Supplementary file to "Comparing the cancer potencies of emissions from vapourised nicotine products including e-cigarettes with those of tobacco smoke" by W.E.Stephens

SUPPORTING INFORMATION

Smoke toxicants conversion

The technical requirement is to convert smoke emissions data for carcinogens (typically μg/cigarette) into concentrations. If N is the number of puffs drawn in the smoking experiment and P is the volume of each puff then the volume V of smoke collected from the i^{th} cigarette over the smoking experiment is

$$V_i = N_i P \qquad \text{(S1)}.$$

However in terms of exposure this parameter overlooks the role of filter ventilation that allows air to enter the smoke after combustion but just prior to inhalation. This air has not passed through the combustion zone and is thus largely uncontaminated with smoke toxicants. An estimate of the volume of undiluted smoke can thus be made using

$$V^* = V(1 - D) \qquad \text{(S2)}$$

where D is the fraction of the total flow entering through vents in the filter.[1] Accounting for the different puff volumes (S) and ventilation conditions associated with machine smoking protocols

$$V^*_{k,i} = N_{k,i} S_k (1 - D_k) \qquad \text{(equation 1 in main text)}$$

where k is the selected machine smoking protocol applied to the i^{th} sample (cigarette). For the ISO protocol S=35 mL and D has a measured value in the range 0 to 1, for MDPH S=45 mL and D is assigned a value of half the measured filter ventilation, and for the HCI protocol S=55 mL and D=0. The units for V^* are mL/cigarette.

The usefulness of the V^* parameter is illustrated in figure 1 in which nicotine concentrations from the various smoking machine experiments are plotted against $V^*_{k,i}$ using one of the few published datasets

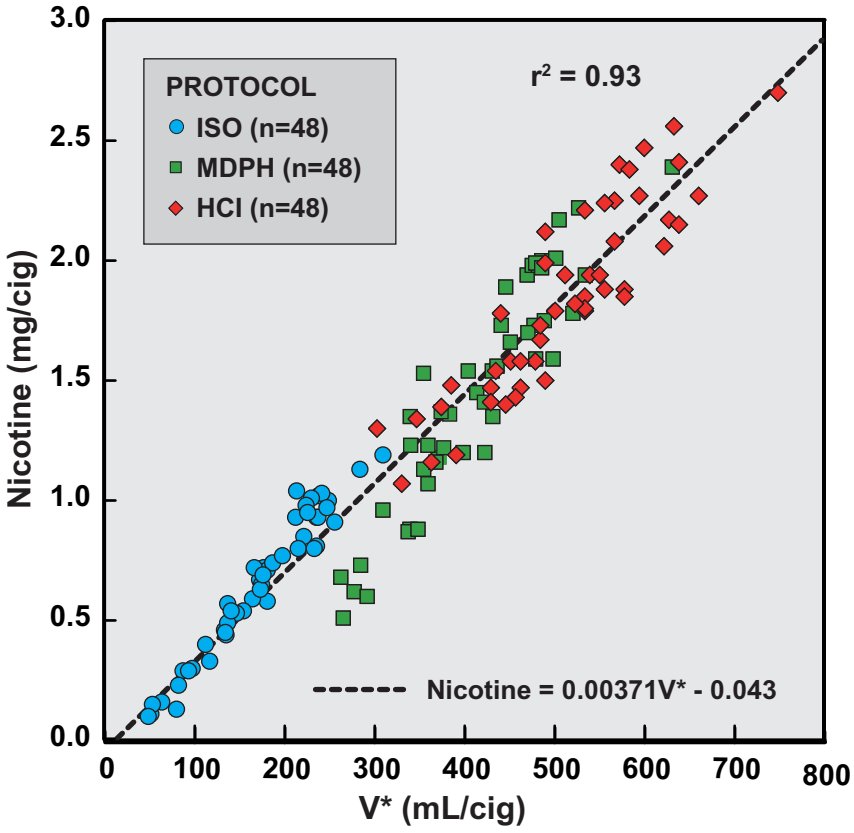
that includes the necessary variables to compute V^*.[2] Emissions were measured using the ISO, MDPH and HCI protocols and the graph shows that a very strong correlation exists between undiluted smoke volume V^* and nicotine concentration per cigarette (r^2=0.93, p<0.01) with the linear regression intercept close to the origin. The correlation of nicotine with the measured volume of diluted smoke V is much poorer (r^2 for the diluted volume V is 0.73, p<0.01) indicating that the volume of undiluted smoke is the major determinant of nicotine emissions. Other variables such as tobacco type, paper porosity, burn modifiers etc. are undoubtedly important but figure 1 demonstrates that these controls are subordinate.[1] Approximate co-linearity of all protocols for V^* over the major carcinogens under consideration provides a means of expressing smoke carcinogens as concentrations in a form independent of machine smoking protocol.

