD)-dominant strains by province and territory and legal status (November to December 2018)*

	Legal retailers				Illegal retailers			
Province or territory	*n*	THC-dominant (%)	Balanced (%)	CBD-dominant (%)	*n*	THC-dominant (%)	Balanced (%)	CBD-dominant (%)
AB	56	85.7	12.5	1.8	3	100.0	0.0	0.0
BC	120	83.3	15.8	0.8	22	100.0	0.0	0.0
MB	39	87.2	12.8	0.0	13	69.2	15.4	15.4
NB	44	84.1	13.6	2.3	43	90.7	9.3	0.0
NL	48	85.4	10.4	4.2	18	72.2	22.2	5.6
NS	84	83.3	15.5	1.2	16	81.3	12.5	6.3
NT	3	100.0	0.0	0.0	6	83.3	16.7	0.0
NU	3	66.7	33.3	0.0	4	100.0	0.0	0.0
ON	72	86.1	11.1	2.8	18	94.4	5.6	0.0
PE	57	86.0	12.3	1.8	28	85.7	10.7	3.6
QC	42	81.0	11.9	7.1	33	90.9	6.1	3.0
SK	95	84.2	15.8	0.0	15	80.0	6.7	13.3
YK	23	91.3	8.7	0.0	8	75.0	12.5	12.5
Total	686	84.7	13.6	1.7	227	86.8	9.3	4.0

AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; NU, Nunavut; ON, Ontario; PE, Prince Edward Island; QC, Quebec; SK, Saskatchewan; YT, Yukon.

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Table 5. *Average advertised prices and Δ9-tetrahydrocannabinol (THC) content of cannabis cookies available at illegal retailers by province and territory (November to December 2018)*[a]

	THC per cookie (in mg)		Price per cookie		Price per 10 mg of THC	
Province or territory	*n*	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)
AB	12	65.3 (80.4)	12	7.75 (4.39)	12	1.63 (0.46)
BC	10	52.0 (37.9)	12	7.04 (2.96)	10	2.39 (1.66)
MB	16	88.2 (121.5)	16	9.73 (6.06)	17	2.31 (1.63)
NB	18	79.7 (46.1)	22	7.88 (3.91)	17	1.32 (1.14)
NL	26	97.7 (84.2)	29	8.58 (3.51)	26	1.45 (1.07)
NS	20	153.2 (126.3)	20	14.65 (9.53)	20	1.55 (1.58)
NT	20	73.3 (67.1)	21	8.00 (4.17)	20	1.57 (0.98)
NU	40	105.8 (99.4)	41	9.66 (6.79)	41	1.35 (1.09)
ON	6	95.8 (40.8)	16	11.06 (2.49)	7	1.46 (0.92)
PE	56	101.2 (95.5)	61	9.63 (5.55)	55	1.54 (1.36)
QC	26	100.3 (85.9)	30	9.24 (3.55)	26	1.68 (1.50)
SK	11	113.7 (133.9)	11	13.09 (10.01)	11	2.16 (1.83)
YK	33	78.2 (53.0)	34	7.38 (3.93)	33	1.22 (0.89)
Total	294	95.7 (90.3)	325	9.38 (5.66)	295	1.57 (1.28)

[a]Prices are in Canadian dollars. AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland and Labrador; NS, Nova Scotia; NT, Northwest Territories; NU, Nunavut; ON, Ontario; PE, Prince Edward Island; QC, Quebec; SK, Saskatchewan; YT, Yukon.

across P/Ts, while average CBD levels ranged from 0% to 2.7%. In each P/T, THC-dominant strains were the most common strain type, accounting for 85% of legal strains sampled (Table 4).

Public retailers had higher CBD levels than private retailers [1.8% vs. 1.5%; B = 0.43 (0.07, 0.79); P = 0.02], with similar THC levels [16.1% vs. 15.8%; B = 0.33 (−0.83, 1.49); P = 0.58].

Illegal stores. Average THC and CBD levels of illegal DH were 20.5% and 2.4%, respectively. THC and CBD levels varied little between storefronts and delivery-only retailers; however, both THC and CBD levels varied by P/T: average THC levels ranged from 18.0% to 22.0%, and average CBD levels ranged from 0.3% to 6.5% (Table 3). Similar to the legal market, in each P/T, THC-dominant strains were most common (Table 4). Relative to the legal market, the illegal market had significantly higher THC [20.5% vs. 16.1%; B = 4.31 (3.44, 5.19); $P < 0.001$] and CBD levels [2.4% vs. 1.7%; B = 1.23 (0.05, 2.41); P = 0.04].

