Supplementary Appendix for:

Armstrong M.J. 2021, Relationships between sales of legal medical cannabis and alcohol in Canada. *Health Policy*. https://doi.org/10.1016/j.healthpol.2022.11.012

S1. Introduction

This appendix contains more details about the data preparation and statistical results.

S2. Method

S2.2. Data Preparation

Statistics Canada reported most population counts and demographic measures only annually, as of July each year. This study approximated values for the other months by interpolation: e.g., each province's age 15+ population for August 2017 was calculated as 11/12 of the July 2017 value plus 1/12 of the July 2018 value. This smoothing prevented artificial discontinuities appearing between December of one year and January of the next.

For medical cannabis, Statistics Canada reported only national quarterly purchase totals; so, province-month sales were approximated as follows. From April 2017 onward, when most sales occurred, Statistics Canada's quarterly national dollar totals were allocated in proportion to Health Canada's shipment counts for each province-month. From April 2015 to March 2017, when sales were rapidly growing, the allocations were instead based on provinces' average monthly of shipments between April 2017 and March 2018. For March 2015 and earlier, when sales were minimal, the province-month values were set to zero to avoid undue extrapolation.

For the sales measures, each provincial sales total was divided by the province's population aged 15 or above to get sales per capita.

Alcohol sales were seasonally adjusted as follows. First, each province-month value was divided by that year's mean to get a seasonality ratio. (E.g., Ontario's July 2017 sales were divided by Ontario's 2017 monthly mean.) Next, each province's seasonality ratios were averaged together by month to get its seasonality adjustments. (E.g., the nine Ontario ratios for July, from 2011 to 2019, were averaged to get Ontario's July adjustment.) Finally, each sales number was divided by the corresponding adjustment factor to get its seasonally adjusted equivalent. (E.g., Ontario's July 2017 sales were divided by its July average adjustment.)

Retail trade sales were converted into constant 2019 dollars using the "all items" inflation index, alcohol sales used the "alcoholic beverages purchased from stores" subindex, and grocery sales used the "food purchased from stores" subindex. Inflation from January 2011 to September 2018 was relatively low: nationally, the all-items index rose 13.5%, alcohol rose 10.3%, and food rose 13.7%. The medical cannabis sales figures were not adjusted due to their newness and the lack of an appropriate index.

Provincial impaired driving changes were modeled using binary indicator variables set to 0 for each month before the change and to 1 for each month afterward. If a change took effect at the beginning of a month (e.g., 1 November), that month was coded with a 1; if it occurred part way through (e.g., 16 September) the month received a decimal value prorated to the number of days in effect (e.g., 15/30 = 0.5). Two changes were excluded from the data: Nova Scotia increased its penalties (1 May 2013) but only for the very limited case of impaired driving with children in the car; and British Columbia amended its rules (15 June 2012), but only to make appeal procedures more forgiving for drivers.

S2.3. Regression equations

The regression equations are shown below, with variables indexed by province i = 1 to 7 and/or month t = 1 to 93 as appropriate.

The base model was formulated as follows.

$$Alcohol_{i,t} = Constant + \alpha_i + Trend_i\ t + B_1\ Educated_{i,t} + B_2\ Unemployed_{i,t} + B_3\ RetailTrade_{i,t} + B_4\ AlcoholPrice_{i,t} + B_5\ LawChange_{i,t} + \varepsilon_{i,t}$$

The current month cannabis sales model added $B_6\ Cannabis_{i,t}$. The prior month cannabis sales model replaced $Cannabis_{i,t}$ with $Cannabis_{i,t-1}$. The demographic robustness check added $B_7\ Male_{i,t}$, $B_8\ Twenty_{i,t}$, and $B_9\ Married_{i,t}$. The grocery robustness check instead replaced $Alcohol_{i,t}$ with $Grocery_{i,t}$ and $AlcoholPrice_{i,t}$ with $FoodPrice_{i,t}$.

