TECHNICAL APPENDIX TO *CANCER RISK FACTORS IN ONTARIO: ALCOHOL*

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POPULATION ATTRIBUTABLE FRACTIONS (PAF) FOR ALCOHOL CONSUMPTION

- Population attributable fraction (PAF) for alcohol consumption was calculated as follows:

$$\mathrm{PAF} = \frac{\sum(\mathrm{p_x} \times \mathrm{ERR_x})}{1 + \sum(\mathrm{p_x} \times \mathrm{ERR_x})}$$

  where p_x is the proportion of the population in consumption category x and ERR_x is the excess relative risk ($RR_x - 1$) in consumption category x.

- The ERR of alcohol consumption for each category x was calculated as follows:

$$\mathrm{ERR_x} = \exp\left(\mathrm{R_g} \times \mathrm{G_x}\right) - 1$$

  where R_g is the increase in risk per gram of alcohol intake and G_x is the quantity of alcohol consumed (grams per day) in consumption category x.

- PAFs were calculated by sex and age using the age groups 19–29, 30–44, 45–64, and 65+.

Data source for prevalence of exposure to alcohol

The proportion of the population exposed to different levels of alcohol consumption was derived from the Canadian Community Health Survey (CCHS), cycle 1.1 (2000/01), the earliest year for which data on alcohol consumption could be easily extracted.

Derivation of alcohol consumption categories

- Each survey respondent was assigned to an alcohol consumption category based on their response to the following questions:
  1. Thinking back over the past week, did you have a drink of beer, wine, liquor or any other alcoholic beverage? If yes, how many drinks did you have on each day?
  2. During the past 12 months, how often did you drink alcoholic beverages?
  3. Have you ever had a drink? If yes, did you ever regularly drink more than 12 drinks a week? (Respondents were only asked this question if they reported not drinking during the past 12 months).
- Based on responses to the above questions, each respondent was assigned to an alcohol consumption category in one of three possible ways:
  - **Respondents who reported drinking during the past week** were divided into five categories based on their average daily number of drinks consumed (categories 1–5; Table 1). The average number of drinks

consumed per day during the past week was calculated by dividing the total number of drinks consumed during the past week by 7.

  - **Respondents who reported not drinking during the past week** were assigned to one of seven categories based on the frequency of drinking during the past 12 months (categories 6–12; Table 1).
  - **Respondents who reported not drinking alcohol during the past 12 months but had consumed at least one drink in their lifetime were** assigned to one of two categories based on how much they used to drink (categories 13–14; Table 1).

- The proportion of the population within each consumption category, based on the 2000/01 CCHS data, is shown by sex and age group in Table 1.

Calculation of exposure levels

For each consumption category, the quantity of alcohol consumed (measured in grams per day) was estimated and assigned by sex and age. This was done by assigning each category a specific number of drinks per day and then multiplying this number by 13.6 (the amount of alcohol, in grams, in one standard drink) to get a quantity of alcohol in grams per day. The number of drinks assigned to each consumption category was sex- and age-specific and determined as follows (for calculated exposure levels by sex and age group, see Table 2):

- Categories 1–5 were assigned the median number of drinks per day reported by respondents within each category.
- Categories 6–12 were assigned the median number of drinks per drinking occasion reported by respondents within each drinking category, which was then adjusted to reflect the frequency of drinking during the past 12 months. Because individuals in these categories did not report drinking during the past week, information about the number of drinks consumed was not available; the median number of drinks per drinking occasion assigned to each of these categories was based on respondents who reported the same drinking frequency during the past 12 months but who also reported drinking during the past week. Specifically:
  - The median number of drinks per drinking occasion was estimated based on the average number of drinks per drinking occasion reported by respondents who drank during the past week. For respondents who reported drinking in the past week, the average number of drinks per drinking occasion was calculated by dividing the total number of drinks they reported in the past week by the number of days that they had at least one drink. Respondents who drank during the past week were then categorized based on their self-reported frequency of drinking during the past 12 months (the same categories as 6–12) and, for each category of self-reported drinking frequency, the median of the average number of drinks per drinking occasion was calculated by sex and age.
  - Categories 6–12 (i.e., respondents who reported drinking during the past 12 months but not during the past week) were then assigned the median of the average number of drinks per drinking occasion for respondents of the same sex and age who reported the same drinking frequency during the past 12 months (i.e., the median number of drinks per drinking occasion calculated in the previous step). To obtain the number of drinks consumed per day, the median number of drinks per drinking occasion was then adjusted based on the frequency of drinking during the past 12 months as follows:
    - Category 6: median number of drinks per drinking occasion was arbitrarily divided by 60 to reflect drinking once every two months,
    - Category 7: median number of drinks per drinking occasion was divided by 30 to reflect drinking once a month,