Illegal cannabis cookies

On average, each ICR sold three types of cannabis cookies. Of 225 ICRs sampled, 36% of storefronts and 46% of delivery-only services sold cannabis cookies. Table 5 shows the average amount of THC per cookie, price per cookie and price per 10 mg of THC. Across Canada, the average amount of THC per cookie was 96 mg; however, this ranged from 52 to 153 mg across P/Ts. On average, cannabis cookies cost $1.57 per 10 mg of THC. BC had the highest cost ($2.39 per 10 mg) and YT had the lowest ($1.22 per 10 mg).

Discussion

To our knowledge, this study is the first to objectively compare legal and illegal cannabis markets using data collected from retailers. Two months after legalisation, the Canadian cannabis market was in an early stage of transition, with more than five times as many ICRs as LCRs (944 vs. 185, respectively). Apart from differences in pricing and potency, ICRs persist due to a lack of enforcement, difficulty preventing illegal online sales, and delays in legal store licensing. At the time of data collection, no legal physical storefronts had opened in ON, Canada's most populated province, and AB was the only province with more LCRs than ICRs. The two provinces with the lowest number of legal stores per capita—ON and BC—had the highest number of ICRs. This finding reflects lower levels of enforcement that pre-date legalisation given that ON and BC also had the highest number of illegal storefronts pre-legalisation [21]. P/Ts without illegal storefronts (AB, MB, PE, YK and NU) also had few storefronts pre-legalisation, suggesting that higher levels of enforcement have continued post-legalisation [21]. Consistent with US data, the findings demonstrate that legal retail markets require several years to

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establish following legalisation. Indeed, as of July 2019—approximately 10 months after the current study was conducted—the number of legal stores in Canada had more than doubled to 407, along with increases in the proportion of Canadian consumers who reported purchasing cannabis legally [31,32].

Overall, the average price of legal DH was 19% higher than illegal DH, and the price differential increased with the amount purchased. Compared to Statistics Canada's crowdsourced data for the same time period, the current price estimates are moderately higher for legal DH ($10.51/g vs. $9.82/g, 7% difference) and substantially higher for illegal DH ($8.82/g vs. $6.51/g, 35% difference) [19]. The current price estimates are also close to those from two population-based surveys conducted in late 2018 in Canada, which estimated a combined legal and illegal price of $9.56/g [33] and $8.62/g [20]. The findings suggest little change in the retail price of illegal DH compared to estimates 12 months prior to legalisation ($10.02/g) [21]. However, due to differences in methodology, direct comparisons of the price estimates of the current study and the pre-legalisation scan cannot be made.

Similar to previous studies, retail prices exhibited substantial 'quantity discounts', in which larger quantities of DH are less expensive per gram [21,22,25,33–38]. In the current study, LCRs offered similar quantity discounts to ICRs. However, federal law imposes a limit of 30 g (1 oz) per purchase, creating a ceiling to legal quantity discounts [39]. For this and other reasons, 'heavy' cannabis users may be more likely to continue using illegal sources post-legalisation. Statistics Canada's crowdsourced data in the year following legalisation demonstrates this phenomenon: the average purchase quantity from legal sources was 8.7 g of cannabis, compared with 22.1 g for purchases from illegal sources [40]. This pattern of consumer behaviour inflates the actual legal-illegal price differential: prices from the illegal market appear much lower primarily because these consumers are purchasing in higher quantities and receiving a greater quantity discount. Overall, although illegal DH prices are somewhat lower than legal prices in Canada, the differential is much less than 'unadjusted' crowdsourced and self-reported data would suggest. The findings highlight the importance of adjusting for purchase quantity when reporting self-reported price data.

The legal cannabis market in Canada is unique in that it includes both government-run and private retailers. The average price of DH was higher in the private market, with modest differences in THC and CBD levels. These differences may be due to the smaller sample size of strains collected from private compared to public retailers. Future research should consider potential differences between private and government-run cannabis markets in Canada given that government monopolies on alcohol sales are associated with reduced public consumption and harm, a higher price-point of goods and reduced youth access [6,41,42].

