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Retail price and availability of illicit cannabis in Canada

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HIGHLIGHTS

- There is a well-established retail cannabis market in Canada prior to legalization.
- In 13 cities, 997 retailers were identified, including 215 physical storefronts.
- The amount and type of retailers varied by city, implying differential enforcement.
- The average price of the most popular varieties was approximately $10 CAD.
- The average price of $10 CAD aligns with the price targeted for the legal market.

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ABSTRACT

Introduction: This study sought to estimate the number of illicit retailers and the average price of cannabis in the largest municipality in each province and territory in Canada by obtaining information from retailers.
Methods: Online search engines were used to identify retailers in each municipality. The advertised prices for various volumes of the least expensive, most expensive, and most popular dry herb were determined using the retailer's website, Weedmaps, or Leafly. Data was collected between October 2017 and May 2018, including two waves in Toronto to examine changes over a five-month period.
Results: Across the 13 municipalities, 997 cannabis retailers were identified, including 215 physical storefronts. The average price per gram of cannabis was $10.02, $7.80, and $12.30 for the most popular, least expensive, and most expensive strains, respectively. The price-per-gram decreased as purchase volume increased: purchasing one-eighth of an ounce and one ounce of cannabis led to savings of up to 9% and 27%, respectively. Prices were consistent across municipalities, although the number of outlets varied greatly. Prices were similar between storefronts and delivery-only services; however, delivery services offered larger discounts for cannabis purchased by the ounce. The five-month comparison in Toronto revealed modest changes in the number of retailers and more pronounced changes in the price of the most popular and least expensive strains.
Conclusion: The findings depict a well-established retail cannabis market in Canada in the year prior to legalization. The average advertised price of the most popular cannabis varieties was approximately $10, which aligns with the projected retail price of cannabis from licensed sources following legalization in Canada.

1. Introduction

Canadians have had legal access to medical cannabis since 2001 and became only the second country to legalize non-medical cannabis in October 2018 (Health Canada, 2017; Health Canada, 2016; Parliament of Canada, 2018). Reducing the illicit market for cannabis is a primary objective of the federal legalization. Accordingly, the government has proposed a tax strategy to minimize the price differential between cannabis purchased through the legal framework and illicit cannabis. In addition, provinces will serve as wholesalers, and eight of ten Canadian provinces will set retail prices directly through publicly-run storefronts and/or publicly-run online retail systems.

Understanding the price of cannabis in the illicit market is essential for establishing appropriate pricing in the legal market. The price of cannabis in the legal market has the potential to influence the size of illegal markets, tax revenues, and overall consumption (Ouellet, Macdonald, Bouchard, Morselli, & Frank, 2017). In addition, determining the prices of cannabis in the illegal market prior to legalization is important to examining potential changes in cannabis pricing and consumption following legalization.

There is little data available on the price of non-medical cannabis in Canada. What little data exists suggests considerable variation in price

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across Canadian provinces and territories, with prices inversely related to production and consumption (Aston, Metrik, & MacKillop, 2015; Clements, 2008; Kilmer, Caulkins, Pacula, MacCoun, & Reuter, 2010; Ouellet et al., 2017; Stockwell et al., 2010; Werb et al., 2012; Zeisser et al., 2012). Statistics Canada is currently using crowdsourced data from websites to determine the average price for one gram of cannabis. In May 2018, Statistics Canada estimated the average price of cannabis at $6.80 per gram, with provincial averages ranging from $5.86 to $9.51 per gram (Statistics Canada, 2018b). Data from a population-based survey of young Canadians (n = 140), estimated the average price of cannabis at $6.22 per gram based on self-reported data (Sikorski, Leos-Toro, & Hammond, 2018). Another report used data self-reported anonymously to the Price of Weed website between 2011 and 2015 (Price of Weed, n.d.). This report estimated the average price per gram across Canada was $7.69, $7.14, and $7.26 for "high", "medium", and "low" quality cannabis, respectively (Ouellet et al., 2017). The average price per gram across the provinces ranged from $6.83 to $13.04 for high quality cannabis, $5.85 to $14.28 for medium quality cannabis, and $5.76 to $11.27 for low quality cannabis (Ouellet et al., 2017). The reliability of crowdsourced data remains highly uncertain and untested. Price of Weed does not collect product type (it only refers to 'low, medium, or high quality'), purchase quantity, or purchase source, which is critical to distinguish legal from illegal sources. Crowdsourced data is particularly susceptible to self-selection bias and potential manipulation.