    - Category 8: median number of drinks per drinking occasion: was multiplied by 2.5 and divided by 30 to reflect drinking between two and three times a month,
    - Category 9: median number of drinks per drinking occasion was divided by 7 to reflect drinking once a week,
    - Category 10: median number of drinks per drinking occasion was multiplied by 2.5 and divided by 7 to reflect drinking between two and three times a week,
    - Category 11: median number of drinks per drinking occasion was multiplied by 5 and divided by 7 to reflect drinking five times a week and
    - Category 12: median number of drinks per drinking occasion was multiplied by 1 to reflect drinking every day.
- Category 13 was assigned 13 drinks per week or 1.9 drinks per day. A more conservative estimate was applied to this category by assigning the minimum number of drinks that were regularly consumed by these drinkers previously in their lifetime.
- Category 14 was assigned the same quantity as category 6. A more conservative estimate was applied to this category by assigning the same quantity as was assigned to the category with the lowest consumption.

Table 1. Estimated proportion of the population (%) aged 19+ in alcohol consumption categories, by sex and age group, Ontario, 2000/01

Consumption Category		Males by age (years)				Females by age (years)			
		19–29	30–44	45–64	65+	19–29	30–44	45–64	65+
1	Drank during past week: average ≤1 drink/day	32.4	37.1	37.1	33.7	31.8	37.4	36.0	25.5
2	Drank during past week: average 1–2 drinks/day	12.9	11.4	12.6	9.7	6.3	5.8	4.6	3.4
3	Drank during past week: average 2–3 drinks/day	6.4	4.4	5.0	3.3	1.6	1.0	0.9	1.0
4	Drank during past week: average 3–4 drinks/day	3.2	1.7	2.0	1.0	0.5	0.3	0.1	0.0
5	Drank during past week: average ≥ 4 drinks/day	3.4	1.8	1.4	1.3	0.5	0.2	0.1	0.0
6	No drinking past week but drank during past year ≤1 time/month	9.0	11.8	10.5	11.9	18.3	19.9	18.9	19.4
7	No drinking past week but drank during past year 1 time/month	7.1	5.8	4.1	3.5	8.6	5.9	5.5	3.6
8	No drinking past week but drank during past year 2–3 times/month	6.4	5.3	4.4	3.9	8.8	4.7	4.9	3.4
9	No drinking past week but drank during past year 1 time/week	4.6	4.6	3.6	2.0	3.6	2.6	2.8	2.2
10	No drinking past week but drank during past year 2–3 times/week	1.9	1.8	1.9	1.8	1.5	1.1	1.1	1.3
11	No drinking past week but drank during past year 4–6 times/week	0.1	0.5	0.2	0.3	0.1	0.1	0.2	0.2
12	No drinking past week but drank during past year everyday	0.2	0.2	0.4	1.3	0.1	0.1	0.1	0.1
13	Has had ≥ 1 drink in lifetime: used to regularly drink >12 drinks/week	0.4	2.7	4.6	5.3	0.4	0.9	1.2	0.7
14	Has had ≥ 1 drink in lifetime: did not regularly drink >12 drinks/week	4.8	5.7	7.0	13.5	6.9	9.8	13.7	24.4
15	Lifetime abstainers*	7.2	5.2	5.2	7.4	11.0	10.1	9.7	14.8

*This category is not required for PAF calculations but has been provided here for information.

Table 2. Quantities of alcohol consumed (grams per day) calculated for alcohol consumption categories

Consumption Category		Males by age (years)				Females by age (years)			
		19–29	30–44	45–64	65+	19–29	30–44	45–64	65+
1	Drank during past week: average ≤1 drink/day	4.8	4.8	5.6	5.5	4.1	3.7	3.7	3.5
2	Drank during past week: average 1–2 drinks/day	18.2	18.4	19.8	22.2	17.6	18.3	19.1	25.4
3	Drank during past week: average 2–3 drinks/day	32.7	32.6	33.6	36.7	32.3	30.6	31.5	38.9
4	Drank during past week: average 3–4 drinks/day	48.6	47.2	47.6	47.8	48.1	49.0	44.3	44.7
5	Drank during past week: average ≥ 4 drinks/day	73.1	68.1	70.9	67.9	59.9	67.1	85.8	58.3
6	No drinking past week but drank during past year ≤1 time/month	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
7	No drinking past week but drank during past year 1 time/month	0.5	0.7	0.5	0.5	0.5	0.5	0.5	0.5
8	No drinking past week but drank during past year 2–3 times/month	1.8	2.1	1.6	1.1	2.2	1.2	1.1	1.1
9	No drinking past week but drank during past year 1 time/week	5.0	3.8	3.4	1.9	3.8	3.4	2.5	1.9
10	No drinking past week but drank during past year 2–3 times/week	19.2	9.6	9.0	6.1	12.0	8.3	6.4	5.3
11	No drinking past week but drank during past year 4–6 times/week	34.3	19.3	21.0	11.5	20.5	15.0	13.5	9.7
12	No drinking past week but drank during past year everyday	42.6	27.1	25.6	17.8	13.6	21.1	15.5	13.6
13	Has had ≥ 1 drink in lifetime: used to regularly drink >12 drinks/week	25.3	25.3	25.3	25.3	25.3	25.3	25.3	25.3
14	Has had ≥ 1 drink in lifetime: did not regularly drink >12 drinks/week	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Adjustment for survey undercoverage of alcohol consumption