The current findings add to the existing literature on the increasing potency of cannabis products in both legal and illegal markets. Despite increasing consumer interest in CBD for its potentially therapeutic effects, CBD-dominant and 'balanced' strains were scarce, and the market largely consists of THC-dominant DH strains. THC and CBD levels were moderately higher for illegal compared to legal DH, although the accuracy of the THC and CBD levels reported by ICRs may be unreliable [43]. Previous studies have also raised questions about the accuracy of cannabinoid labelling on legal products in US states due to variability in testing results across laboratories [44]. In Canada, the *Cannabis Act* includes mandatory regulations for laboratory testing and labelling of THC and CBD levels, and Health Canada has conducted compliance testing and issued product recalls for inaccurate labels [1]. Overall, the accuracy of THC and CBD labels are likely to be higher for products manufactured and sold through legal sources compared to illicit sources. The THC level of legal DH is consistent with recent trends in the USA, including legal markets in Colorado and Washington State [3,25–27].

The findings also document the high THC content in cannabis edibles: the average THC content in cookies sold on the illegal market was approximately 10 times the 10 mg serving size used by regulators in Canada and several US states [45–47]. Cannabis cookies were examined after an informal scan of ICRs revealed cookies to be the most common edible; however, the findings on cannabis cookies may not be indicative of other edibles. Edibles have been associated with an increased risk of adverse events and health-care interactions due to overconsumption and problems with effective 'dosing' [48–50]. In an effort to address this issue, Canada has set a regulatory precedent by requiring that edible products contain no more than 10 mg of THC in each product [51]. The extent to which the THC limit on edibles influences consumer consumption and purchasing patterns—including whether edible consumers are more or less likely to transition to the legal market—represents an important focus for future research.

Several limitations of the current study should be noted. Data collection was restricted to information obtainable online, as most retailers were not willing to provide data over the phone. The extent to which online directories for retailers accurately represent the illegal market is unknown and very difficult to determine. Furthermore, some retailers on Weedmaps may not have been actively operating at the time of data collection;

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indeed, discrepancies between Weedmaps listings and businesses' actual operational status have been reported [52]. However, the impacts of these discrepancies were minimised, as product data was primarily collected from retailer websites. Weedmaps was only used to source product data if the retailer did not have product information on their website and the retailers' Weedmaps menus or social media pages had been updated within 1 month of data collection. In addition, the study did not collect data on 'in person dealers' and other social sources of cannabis, which account for a substantial proportion of illegal cannabis sales in Canada [2,33]. However, recent research suggests that cannabis prices from these sources are similar to the 'formal' retailers included in the current study [33]. Finally, it is important to note that the estimates reported in the current paper do not reflect sale-weighted prices, which can help account for differences between 'objective' market prices and self-reported prices in population-based surveys.

Conclusion

The current study provides a snapshot of the recreational cannabis market immediately after legalisation in Canada. The findings depict a market in the early stages of transition, with a greater number of ICRs than LCRs. Although illegal DH prices were lower than legal prices, these differences were substantially less than self-reported data suggest, likely because consumers purchase greater quantities of DH from the illegal market and receive greater 'quantity discounts' in price. The findings underscore the importance of adjusting for purchase quantity when reporting self-reported price data, particularly for the purpose of inferring differences between legal and illegal prices. To the extent possible, future studies should incorporate 'objective' measures of the cannabis market along with self-reported data from population surveys to understand the impact of cannabis legalisation. Finally, the findings demonstrate the same trend of increasing THC levels in Canada that has been observed in other countries, including the incredibly high level of THC in many cannabis edibles. Regulatory precedents in Canada— including the federal limit of 10 mg of THC per cannabis edible and the 30% THC limit on all cannabis products in the province of Quebec— provide an opportunity to examine the effectiveness of policy measures to discourage consumption of high THC products.

Conflict of Interest

This work was supported by a Canadian Institutes of Health Research Project Grant (DH). Additional funding was provided by a Canadian Institutes of Health Research-Public Health Agency of Canada Applied Chair in Public Health (DH). The funders had no role in the study design, collection, analysis or interpretation of the data, writing the manuscript or the decision to submit the paper for publication. The authors have no conflicts of interest to declare.

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