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Tobacco Emissions of Canadian Cigarettes: A look back on 10 years

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Introduction

Tobacco use remains the leading preventable cause of premature death and disease in Canada, with an estimated 45,000 deaths attributable to smoking each year. Health Canada is committed to reducing the health care burden of smoking by implementing policies that aim to decrease the harms caused by the use of tobacco products[1].

To support their decision-making, Health Canada requires industry to submit information on the constituents and machine-smoked emissions of cigarettes sold in Canada, via the Tobacco Reporting Regulations[2]. To date, over 15 years worth of data has been collected on 40 analytes. Emissions are reported using two smoking regimens, the ISO 3308 and the Health Canada Intense, which represent lower and upper bounds of exposure, respectively (Table 1).

Table 1. Smoking parameters for ISO 3308 and HC Intense collection methods

Smoking Regimen	Puff Volume (mL)	Puff Frequency	Ventilation holes
ISO 3308	35	Once every 60s	No modifications
Modified (HC Intense)	55	Once every 30 s	All ventilation holes blocked with adhesive tape

Objective

This work characterized the levels of chemical emissions from Canadian cigarettes over the past decade and identified any trends.

Methods

The data comprised of measurements of 40 constituents in mainstream smoke emissions (ISO and HCI methods) for 386 "benchmark" brands of cigarettes sold in Canada in the period from 2005 to 2015. Data was provided by 5 companies and collected using smoking machines.

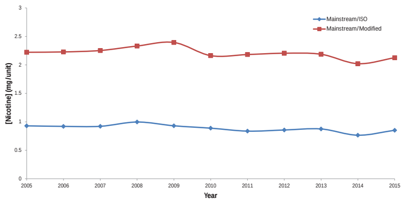
Duplicate records based on the combination of year, brand and smoking condition were removed. Extreme values were identified using visuals (boxplots) and quantitative measures (multiples of the interquartile range of the distribution of values within a year and by smoking method). Extreme values deemed the result of keying errors and/or implausible in comparison to the distribution for the brand in question were removed. Values that did not correspond to the original data extract (e.g. text value where numeric value should have existed) were corrected as needed.

Values below the limit of detection (LOD) or limit of quantification (LOQ) were imputed using LOD/√2 or LOQ/√2, respectively, provided the percentage of non-detects did not exceed 5%. Five of the 40 emissions (lead, NAB, NNK, NNN and resorcinol) had a percentage of non-detects exceeding 30% and were not imputed to avoid introducing patterns into the data and/or bias into subsequent analyses. The final data set comprised of 2,374 records across all smoke constituents.

Descriptive statistics were computed by method and/or year, and mean concentrations by method were plotted over time for each of the 40 emissions. Ordinary Least-Squares (OLS) linear regression models were used to examine the change in mean concentrations of smoke constituents over time (year) and by smoking method. For each smoking method, independent samples t-tests were run to compare the difference in mean concentration of mainstream smoke constituents between two classes of brand descriptors used until 2008 (light/mild and regular), and related colour coding. All analyses were conducted using the SAS Enterprise Guide (EG v. 5.1) statistical software.

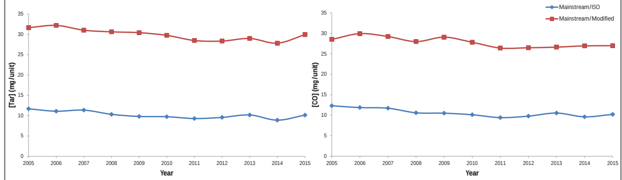
Results

Trends for nicotine, tar & CO, and two tobacco specific nitrosamines are shown in Figures 1-3 below.



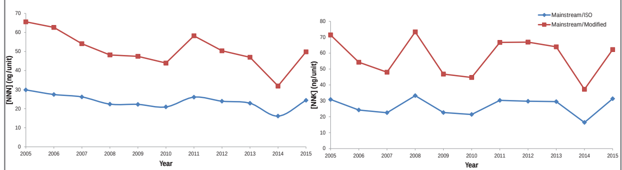
	n	Average (mg)	CV%
Modified	1141	2.23 ± 0.37	16
ISO	1157	0.91 ± 0.30	33

Figure 1. Mean nicotine emissions measured with ISO and HC Intense methods between 2005-2015. Overall significant difference in mean concentration over the years for both methods, showing a downward trend.



	Tar		CO	
	Average (mg)	CV%	Average (mg)	CV%
Modified	30.3 ± 4.7	15	28.1 ± 4.9	17
ISO	10.4 ± 4.6	44	10.9 ± 4.3	40

Figure 2. Mean tar (left) and carbon monoxide (right) emissions measured with ISO and HC Intense methods. Changes in mean concentration for both constituents are statistically significant and decreasing overall for the period between 2005 and 2015.