- To evaluate the potential impact of using underestimates of alcohol exposure to calculate the alcohol-attributable fractions, the 2000/01 CCHS data on alcohol consumption were adjusted according to its coverage rate (the proportion of total alcohol sold captured by survey data). The coverage rate was calculated as follows:

$$Coverage\ rate\ = \frac{Per\ capita\ consumption\ captured\ by\ CCHS\ (g/day)}{Total\ (recorded\ and\ unrecorded)\ per\ capita\ consumption\ (g/day)} \times 100$$

- The per capita consumption of alcohol (measured in grams per day) captured by the 2000/01 CCHS was calculated by taking the average of the male and female per capita consumption. For both males and females, per capita daily consumption was calculated for all age groups combined by taking the weighted sum of the average quantity of alcohol consumed in grams per day (calculated as in Table 2 but for all age groups combined) for each of the 14 consumption categories. Based on this calculation, average per capita consumption as reported in the 2000/01 CCHS was calculated as 9.4 grams per day for males and 3.4 grams per day for females for an average per capita consumption of 6.4 grams per day for both sexes combined.
- Total per capita consumption was calculated as the sum of recorded consumption (per capita consumption aged 19+ in Ontario based on sales data, averaged for 2000 and 2001) and unrecorded consumption (calculated as 19.5% of total consumption based on an Ontario study[1]). Recorded per capita consumption based on sales data was 7.9 litres per year, or 17.2 grams per day; this was calculated by dividing total sales by the population of Ontario aged 19+.[2] After adjusting for unrecorded consumption, total per capita consumption was estimated to be 21.3 grams per day. The coverage rate of the 2000/01 CCHS was thus calculated to be 30% of total per capita consumption, which was used to adjust exposure level for each consumption category following methods used by Shield et al.[3] The quantity of alcohol consumed assigned to each consumption category was multiplied by 80% of the inverse of the coverage rate, upon the assumption that 20% of the estimated total volume was not consumed due to wastage and spillage and to account for undercoverage in the studies used to determine the risk estimates.

Estimates of the relative risk of cancer associated with alcohol consumption

- Risk estimates for each cancer type associated with alcohol consumption (increase in risk per gram of alcohol intake; Table 3) were obtained from Parkin's study of cancers attributable to alcohol consumption,[4] which, in turn, were derived from several meta-analyses and large epidemiologic studies.[5-10]

TABLE 3. Increase in risk of cancer associated with 1 gram of alcohol per day[4]

Cancer type	Increase in risk per gram of alcohol per day
Oral cavity and pharynx[5]	0.0185
Esophagus[5]	0.0129
Colorectal[6-9]	0.0080
Liver[5]	0.0059
Larynx[5]	0.0136
Breast[10]	0.0071

Calculation of number of cancers attributable to alcohol, Ontario, 2010

- Cancers diagnosed in 2010 were examined, allowing for a latent period of 10 years between the time of exposure to alcohol and the time of cancer diagnosis. Based on this 10-year latency, the age groups used for extracting cancer incidence data were 29–39, 40–54, 55–74 and 75+.
- For each cancer type, the number of cases attributable to alcohol was calculated by sex and age group by multiplying the total number of cases diagnosed in 2010 by the PAF for that sex and age group. The overall number of cases attributable to alcohol was then calculated for males and females by summing up the number of attributable cases in each age group.