There is also a lack of data available on the number of illicit cannabis retailers in Canada. Prior to October 2018, 'licensed producers' of non-medical cannabis in Canada could only distribute cannabis products to authorized users by mail and no retail 'storefronts' were permitted. However, anecdotal evidence and informal environmental scans indicated an increasing number of cannabis retail outlets across Canadian cities, to the extent that Vancouver officially licensed cannabis retailers in 2015 even though they were technically prohibited from operating retail storefronts under federal legislation (City of Vancouver, 2018). In addition to retail storefronts, businesses offering discreet delivery services have become more prominent.

There is also little data on price variation across different geographic regions or types of cannabis retailers in Canada. Price variability for consumer goods can be influenced by a wide range of factors, including supply, product costs, competition, and product quality. Price variability may be greater for illicit drugs because of the high turnover of sellers and buyers, difficulties in ascertaining the quality of a product, and potential costs associated with searching for the 'best buy' (Reuter & Caulkins, 2004). For example, many consumers may want to limit their interactions or exposure to illegal cannabis retailers. It is unclear how the diversification of the cannabis market, in terms of both retail storefronts and online retail options, may have affected price variation.

Different methodologies have been used in previous studies to identify illicit cannabis retailers. Researchers in the U.S. have used online directories, some of which are unique to the state under study (Freisthler & Gruenewald, 2014; Freisthler, Ponicki, Gaidus, & Gruenewald, 2016; Hsu, Koçak, & Kovács, 2018; Mukhija & Loukaitou-Sideris, 2015). Of the online directories used, Weedmaps has been used most often and provides the most coverage of retailers (Freisthler et al., 2016; Freisthler & Gruenewald, 2014; Hsu et al., 2018; Mukhija & Loukaitou-Sideris, 2015).

The current study sought to estimate the number of illicit retailers and the average price of cannabis in the largest municipality in each of the 10 provinces and three territories in Canada by obtaining advertised prices directly from established retailers. This study also examined how the price of cannabis differed between municipalities, between storefront and delivery-only retailers, and over time in Canada's largest municipality.

2. Methods

Between October 2017 and May 2018, the average price of cannabis in the largest municipality in each Canadian province and territory was determined. The largest municipality in each Canadian province and territory was determined using Canada 2016 Census data (Statistics Canada, 2017). Online searches of three data sources were used to identify cannabis retailers in each municipality: Weedmaps, Leafly, and Google Maps.

Weedmaps, the largest and most comprehensive cannabis directory, is a private company that was established to allow retailers and customers to communicate product selection and availability (Business Wire, 2016). The directory was accessed via https://weedmaps.com/earth/ca, and the municipality name was entered in the location search bar. For Toronto, two searches were conducted: "Toronto East" and "Toronto West". These two searches were conducted separately as prompted by Weedmaps. Similarly, for Vancouver, four searches were conducted: "Downtown Vancouver", "North Vancouver", "West Side Vancouver", and "East Side Vancouver". For all other locations, only the municipality name was entered into the search bar.

Leafly, another private company, is the largest cannabis website in the world and serves several purposes, one of which is to help users locate retailers by municipality (Engadget, 2015). The Leafly search was conducted by accessing https://www.leafly.com/finder/browse and clicking the name of the municipality, which then generated a page displaying all retailers registered with Leafly in the selected location.

For the Google Maps search, the search statement "[municipality] marijuana dispensary" was used. Similar search statements were considered, however this statement yielded the most results. No search filter was applied to any of the search engines, meaning all business types were identified, including physical storefronts, delivery services, and medical clinics.

Each search engine was searched independently and duplicates (i.e., identical address if a storefront and identical website if an online-only retailer) were removed. In the case of a retail chain with multiple outlets located in one municipality, all outlets were recorded in the total number of cannabis retailers; however, when collecting pricing data, it was assumed all outlets in a single municipality would have the same price. If a retail chain served multiple municipalities, prices were recorded separately for each municipality.

The advertised prices of the least expensive, most expensive, and most popular dry herb at each retailer were determined using the retailer's website. If a retailer did not have a website, the website did not list any prices, or the website required users to create an account, the retailer's profiles on Weedmaps or Leafly were used to determine the price. Any price list discrepancies between Weedmaps and Leafly were resolved by using the most recently updated profile. If pricing information was not available online, retailers were contacted via telephone. The prices of dry herb were determined for one gram, one-eighth of an ounce, and one ounce. Occasionally, a price range was provided (e.g., $10–11 per gram). For the least expensive, the lower price (e.g., $10) was recorded. For the most expensive, the higher price (e.g., $11) was recorded. For the most popular, the average of the lower price and higher price (e.g., $10.50) was recorded.