The DID model was formulated as follows.

$$Alcohol_{i,t} = Constant + \alpha_i + Trend_i\ t + B_1\ Educated_{i,t} + B_2\ Unemployed_{i,t} + B_3\ RetailTrade_{i,t} + B_4\ AlcoholPrice_{i,t} + B_5\ LawChange_{i,t} + B_6\ CommonTrend_t. + B_7\ TreatTrend_{i,t}. + B_8\ CommonIndicator_t. + B_9\ TreatIndicator_{i,t}. + \varepsilon_{i,t}$$

$CommonIndicator_t$ was a binary indicator variable shared by all provinces: it equaled 0 in each month up to March 2015, i.e., months 1 to 51, and 1 in each month thereafter. $CommonTrend_t$ was the trend change common to all provinces and was calculated as the product of $CommonIndicator_t$ and month t: so, it equaled 0 for months up to March 2015, and then increased from 52 to 93 thereafter. $TreatIndicator_{i,t}$ was an indicator for each province that equaled 0 up to March 2015 and equaled its treatment level thereafter; e.g., 0 for Quebec and 0.0763 for Ontario. $TreatTrend_{i,t}$ was the treatment trend change measure and was calculated as the product of $TreatIndicator_{i,t}$ and month t: so, it equaled 0 for months up to March 2015, and then, e.g., for Quebec it remained 0, while for Ontario it increased from 3.97 to 7.10.

The models did not include terms for medical cannabis policy details that, e.g., restricted patient access (Veligati et al., 2020) or allowed home-growing. That was because this study directly measured differences in cannabis sales, whereas earlier work had used policy details to imply those sales differences.

Before analyzing the DID model, the national total alcohol sales time series was checked for structural breaks using Wald tests. Stata's "sbsingle" feature reported the most likely break location was in July 2015 (p = .0005), i.e., the second quarter of MMRP cannabis sales growth. When Stata's "sbknown" tested specifically for a break in April 2015, i.e., when MMRP sales began, it indicated this was only marginally less likely as a break point (p = .0012); so, that month was used in the DID formulation.

A technical difference between this study and some previous research is the panel data structure. This study had a "long" panel with many more time periods (93 months) than jurisdictions (7 provinces), whereas some U.S. studies had "wide" panels with more jurisdictions (up to 50 states) but fewer time periods (at most 10 years). The different structures led to different statistical algorithms being appropriate.

S3. Results

S3.1 Regression results

Figure S1 shows that the residuals from the prior month cannabis sales regression followed a bell-curve distribution. Figure S2 shows that they displayed no obvious pattern when plotted by month. Both figures suggest linear regression was reasonable for this data. The diagrams do not include two outliers that occurred due to unusually low alcohol sales in Saskatchewan in January and February of 2012. The two points are visible in the lower left part of Figure S3, which shows the provincial time series alcohol sales plots. Those two points were included in the study's regressions; a trial regression omitting those two points gave almost identical results.

Tables S1 to S8 show Stata's regression output. The seven "Trend …" variables represent average monthly growth in the region indicated by the suffix: QC Quebec, ON Ontario, MB Manitoba, SK Saskatchewan, AB Alberta, BC British Columbia, and ATL Atlantic. The seven provincial fixed effect constants are omitted for brevity. The columns show the variable name, non-standardized coefficient *B*, Driskoll-Kraay standard error *SE*, calculated *t*-statistic *t*, significance *p,* low end of the 95% confidence interval *95% Lo,* and the high end of the 95% confidence interval *95% Hi*.

S3.2 New consumption versus diverted consumption

In the cannabis data, legal sales increases do not directly correspond to total consumption increases, because some patients were already buying cannabis illegally. Each legal sales dollar therefore represented a mix of consumption from new users and consumption that existing users had diverted from the illicit market. Thus, the legal sales increases were presumably offset by smaller illegal sales decreases, with the difference being the net new sales.

If we somehow knew what percentage was net new consumption in each month, we could adjust the data and redo the analysis in those terms. For example, if we knew that half the legal sales were new, and half had been diverted, we would cut all the cannabis sales figures in half. The regression would then show that the cannabis coefficient had doubled from $0.74 *per*

dollar of legal sales to $1.48 *per dollar of net new sales*, because the same alcohol changes would be attributed to only half as much cannabis. However, the regression coefficient's significance would remain unchanged at $p = .022$, because what matters there is the cannabis sales pattern and its correlations, not its size. Of course, if the net new percentage was not constant across every month and province, then the coefficient and its significance could change in various ways.

TABLE S1. Regression for base model without cannabis variables.