Assumptions and limitations

- This method of calculating PAF for alcohol consumption adopts several assumptions that may result in somewhat conservative estimates:
  - For each respondent, past-week consumption is representative of their typical consumption.
  - Current consumption reflects past consumption. (Such an assumption is commonly made in PAF calculations, for which longer-term consumption information is usually unavailable.)
  - Survey respondents who reported consuming alcohol in the past 12 months, but did not report drinking during the past week, regularly drink the same amount of alcohol as those who did.
  - Former drinkers have the same magnitude of increased cancer risk as current drinkers.
  - A latent period of 10 years between exposure to alcohol and an increased risk of cancer is appropriate.
  - The increase in cancer risk per gram of alcohol intake is linear on a logarithmic scale.

Comparison of Ontario and United Kingdom estimates

Table 4 compares the estimated proportions of cancer cases that are attributable to alcohol consumption in Ontario with estimates for the United Kingdom (UK). The methods used to calculate the unadjusted estimates for Ontario are similar to those used by Parkin to calculate estimates for the UK.[4] Both sets of estimates are for cancer cases diagnosed in 2010 that are attributable to alcohol consumption in 2000–2001. For all cancer types, the proportion of cases attributable to alcohol consumption is substantially higher in the UK compared with Ontario, which reflects the higher levels of alcohol consumption in the UK.[4]

Table 4. Proportion (%) of cancer cases diagnosed in 2010 attributable to alcohol consumption in 2000–2001, Ontario (unadjusted, adjusted for survey undercoverage of alcohol consumption) and United Kingdom[4]

Cancer type	Males		Females	
	Ontario (unadjusted, adjusted)†	United Kingdom (Parkin, 2011)‡	Ontario (unadjusted, adjusted)†	United Kingdom (Parkin, 2011)‡
Oral cavity and pharynx	18.8, 55.8	37.3	6.6, 22.8	16.9
Esophagus	12.7, 37.1	25.3	4.2, 13.2	11.3
Colorectal	7.7, 21.8	15.5	2.5, 7.5	6.9
Liver	5.7, 15.8	11.4	1.9, 5.3	5.0
Larynx	13.5, 39.5	27.3	4.7, 15.0	12.2
Breast	---	---	2.4, 7.0	6.4
All cancers	**1.9, 5.6**	**4.6**	**1.1, 3.2**	**3.3**

†Cancer cases aged 29 and older at diagnosis

‡Cancer cases aged 25 and older at diagnosis

REFERENCES

1. Macdonald S, Wells S, Giesbrecht N. Unrecorded alcohol consumption in Ontario, Canada: estimation procedures and research implications. Drug Alcohol Rev. 1999;18(1):21–9.
2. Statistics Canada. Table 183-0019: Volume of sales of alcoholic beverages in litres of absolute alcohol and per capita 15 years and over, fiscal years ended March 31, annual (litres), CANSIM (database) [Internet]. Ottawa: Statistics Canada; 2013 [cited 2013 Oct 18]. Available from: http://www5.statcan.gc.ca/cansim/a05?lang=eng&id=1830019.
3. Shield KD, Kehoe T, Taylor B, Patra J, Rehm J. Alcohol-attributable burden of disease and injury in Canada, 2004. Int J Public Health. 2012;57(2):391–401.
4. Parkin DM. 3. Cancers attributable to consumption of alcohol in the UK in 2010. Br J Cancer. 2011 Dec 6;105 Suppl 2:S14–18.
5. Corrao G, Bagnardi V, Zambon A, La Vecchia C. A meta-analysis of alcohol consumption and the risk of 15 diseases. Prev Med. 2004;38(5):613–9.
6. World Cancer Research Fund/American Institute for Cancer Research. Food, nutrition, physical activity, and the prevention of cancer: a global perspective. Washington, DC: AICR; 2007.
7. Cho E, Smith-Warner SA, Ritz J, van den Brandt PA, Colditz GA, Folsom AR, et al. Alcohol intake and colorectal cancer: a pooled analysis of 8 cohort studies. Ann Intern Med. 2004;140(8):603–13.
8. Ferrari P, Jenab M, Norat T, Moskal A, Slimani N, Olsen A, et al. Lifetime and baseline alcohol intake and risk of colon and rectal cancers in the European prospective investigation into cancer and nutrition (EPIC). Int J Cancer. 2007;121(9):2065–72.
9. Moskal A, Norat T, Ferrari P, Riboli E. Alcohol intake and colorectal cancer risk: a dose-response meta-analysis of published cohort studies. Int J Cancer. 2007;120(3):664–71.
10. Hamajima N, Hirose K, Tajima K, Rohan T, Calle EE, Heath CW Jr, et al. Alcohol, tobacco and breast cancer--collaborative reanalysis of individual data from 53 epidemiological studies, including 58,515 women with breast cancer and 95,067 women without the disease. Br J Cancer. 2002;87(11):1234–45.