The least expensive and most expensive strains were determined using the 'sort by price' function on the retailer's website. If the website did not have this function, the researcher visually scanned the list of prices to determine the least and most expensive strains. To determine the most popular strains, the 'sort by popularity' function on the retailer's website was used. If the website lacked the ability to sort strains, the researcher used the website's chat option to ask a sales representative for the most popular strain. If no answer was received or the website lacked a chat option, Leafly, which had a 'sort by popularity' function at the time of data collection, was used to determine the most popular strain. In such situations, Leafly was only used to

Table 1
The number of cannabis retailers in the largest municipality in each province and territory in Canada.

Municipality	Population of Each City	Total Number of Retailers (n)	Storefront (n)	Delivery-Only Service (n)	Storefront with Delivery Service (n)	Number of Retailers Per 1000
Vancouver	631,486	185	69	85	31	0.29
Toronto	2,731,571	152	62	82	8	0.06
Winnipeg	705,244	94	2	91	1	0.13
Montreal	1,704,694	87	3	79	5	0.05
Calgary	1,239,220	84	0	84	0	0.07
Halifax	403,131	81	11	69	1	0.20
St. John's	108,860	77	2	74	1	0.71
Charlottetown	36,094	62	1	61	0	1.72
Saskatoon	246,376	58	2	55	1	0.24
Moncton	71,889	57	5	51	1	0.79
Iqaluit[a]	7740	20	0	20	0	2.58
Whitehorse[a]	25,085	20	0	20	0	0.80
Yellowknife[a]	19,569	20	0	20	0	1.02
Total		997	157	791	58	

[a] The 20 delivery-only businesses that serve Iqaluit are the same businesses that serve Whitehorse and Yellowknife.

determine which strain was most popular, and the retailer's website was used to determine its price.

A second wave of data was collected in Toronto to facilitate a five-month comparison. The first wave of data collection concluded in December 2017, and the second wave concluded in May 2018. The process described above for identifying retailers and collecting pricing data was followed for both waves.

3. Results

3.1. Number of retailers

Table 1 shows the number of retailers in each municipality by business type. A total of 997 retailers were identified, 61% of which were present in multiple municipalities. There was a greater number of delivery-only services than other business types in each municipality. Vancouver had the most retailers overall (185), while Iqaluit, Whitehorse, and Yellowknife had the fewest (20). Vancouver also had the most storefronts (69) and storefronts with delivery services (31), while Winnipeg had the most delivery-only services (91). All retailers serving Calgary and the territorial municipalities in Northern Canada (Iqaluit, Whitehorse, and Yellowknife) were delivery-only businesses.

Of the retailers identified, pricing information could not be found online for 14 retailers across the 13 municipalities. When contacted by telephone, only one provided pricing information. Overall, pricing data was collected from 99% of the retailers.

3.2. Price by municipality

The average advertised prices for one gram, one-eighth of an ounce, and one ounce of the least expensive, most expensive, and most popular strains of cannabis in each municipality were calculated (see Table 2). There was notable variability in pricing across the municipalities. The price for one gram of the least expensive cannabis varied by approximately 15%, while the price for one gram of the most expensive strains varied by approximately 10%. The price also varied by approximately 10% for one-eighth of an ounce of all strain types. Variability in the price for one ounce was somewhat greater: price per ounce varied by approximately 16% for both the least and most expensive strains, and 22% for the most popular strains. In most cases, the prices were highest in Toronto and Vancouver and lowest in the territorial cities and Saskatoon.

3.3. Price by type of retailer

The average advertised prices were also examined by the type of retailer (see Table 3). There was little variability in prices between retailer types for small amounts purchased by the gram or an eighth of an ounce. However, prices per ounce were substantially less for delivery-only services, ranging from approximately 15% less per ounce for the most popular and least expensive strains, and approximately 10% less per ounce for the most expensive strains.

3.4. Prices & product volume

To determine if there were discounts for bulk purchasing, all pricing data collected was converted to the unit price for one gram. As shown in Table 4 and Fig. 1, the price-per-gram decreased as the amount purchased increased. Purchasing one-eighth of an ounce of the most popular, least expensive, and most expensive strains resulted in reductions of 9%, 4%, and 7%, respectively. The savings of purchasing one ounce were more pronounced: prices were 27%, 24%, and 21% lower when purchasing one ounce of the most popular, least expensive, and most expensive strains, respectively.