	B	*SE*	*t*	*p*	95% Lo	95% Hi
Educated	0.584	0.213	2.74	0.007	0.161	1.008
Unemployed	0.766	0.354	2.16	0.033	0.062	1.470
RetailTrade	5.327	3.665	1.45	0.150	-1.952	12.606
AlcoholPrice	-0.158	0.061	-2.61	0.011	-0.279	-0.038
LawChange	-3.640	1.779	-2.05	0.044	-7.172	-0.107
TrendQC	0.015	0.021	0.70	0.488	-0.027	0.056
TrendON	0.014	0.023	0.60	0.552	-0.032	0.060
TrendMB	-0.072	0.031	-2.36	0.020	-0.133	-0.012
TrendSK	0.086	0.029	2.99	0.004	0.029	0.143
TrendAB	-0.071	0.029	-2.41	0.018	-0.129	-0.012
TrendBC	0.155	0.025	6.10	0.000	0.105	0.206
TrendAtl	-0.013	0.025	-0.54	0.592	-0.063	0.036
Constant	41.73	14.25	2.93	0.004	13.42	70.04
R^2 within	38.98%					

TABLE S2. Regression using current month cannabis sales.

	B	*SE*	*t*	*p*	95% Lo	95% Hi
Educated	0.514	0.205	2.50	0.014	0.106	0.921
Unemployed	0.982	0.354	2.78	0.007	0.280	1.685
RetailTrade	6.103	3.353	1.82	0.072	-0.557	12.764
AlcoholPrice	-0.157	0.061	-2.60	0.011	-0.278	-0.037
LawChange	-2.661	1.546	-1.72	0.089	-5.730	0.409
Cannabis	**-0.735**	**0.314**	**-2.34**	**0.022**	**-1.359**	**-0.111**
TrendQC	0.026	0.021	1.22	0.226	-0.016	0.068
TrendON	0.041	0.027	1.55	0.124	-0.012	0.094
TrendMB	-0.057	0.030	-1.94	0.056	-0.116	0.001
TrendSK	0.099	0.029	3.47	0.001	0.042	0.156
TrendAB	-0.029	0.035	-0.81	0.420	-0.099	0.042
TrendBC	0.169	0.028	6.13	0.000	0.114	0.224
TrendAtl	0.008	0.027	0.30	0.765	-0.046	0.062
Constant	41.79	13.78	3.03	0.003	14.41	69.16
R^2 within	39.59%					

TABLE S3. Regression using prior month cannabis sales.

	B	*SE*	*t*	*p*	95% Lo	95% Hi
Educated	0.490	0.206	2.37	0.020	0.080	0.900
Unemployed	0.971	0.353	2.75	0.007	0.269	1.673
RetailTrade	6.017	3.371	1.78	0.078	-0.678	12.713
AlcoholPrice	-0.159	0.061	-2.62	0.010	-0.279	-0.038
LawChange	-2.357	1.525	-1.55	0.126	-5.386	0.672
Cannabis *t*-1	**-0.836**	**0.314**	**-2.66**	**0.009**	**-1.460**	**-0.212**
TrendQC	0.028	0.021	1.31	0.194	-0.014	0.070
TrendON	0.045	0.026	1.71	0.090	-0.007	0.098
TrendMB	-0.053	0.029	-1.81	0.074	-0.112	0.005
TrendSK	0.103	0.029	3.55	0.001	0.045	0.161
TrendAB	-0.020	0.036	-0.55	0.582	-0.091	0.051
TrendBC	0.172	0.028	6.15	0.000	0.116	0.227
TrendAtl	0.011	0.027	0.42	0.677	-0.043	0.065
Constant	43.21	13.86	3.12	0.002	15.68	70.74
R^2 within	39.80%					

TABLE S4. Regression for difference-in-differences model.