	NNN		NNK	
	Average (ng)	CV%	Average (ng)	CV%
Modified	52.2 ± 73.0	140	57.8 ± 38.2	66
ISO	24.5 ± 33.7	138	26.7 ± 17.5	66

Figure 3. Tobacco specific nitrosamines NNN (left) and NNK (right) were not found to follow a trend with respect to time. Spikes in emissions have been associated with human biomarker levels for those same time periods through the Canadian Health Measures Survey and may be attributed to changes in the tobacco curing processes[3].

The World Health Organization has identified certain tobacco smoke constituents of high concern due to their classifications as carcinogens and respiratory tract irritants[4]. A summary of the descriptive statistics for these, as well as tar and CO, is shown in Table 2.

Table 2. Constituents in tobacco smoke emissions (per cigarette), by smoking method, 2005-2015 combined (n=2,374)

	Mainstream smoke (ISO)			Mainstream smoke (HCI)		
Constituents	n	Mean (SD)	CV (%)[1]	n	Mean (SD)	CV (%)[1]
Tar (mg/cig)	1158	10.38 (3.85)	37.1	1141	30.32 (4.67)	15.4
Nicotine (mg/cig)*	1157	0.91 (0.30)	33.1	1141	2.23 (0.37)	16.4
CO (mg/cig)*	1158	10.89 (4.30)	39.5	1141	28.11 (4.90)	17.4
Ammonia (µg/cig)	1084	8.84 (3.70)	41.9	1081	25.15 (7.88)	31.3
NNN (ng/cig)	871	24.49 (33.75)	137.8	913	52.15 (73.04)	140.1
NNK (ng/cig)	663	26.68 (17.50)	65.6	687	57.84 (38.16)	66
Acrolein (µg/cig)	1084	50.55 (20.65)	40.8	1081	154.27 (24.41)	15.8
Acetylaldehyde (µg/cig)*	1084	439.78 (162.40)	36.9	1081	1211.24 (201.19)	16.6
Formaldehyde (µg/cig)*	1168	48.45 (28.17)	58.1	1165	159.10 (42.29)	26.6
Benzene (µg/cig)*	1168	34.84 (13.00)	37.3	1165	80.88 (16.22)	20
Benzo-A-pyrene (ng/cig)	1083	8.15 (2.81)	34.5	1081	18.44 (4.06)	22
1,3-Butadiene (µg/cig)*	1084	39.01 (39.31)	100.8	1081	92.48 (16.21)	17.5

[1] The coefficient of variation (CV) is equal to the ratio of the standard deviation to the mean often expressed as a percentage. The CV is used to quantify the dispersion or variability within a sample/population. The higher the CV values, the greater the variability of data points around the mean.
* Statistically significant differences in mean concentration with respect to time.

Mean concentrations for most emissions including nicotine, tar and CO were significantly higher for products not containing the descriptors 'light' or 'mild' in comparison to "Light/Mild" brands under both smoking conditions, with the exception of TSNAs, acrolein, formaldehyde, and resorcinol under the HCI method.

Limitations

- Some smoke constituents had a large % of non-detects (<LOD and/or <LOQ) in addition to true missing values.
- There were extreme values which could have affected trends. Most remained in the data if they were not deemed data entry errors and appeared typical for the brand in question.
- The data from 2014 comprised brands measured from one company only and has a limited number of data points.

Conclusions & Future Directions

The levels of more than two-thirds of chemical substances found in Canadian tobacco emissions have been mostly unchanged. These results will be further evaluated with time series analysis of the data and incorporation of a more robust method for imputation of missing data.

The emissions of most smoke constituents of cigarettes labelled with the brand descriptors 'light' or 'mild' were significantly lower than those without. The analysis will be expanded to compare products across individual brands.

The data will further be sales-weighted to elucidate if there is a relationship between the levels of certain emissions (e.g. nicotine) and market share.

References

1. Health Canada (2018) Canada's Tobacco Strategy. https://www.canada.ca/en/health-canada/services/publications/healthy-living/canada-tobacco-strategy.html
2. Canada Tobacco Reporting Regulations (2018). https://laws-lois.justice.gc.ca/PDF/SOR-2000-273.pdf
3. Czoli, C.D. & Hammond, D. (2018). Cancer Epidemiol Biomarkers Prev; 27(3): 262-267.
4. World Health Organization (2008). The Scientific Basis of Tobacco Product Regulation (WHO Technical Report).

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