3.5. Price and number of retailers over time

Table 5 shows how the number of retailers and the advertised price of cannabis in Canada's largest municipality (Toronto) changed from December 2017 to May 2018. Over this five-month period, there were minor increases in the number of storefronts, delivery-only services, and storefronts with delivery services. Regardless of purchase volume, the advertised prices for the least expensive strains increased, while the prices for both the most expensive and most popular strains decreased. The changes in price were unremarkable, with the exception of the most popular strains, which showed an annualized rate of price decline of 21%, 13%, and 34% for one gram, one-eighth of an ounce, and one ounce, respectively. The annualized rates of change were less than 10% for all other strains and purchase volumes. When controlling for retailer, the annualized rates of change were only modest with the exception of one gram and one ounce of the most popular strain (20% and 34% decline, respectively) and one gram of the least expensive strain (15% increase). In May 2018, pricing information for six retailers could not be determined online or over the telephone. Overall, pricing data was determined for 96% of the retailers identified in this search.

4. Discussion

To our knowledge, the current study presents the first systematic effort to objectively characterize the number of illicit retailers and retail cannabis prices in Canada. The findings depict a well-established retail cannabis market in Canada in the year prior to legalization. Overall, we

Table 2
The average advertised prices for one gram, one eighth of an ounce, and one ounce of the most popular, least expensive, and most expensive strains of cannabis by municipality.

	Price for Most Popular Strains						Price for Least Expensive Strains						Price for Most Expensive Strains					
	1 g		1/8 oz		1 oz		1 g		1/8 oz		1 oz		1 g		1/8 oz		1 oz	
Municipality	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)
Vancouver	57	10.77 (9.22)	60	31.11 (6.95)	69	215.55 (65.32)	131	7.23 (2.01)	126	25.03 (6.25)	130	169.39 (46.01)	130	12.41 (2.36)	125	40.13 (6.12)	130	284.57 (70.40)
Toronto	60	10.32 (2.53)	52	33.88 (8.40)	69	230.40 (62.35)	121	8.08 (2.46)	113	27.74 (7.85)	126	183.94 (58.15)	120	12.82 (2.13)	113	42.22 (7.95)	126	292.53 (62.28)
Charlottetown	29	10.14 (2.47)	34	32.79 (6.77)	45	207.62 (66.14)	45	8.11 (1.92)	44	26.62 (6.16)	60	167.28 (53.10)	45	11.88 (2.40)	44	39.19 (8.05)	60	268.36 (60.27)
Moncton	25	10.03 (2.55)	27	31.32 (7.25)	36	203.86 (67.15)	41	7.97 (2.18)	38	26.38 (6.54)	51	168.06 (57.60)	41	11.94 (2.63)	38	40.62 (8.38)	51	273.09 (60.46)
Iqaluit	11	9.97 (1.83)	12	30.50 (8.98)	15	185.13 (54.29)	14	8.50 (1.83)	16	26.63 (6.87)	20	161.61 (41.67)	14	12.18 (2.35)	16	38.19 (7.01)	20	248.10 (53.13)
Whitehorse	11	9.97 (1.83)	12	30.50 (8.98)	15	185.13 (54.29)	14	8.50 (1.83)	16	26.63 (6.87)	20	161.61 (41.67)	14	12.18 (2.35)	16	38.19 (7.01)	20	248.10 (53.13)
Yellowknife	11	9.97 (1.83)	12	30.50 (8.98)	15	185.13 (54.29)	4	8.50 (1.83)	16	26.63 (6.87)	20	161.61 (41.67)	14	12.18 (2.35)	16	38.19 (7.01)	20	248.10 (53.13)
Winnipeg	39	9.95 (2.54)	48	31.99 (7.06)	60	202.31 (64.87)	66	7.94 (2.23)	71	26.67 (6.24)	88	163.42 (50.81)	66	12.37 (2.16)	71	40.12 (7.07)	88	265.72 (58.07)
Calgary	30	9.71 (2.80)	39	31.99 (8.05)	50	202.95 (69.02)	57	7.75 (2.14)	67	25.60 (6.24)	81	157.14 (47.98)	57	12.30 (2.42)	67	40.11 (7.93)	81	269.85 (61.58)
St. John's	34	9.71 (2.40)	40	32.35 (6.96)	50	196.73 (65.58)	52	8.22 (2.11)	56	27.03 (6.64)	73	161.12 (54.74)	52	12.23 (2.30)	56	38.67 (7.93)	74	263.24 (61.92)
Halifax	30	9.69 (2.69)	37	31.83 (7.75)	47	200.13 (67.48)	57	7.44 (2.09)	65	25.53 (6.03)	76	158.89 (51.00)	57	11.93 (2.25)	65	39.85 (7.67)	76	271.70 (58.14)
Montreal	35	9.67 (3.02)	42	32.15 (8.13)	55	201.66 (66.32)	64	7.57 (2.38)	71	26.06 (6.36)	84	160.43 (48.82)	64	12.57 (2.20)	70	39.93 (7.17)	84	272.11 (60.02)
Saskatoon	26	9.30 (2.54)	28	31.22 (6.19)	36	193.76 (64.03)	43	7.73 (2.08)	38	26.10 (5.97)	53	155.02 (45.77)	43	11.56 (2.03)	38	39.26 (4.67)	53	260.82 (47.40)
Total	398	10.02 (4.19)	443	31.98 (7.52)	562	205.30 (65.30)	719	7.80 (2.18)	737	26.28 (6.58)	882	165.59 (51.30)	717	12.30 (2.29)	735	40.09 (7.33)	883	272.73 (61.65)