	B	*SE*	*t*	*p*	95% Lo	95% Hi
Educated	0.286	0.205	1.39	0.167	-0.122	0.694
Unemployed	0.460	0.341	1.35	0.181	-0.217	1.137
RetailTrade	4.401	3.853	1.14	0.256	-3.251	12.053
AlcoholPrice	-0.188	0.058	-3.26	0.002	-0.302	-0.073
LawChange	-1.684	1.537	-1.10	0.276	-4.738	1.369
CommonTrend	0.026	0.032	0.81	0.418	-0.038	0.090
TreatTrend	**-0.925**	**0.335**	**-2.76**	**0.007**	**-1.590**	**-0.259**
CommonInd	-0.717	2.003	-0.36	0.721	-4.696	3.262
TreatInd	65.155	19.416	3.36	0.001	26.592	103.717
TrendQC	0.012	0.023	0.53	0.597	-0.033	0.057
TrendON	0.021	0.027	0.77	0.444	-0.033	0.075
TrendMB	-0.050	0.030	-1.68	0.096	-0.110	0.009
TrendSK	0.107	0.031	3.50	0.001	0.047	0.168
TrendAB	-0.023	0.040	-0.57	0.568	-0.103	0.057
TrendBC	0.158	0.025	6.350	0.000	0.109	0.208
TrendAtl	-0.006	0.027	-0.210	0.833	-0.058	0.047
Constant	62.79	14.52	4.32	0.000	33.95	91.62
R^2 within	40.95%					

TABLE S5. Regression using prior month sales with first six months of data omitted.

	B	*SE*	*t*	*p*	95% Lo	95% Hi
Educated	0.607	0.242	2.51	0.014	0.126	1.089
Unemployed	0.740	0.342	2.16	0.033	0.059	1.421
RetailTrade	5.841	3.701	1.58	0.118	-1.516	13.198
AlcoholPrice	-0.162	0.068	-2.38	0.020	-0.297	-0.027
LawChange	-2.958	1.547	-1.91	0.059	-6.033	0.116
Cannabis *t*-1	**-0.898**	**0.370**	**-2.43**	**0.017**	**-1.633**	**-0.163**
TrendQC	0.009	0.027	0.35	0.727	-0.043	0.062
TrendON	0.030	0.036	0.84	0.402	-0.041	0.101
TrendMB	-0.065	0.035	-1.84	0.069	-0.135	0.005
TrendSK	0.109	0.030	3.66	0.000	0.050	0.168
TrendAB	-0.010	0.047	-0.21	0.832	-0.103	0.083
TrendBC	0.165	0.037	4.44	0.000	0.091	0.239
TrendAtl	0.010	0.034	0.30	0.768	-0.058	0.078
Constant	39.77	17.11	2.32	0.022	5.75	73.79
R^2 within	38.39%					

TABLE S7. Regression using prior month sales and three more control variables. None were significant.

	B	*SE*	*t*	*p*	95% Lo	95% Hi
Educated	0.476	0.207	2.29	0.024	0.064	0.887
Unemployed	1.001	0.393	2.55	0.013	0.220	1.782
RetailTrade	7.284	4.519	1.61	0.110	-1.690	16.259
AlcoholPrice	-0.166	0.056	-2.94	0.004	-0.277	-0.054
LawChange	-3.192	1.720	-1.86	0.067	-6.609	0.224
Cannabis *t*-1	**-1.088**	**0.422**	**-2.58**	**0.012**	**-1.926**	**-0.249**
TrendQC	0.074	0.045	1.65	0.102	-0.015	0.163
TrendON	0.081	0.053	1.52	0.133	-0.025	0.187
TrendMB	-0.010	0.052	-0.19	0.852	-0.112	0.093
TrendSK	0.186	0.088	2.11	0.037	0.011	0.361
TrendAB	0.027	0.071	0.38	0.707	-0.114	0.167
TrendBC	0.171	0.062	2.74	0.007	0.047	0.294
TrendAtl	0.060	0.059	1.02	0.311	-0.058	0.178
Male	-767.7	824.0	-0.93	0.354	-2404.3	868.9
Twenty	258.2	232.2	1.11	0.269	-202.9	719.3
Married	15.1	267.9	0.06	0.955	-517.1	547.2
Constant	371.21	437.30	0.85	0.398	-497.31	1239.74
R^2 within	39.66%					

TABLE S8. Regression for grocery sales. The prior month cannabis sales variable was not significant.