$$E_{k,i,j} = C^{tob}_{k,i,j} / V^*_{k,i} \qquad \text{(equation 2 in main text)}$$

where $C^{tob}_{k,i,j}$ (µg/cigarette) is the mass per cigarette of the j^{th} carcinogen in the i^{th} product that has been machine smoked using protocol k. $E_{k,i,j}$ is the carcinogen concentration in units of µg/mL in undiluted smoke. This transformation has the advantages of expressing tobacco smoke toxicants as concentrations in the product. Furthermore the denominator V* serves as a good proxy for nicotine (figure 1), the acquisition of which is the usual purpose of smoking. Emissions from the few publications concerning HnB products are treated in the same way as tobacco smoke.

With the exception of HnB toxicants in VNP vapours ($C^{vap}_{i,j}$) are usually reported in form of mass/volume concentrations with need only for conversion to µg/mL as appropriate. Adjustment for ventilation is not required for e-cigarettes as air appears exclusively to be introduced prior to the atomising stage with no subsequent dilution between the atomiser and the mouthpiece.

Figure S1. Correlation and regression for nicotine (mg/cigarette) with V* (volume of undiluted smoke per cigarette) in 48 US brands smoked under ISO, MDPH and HCI protocols. Note the significant linear correlation ($p<0.01$) and the small intercept of the linear regression line.



Abbreviations:

ISO International Organisation for Standardisation, MDPH Massachusetts Department of Public Health, HCI Health Canada Intense

Table S1. Sequence of steps involved in calculating the cancer potencies on a common basis for cigarette smoke, vapourised nicotine products (e-cigarette, heat-not-burn and nicotine inhaler) and ambient air. Equation and Table numbers refer to the main text.

Step		Cigarette	Heat not Burn	E-cigarette	Nicotine inhaler	Ambient air
1	**Reported carcinogen mass units. Convert to µg**	µg or ng	µg or ng	mg, µg or ng	µg or ng	µg
2	**Identify smoke or vapour measurement basis**	per cigarette	per tobacco stick	per puff, litre or m^3	per puff	per m^3
3	**Calculate smoke or vapour volume (if required)**	Equation 1	Equation 1	N_{puffs} x V_{puff} convert to mL	N_{puffs} x V_{puff} convert to mL	convert to mL
4	**Calculate concentrations as µg/mL**	C^{tob} (equation 2)	C^{tob} (equation 2)	C^{vap}	C^{vap}	C^{vap}
5	**Select unit risk value for carcinogens (U)**	Table 1	Table 1	Table 1	Table 1	Table 1
6	**Calculate cancer potency (P)**	Equations 2 & 3	Equations 2 & 3	Equation 4	Equation 4	Equation 4
7	**Normalise P**	Equation 5	Equation 5	Equation 5	Equation 5	Equation 5
8	**Calculate Lifetime Cancer Risk (L)**	Equation 6	Equation 6	Equation 7	Equation 7	Equation 7

REFERENCES

[1] Baker RR. Smoke Chemistry. In: Davis DL, Nielsen MT, eds. *Tobacco: Production, Chemistry and Technology*. Oxford: Blackwell Science 1999:398-439.

[2] Counts ME, Morton MJ, Laffoon SW*, et al.* Smoke composition and predicting relationships for international commercial cigarettes smoked with three machine-smoking conditions. *Regulatory Toxicology and Pharmacology* 2005;**41**:185-227.