Note: Prices are in Canadian dollars. n = sample size; M = mean; SD = standard deviation.

Table 3
The average advertised prices for one gram, one eighth of an ounce, and one ounce of the most popular, least expensive, and most expensive strains of cannabis by retailer.

	Price for Most Popular Strains						Price for Least Expensive Strains						Price for Most Expensive Strains					
	1 g		1/8 oz		1 oz		1 g		1/8 oz		1 oz		1 g		1/8 oz		1 oz	
Retailer	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)
Storefront	27	10.00 (2.08)	19	32.08 (7.56)	25	240.88 (55.48)	121	7.40 (2.00)	104	25.71 (6.78)	98	188.57 (53.86)	120	12.28 (1.82)	103	41.32 (6.30)	98	293.12 (43.23)
Delivery-only	359	10.01 (4.36)	413	31.95 (7.54)	525	202.70 (65.24)	566	7.91 (2.22)	610	26.41 (6.58)	756	161.95 (50.37)	565	12.28 (2.36)	610	39.86 (7.41)	757	269.00 (61.68)
Storefront with Delivery	12	10.25 (2.26)	11	32.86 (7.14)	12	245.00 (55.16)	32	7.37 (2.09)	23	25.32 (5.80)	28	186.83 (41.61)	32	12.75 (2.50)	22	40.75 (9.02)	28	302.09 (90.28)
TOTAL	398	10.02 (4.19)	443	31.98 (7.52)	562	205.30 (65.30)	719	7.80 (2.18)	737	26.28 (6.58)	882	165.69 (51.30)	717	12.30 (2.29)	735	40.09 (7.33)	883	272.73 (61.65)

Note: Prices are in Canadian dollars. n = sample size; M = mean; SD = standard deviation.

Table 4
The advertised price for other amounts of cannabis converted to the unit price for one gram of cannabis.

	Most Popular Strains						Least Expensive Strains						Most Expensive Strains					
	Price for 1 g		Unit Price for 1/8 oz (per g)		Unit Price for 1 oz (per g)		Price for 1 g		Unit Price for 1/8 oz (per g)		Unit Price for 1 oz (per g)		Price for 1 g		Unit Price for 1/8 oz (per g)		Unit Price for 1 oz (per g)	
Municipality	n	M	n	M	n	M	n	M	n	M	n	M	n	M	n	M	n	M
Vancouver	57	10.77	60	8.89	69	7.70	131	7.23	126	7.15	130	6.05	130	12.41	125	11.47	130	10.16
Toronto	60	10.32	52	9.68	69	8.23	121	8.08	113	7.93	126	6.57	120	12.82	113	12.06	126	10.45
Charlottetown	29	10.14	34	9.37	45	7.42	45	8.11	44	7.61	60	5.97	45	11.88	44	11.20	60	9.58
Moncton	25	10.03	27	8.95	36	7.28	41	7.97	38	7.54	51	6.00	41	11.94	38	11.60	51	9.75
Iqaluit	11	9.97	12	8.71	15	6.61	14	8.50	16	7.61	20	5.77	14	12.18	16	10.91	20	8.86
Whitehorse	11	9.97	12	8.71	15	6.61	14	8.50	16	7.61	20	5.77	14	12.18	16	10.91	20	8.86
Yellowknife	11	9.97	12	8.71	15	6.61	4	8.50	16	7.61	20	5.77	14	12.18	16	10.91	20	8.86
Winnipeg	39	9.95	48	9.14	60	7.23	66	7.94	71	7.62	88	5.84	66	12.37	71	11.46	88	9.49
Calgary	30	9.71	39	9.14	50	7.25	57	7.75	67	7.31	81	5.61	57	12.30	67	11.46	81	9.64
St. John's	34	9.71	40	9.24	50	7.03	52	8.22	56	7.72	73	5.75	52	12.23	56	11.05	74	9.40
Halifax	30	9.69	37	9.09	47	7.15	57	7.44	65	7.29	76	5.67	57	11.93	65	11.39	76	9.70
Montreal	35	9.67	42	9.18	55	7.20	64	7.57	71	7.45	84	5.73	64	12.57	70	11.41	84	9.72
Saskatoon	26	9.30	28	8.92	36	6.92	43	7.73	38	7.46	53	5.54	43	11.56	38	11.22	53	9.31
TOTAL	398	10.02	443	9.14	562	7.33	719	7.80	737	7.51	882	5.92	717	12.30	735	11.45	883	9.74