	B	*SE*	*t*	*p*	95% Lo	95% Hi
Educated	0.717	0.518	1.38	0.170	-0.312	1.746
Unemployed	-2.104	0.749	-2.81	0.006	-3.592	-0.616
RetailTrade	48.265	11.997	4.02	0.000	24.438	72.092
FoodPrice	-1.467	0.259	-5.66	0.000	-1.982	-0.952
LawChange	4.053	4.670	0.87	0.388	-5.223	13.329
Cannabis *t*-1	**-0.489**	**1.275**	**-0.38**	**0.702**	**-3.020**	**2.042**
TrendQC	0.122	0.064	1.91	0.059	-0.005	0.249
TrendON	-0.031	0.108	-0.29	0.772	-0.245	0.182
TrendMB	-0.286	0.083	-3.45	0.001	-0.451	-0.121
TrendSK	-0.239	0.086	-2.76	0.007	-0.411	-0.067
TrendAB	-0.141	0.121	-1.16	0.248	-0.381	0.100
TrendBC	-0.115	0.082	-1.40	0.165	-0.278	0.048
TrendAtl	-0.328	0.102	-3.22	0.002	-0.530	-0.125
Constant	357.41	44.59	8.02	0.000	268.85	445.96
R^2 within	68.75%					

FIGURE S1. Histogram of residuals from regression using prior month cannabis sales. Two outliers at -16.75 and -13.94 are not shown.

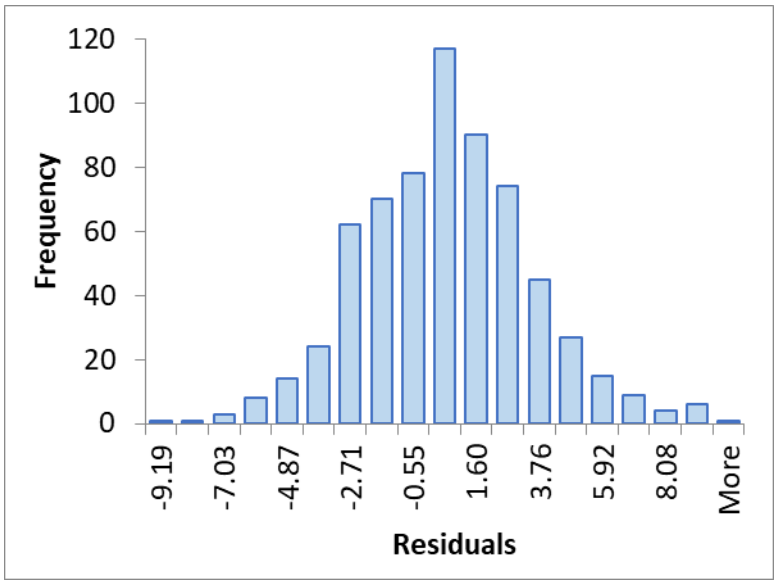

FIGURE S2. Plot of residuals versus month from regression using prior month cannabis sales. Two outliers at -16.75 (month 13) and -13.94 (month 14) are not shown.

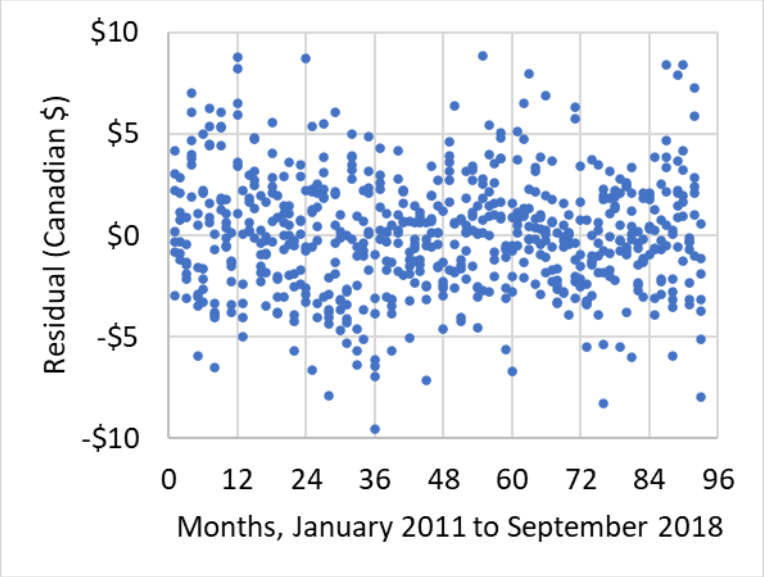

FIGURE S3. Provincial seasonally adjusted liquor store sales, January 2011 to September 2018.