Note: Prices are in Canadian dollars. n = sample size; M = mean.

identified a total of 997 retailers in Canada, including 215 physical storefronts. Of the 997 retailers identified, 61% were operating in multiple municipalities. There were substantial variations in the number of retailers across cities, particularly with respect to storefronts. Two of Canada's largest municipalities, Vancouver and Toronto, had over 70 physical storefronts each. In contrast, Montreal and Calgary—with populations over 1 million—had 0 and 3 retail storefronts, respectively. This large discrepancy in storefront prevalence is likely due to differences in the level of enforcement in each municipality, such as the municipal business licenses provided by the City of Vancouver. Interestingly, Montreal and Calgary had among the highest number of delivery services, suggesting greater difficulty enforcing the online retail environment. Overall, the data suggest that cannabis retail outlets have been tolerated in most large municipalities prior to legalization.

Across the different price segments, the average advertised prices of cannabis were generally highest in Toronto. Toronto is the most populous municipality examined, with a high cost of living and potentially larger demand for cannabis relative to the number of retailers, which may account for higher prices. Apart from higher prices in Toronto, there were other consistent trends. Prices were generally lowest in Saskatoon and the territorial municipalities in Northern Canada. It should be noted that all retailers in the territorial municipalities were delivery-only businesses, which may explain the lower prices. The prices in other municipalities did not display a consistent pattern.

There was no consistent difference in advertised prices between storefronts and delivery services, except that delivery-only services were substantially less expensive for one ounce. While both retailer types offer a wide variety of products and selection, they may cater to different types of consumers. Some consumers may prefer not to visit storefronts in person given the potential of becoming implicated in any 'crack down' or enforcement activities; alternatively, delivery services require an address and a payment method that is less anonymous than cash. Therefore, it is unclear which type of retailer is more likely to be frequented by consumers who seek greater anonymity. Other factors, including geographic proximity and the ability to browse products 'in store', may influence which retailer type is preferred. We are unaware of any other studies that have examined differences between delivery-only and storefront cannabis purchasing patterns.

Comparing the retail cannabis market in Toronto over a five-month period revealed a decline in price for the most popular and most expensive strains, and an increase in price for the least expensive strains. The decline in price was more notable for the most popular strains compared to the most expensive strains, supporting the plausible link between lower prices and popularity among consumers. Findings from the current study are consistent with crowdsourced data in Canada,

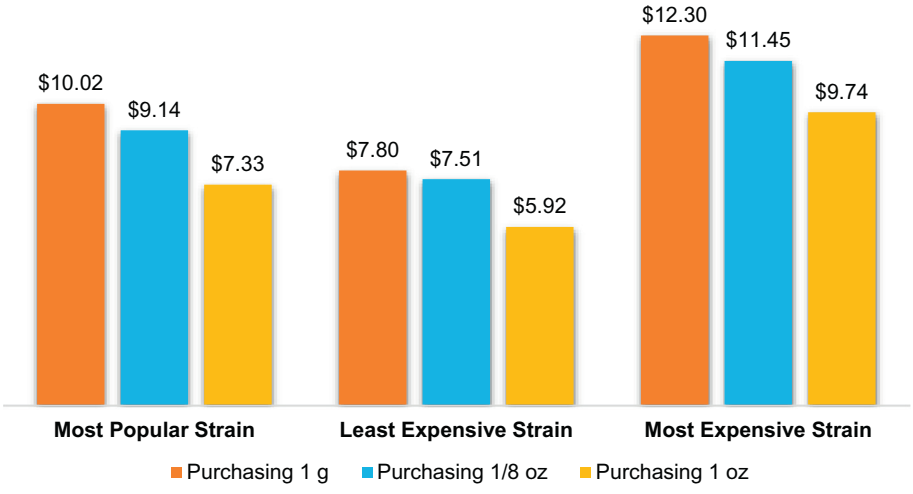

Fig. 1. The average advertised prices for cannabis across all municipalities converted to the unit price for one gram of cannabis.

Table 5
The number of cannabis retailers and advertised pricing in Toronto over a five-month period.

		December 2017		May 2018	
Total number of retailers		152		157	
Storefront		62		64	
Delivery-only		82		84	
Storefront with Delivery		8		9	
Average price		n	M (SD)	n	M (SD)
Most Popular Strains	1 g	60	10.32 (2.53)	54	9.37 (2.36)
	1/8 oz	52	33.88 (8.40)	53	31.92 (7.45)
	1 oz	69	230.40 (62.35)	54	193.80 (61.21)
Least Expensive Strains	1 g	121	8.08 (2.46)	144	8.32 (2.23)
	1/8 oz	113	27.74 (7.85)	144	28.20 (7.63)
	1 oz	126	183.94 (58.15)	144	184.83 (60.65)
Most Expensive Strains	1 g	120	12.82 (2.13)	144	12.55 (2.21)
	1/8 oz	113	42.22 (7.95)	143	42.00 (7.47)
	1 oz	126	292.53 (62.28)	143	290.01 (68.43)
Average price controlling for retailers		n	M (SD)	n	M (SD)
Most Popular Strains	1 g	38	10.40 (2.37)	37	9.46 (2.46)
	1/8 oz	35	33.09 (8.20)	36	32.11 (7.69)
	1 oz	46	231.35 (58.38)	37	194.46 (59.77)
Least Expensive Strains	1 g	78	7.87 (2.34)	90	8.33 (2.33)
	1/8 oz	76	27.06 (7.47)	90	27.92 (7.74)
	1 oz	85	181.05 (54.39)	90	182.56 (61.42)
Most Expensive Strains	1 g	77	12.99 (2.17)	90	12.63 (2.09)
	1/8 oz	76	42.26 (7.96)	89	41.97 (7.22)
	1 oz	85	294.18 (69.93)	89	288.83 (66.01)

Note: Prices are in Canadian dollars. n = sample size; M = mean; SD = standard deviation.

which suggest a decline of approximately 10% in cannabis prices between 2010 and 2017 (Statistics, 2018a). The price declines observed in the current study over a five-month period were notably greater; however, this likely reflects substantial volatility in the illegal cannabis market in the lead up to legalization in October 2018, which was accompanied by greater enforcement efforts in a number of cities. In addition, despite slight increases in the total number of retailers, only 60% of the retailers identified in May 2018 were identified in December 2017, demonstrating the high turnover of illegal retailers in Toronto. Turnover rates are likely to reflect the level of enforcement, which is expected to increase under cannabis legalization in Canada.

More generally, there is little data with which to compare the current findings. Cannabis prices in the current study were consistent with listed prices for medical cannabis in Canada, which ranged from $6.00 to $12.00 per gram from the largest licensed producers (Goodman, 2018). Compared to crowdsourced and self-reported survey data, the price estimates from the current study—$7.80 per gram for the least expensive, $12.30 per gram for the most expensive, and $10.02 per gram for the most popular varieties—are somewhat higher than previous studies which range from an average $6.22 to $7.69 per gram (Ouellet et al., 2017; Statistics Canada, 2018b). This may reflect some degree of self-selection bias in crowdsourced data sources; for example, consumers who voluntarily contribute to crowdsourcing websites may be more frequent users who buy in greater quantities and, therefore, pay lower prices due to bulk discounts. The reliability of crowdsourced cannabis price data is difficult to establish.

The prices collected from retailers in the current study are also higher than prices self-reported in population-based surveys (Sikorski et al., 2018). There are several potential reasons for this price difference. Estimating prices from population-based surveys assume that participants can accurately report consumption or purchase amounts, which is typically measured in grams of dry herb or the number of 'joints'. However, many consumers have difficulty reporting cannabis amounts in grams in the absence of images or other visual aids (Goodman, Leos-Toro, & Hammond, 2018). Most studies also assume a standard 'joint' size when calculating dry herb consumption; in fact, the typical size of joints can vary between 0.2 and 1.2 g—a 6-fold difference (Kilmer & Pacula, 2009; Ridgeway & Kilmer, 2016). Although the measurement bias from these assumptions may seem modest, it can have profound effects on aggregated estimates of consumption and the price of cannabis (Kilmer & Pacula, 2009; Ridgeway & Kilmer, 2016). Self-reported prices also include a greater diversity of purchase sources compared to those assessed in the current study. Consumers who report a lower price may have purchased cannabis from a dealer, which is generally cheaper than an established retailer due to reduced overhead costs such as no rent or shipping expenses (Priceonomics, 2016). Furthermore, dealers may offer regular customers discounts in return for their loyalty.

In general, it would appear that prices of illegal cannabis may be lower in Canada than the U.S. (Priceonomics, 2018). The extent to which the price of illegal cannabis will change following legalization is unknown. In a study of U.S. cities where cannabis is legal, the price of illegally-sourced cannabis was at least 10% lower than the legal rate in 52 of the 66 cities examined; however, the extent of this gap varied substantially by city, due to differences in legal price, retail availability, and enforcement (Caulkins, Kilmer, MacCoun, Pacula, & Reuter, 2012; Denman, 2017; Jensen & Roussell, 2016; NORML, 2016).

Several limitations should be noted. The study only identified cannabis retailers using online tools and resources. While it avoids the biases of self-reporting, this approach does not encompass all active retailers, such as businesses that operate discreetly to avoid police raids, or illicit sales conducted informally through personal contacts and traditional 'dealers', which account for a substantial proportion of cannabis purchase sources in Canada (Sikorski et al., 2018). It is not known how prices from these informal sources compare to more established retailers examined in the current study. The use of both Weedmaps and Leafly may also result in the omission of smaller retailers, as both directories charge retailers a regular fee for advertising, which smaller retailers may not be able to afford (Meshach, 2017). According to Weedmaps, only delivery services are charged, while other businesses can list their services for free (Weedmaps, 2018). Furthermore, searching Weedmaps generates a maximum of 100 search results, meaning that the website alone does not provide comprehensive coverage of municipalities exceeding 100 retailers. However, parallel use of Leafly and Google Maps supplemented the coverage of each municipality. It is also important to note that the estimates made by this study are the result of advertised pricing information and may not reflect the average prices customers pay for cannabis or sales-weighted prices. In addition, data collection occurred over an eight-month period and did not occur simultaneously by municipality; therefore, differences in pricing may be influenced by time, rather than geographical factors. Also, the ability to compare this data to previous estimates is limited, as this study only examined the largest municipality in each province and territory, while other reports were less restrictive and included data from anywhere within a given province or territory.

Future studies should examine direct comparisons between retailer price and the purchasing behaviour from population-based surveys. Greater detail in survey data with respect to retailer, purchase volume, and the specific type of cannabis has the potential to increase the accuracy of estimates. In addition, a standardized measure for the 'quality' or strain of cannabis should be established, as quality is a significant determinant of price. In addition, longitudinal monitoring of price data may increase the reliability of estimates and provide a greater understanding of how illicit prices change over time under a regulated market for cannabis.

5. Conclusion

The findings depict a well-established illicit retail cannabis market in Canada in the year prior to legalization. The average advertised price of the most popular cannabis varieties was approximately $10 CAD, which happens to be the same as the price targeted by the federal government for the legal cannabis market. The lowest price documented would be approximately 20 to 25% less than the projected price under legalization. This suggests that the legal price of cannabis will, at least initially, be similar to what cannabis retailers have been advertising in the illicit market. Monitoring the price differential between legal and illegal cannabis sources following legalization in October 2018 will be critical to informing taxation policies in Canada. Indeed, several U.S. states, including Colorado, Nevada, and Washington, adjusted their tax rates within three years of legalizing cannabis to minimize the price differential between illegal and legal sources (Canadian Centre on Substance Use and Addiction (CCSA), 2015; Colorado Department of Revenue, 2018; State of Nevada, 2017; Washington State Liquor and Cannabis Board, 2016).

The findings also suggest that enforcement may have a strong influence on the number of cannabis retailers. Vancouver had the largest number of physical storefronts and retailers overall and is the one municipality that has actually licensed retail storefronts, despite the federal prohibitions. Given the lack of historical data, it is unclear whether the licensing system increased the number of storefronts in Vancouver, although many storefronts continue to operate without a license (City of Vancouver, 2018).

The study found no consistent difference in prices between storefronts and delivery services. In addition, the study demonstrated the impact of bulk purchasing: the unit price of cannabis was lower if a larger amount was purchased. The five-month comparison in Toronto revealed a noticeable decline in the price of the most popular strains, and demonstrated the high turnover of illegal cannabis retailers. The advertised prices determined from retailers were higher than the self-reported prices found in previous studies. With more information on the number and type of retailers and their prices for cannabis, policymakers will be able to make informed decisions throughout the process of legalization in Canada. Further work is needed to compile comprehensive data that includes information on the source and quality of cannabis in addition to the price.

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