Assessment of the burden of diseases and injuries attributable to risk factors in Canada

from 1990 to 2016

Samiah Alam* MSc^{1,2}, Leah E Cahill* RD PhD^{1,3}, Justin J. Lang PhD⁴, Aaron M. Drucker MD ScM^{5,6}, Carolyn Gotay PhD⁷, Nicole Kozloff MD SM^{8,9}, Kedar Mate PhD¹⁰, Scott B. Patten MD PhD¹¹, Heather M. Orpana PhD^{4,12} and Ashkan Afshin MD ScD¹³ *Co-first Authors

¹Department of Medicine, Dalhousie University, Halifax, NS, Canada

²Department of Community Health and Epidemiology, Dalhousie University, Halifax, NS, Canada

³Department of Nutrition, Harvard T. H. Chan School of Public Health, Boston MS, USA ⁴Centre for Surveillance and Applied Research, Health Promotion and Chronic Disease

Prevention Branch, Public Health Agency of Canada, Ottawa, ON, Canada.

⁵Division of Dermatology, Department of Medicine, University of Toronto and Women's College Hospital and Women's College Research Institute, Toronto, ON, Canada.

⁶Department of Dermatology, Warren Alpert Medical School, Brown University, Providence, RI, USA

⁷Centre of Excellence in Cancer Prevention, Faculty of Medicine, School of Population and Public Health, The University of British Columbia, Vancouver, BC, Canada.

⁸Centre for Addiction and Mental Health, Toronto, ON, Canada

⁹Department of Psychiatry, University of Toronto, Toronto, ON, Canada

¹⁰School of Physical and Occupational Therapy, McGill University, Montreal, QC, Canada.

¹¹Departments of Community Health Sciences and Psychiatry, University of Calgary, Calgary, AB, Canada.

¹²School of Psychology, University of Ottawa, Ottawa, ON, Canada

¹³Institute for Health Metrics and Evaluation, Seattle, WA, USA

Corresponding author: Leah Cahill, Department of Medicine, Dalhousie University, 5790 University Ave, Halifax NS, Canada, B3H 1V7. Email: leah.cahill@dal.ca.

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Abstract word count: 250

1 2		
- 3 4	1	ABSTRACT
5 6	2	Background: An understanding of the risk factors contributing to significant health issues in
7 8 9	3	Canada is critical for informing national health policy.
10 11 12	4	Methods: We conducted a systematic analysis of the epidemiology describing disease states and
13 14	5	injuries in relation to risk factors in Canada as part of the Global Burden of Disease study.
15 16 17	6	Disease burden (metrics were disability-adjusted life years [DALYs, "healthy years of life lost"],
18 19	7	total deaths, and years lived with disability [YLDs]) attributable to each metabolic,
20 21	8	environmental, and behavioural risk factor was determined and ranked for the year 2016, with
22 23 24	9	further examination of changes over time from 1990 to 2016.
24 25 26	10	Results: In 2016, for all Canadians combined, the risk factors accounting for the largest
27 28		
29 30	11	percentage of DALYs were (1) tobacco, (2) diet, (3) high body-mass index (BMI), (4) high
31	12	fasting plasma glucose (FPG), (5) high systolic blood pressure, (6) alcohol and drug use, (7)
32 33 34	13	occupational risks, (8) high total cholesterol, (9) impaired kidney function, and (10) air pollution.
35 36	14	Rankings of the top risk factor rates remained similar from 1990 to 2016 despite some
37 38	15	substantial declines in the burden attributable to these risks, including a 47% decline in the age-
39 40	16	standardized DALY rate attributable to tobacco since 1990. Risk factors with increasing
41 42 43	17	contribution to DALY rates from 1990 to 2016 include high BMI, high FPG, and alcohol and
44 45	18	drug use.
46 47 48 49	19	Interpretation: Metabolic and behavioural risk factors, including modifiable factors such as
50 51	20	tobacco use and diet, remain the leading risk factors contributing to the burden of diseases and
52 53 54 55 56	21	injuries in Canada since 1990.
57 58		
59 60		For Peer Review Only Page 2

22 INTRODUCTION

In Canada, modifiable behavioural factors such as smoking, diet, and physical activity are major determinants of life expectancy.¹ indicating that actionable preventive strategies can lead to improved health outcomes. An understanding of Canada's foremost health problems, their risk factors, and how both are changing over time is crucial to inform national health policy and programs. However, disease burden has traditionally been defined in terms of mortality alone, which misses additional health burden, such as living with a disability. It is difficult for policymakers and researchers to set priorities when disparate diseases and injuries affect population health in diverse ways, and the measurement of their contributions to health burden is not standardized. Therefore, an analysis that examines health loss from both disability and death on the same scale in relation to attributable risk factors is warranted.

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) is a systematic, scientific effort to quantify the comparative magnitude of health loss due to disease, injuries, and risk factors throughout the world to inform evidence-based policymaking.² In the GBD, the goal is not just to measure which diseases or injuries cause death, but also to measure which diseases and injuries prevent someone from living a productive, active, and full life.³

Worldwide, life expectancy is increasing, and the burden of disease is shifting from infectious to chronic diseases; changes in the distribution of risk factors are one of the factors driving this shift, especially among high-income countries.⁴ GBD estimates have recently been summarized for some countries, including the US⁵ and the UK.⁶ However, the estimates for Canada have not yet been similarly presented. The objective of this paper is to identify the leading risk factors associated with the burden of diseases and injuries in Canada from 1990 to 2016.

METHODS

We examined GBD data for Canada from 1990 to 2016. The GBD study is led by the Institute for Health Metrics and Evaluation (IHME) at the University of Washington with the goal of systematically quantifying the global health loss due to diseases, injuries, and risk factors to inform evidence-based policymaking.⁷ The key principles, methodologies, and assumptions of the GBD study have been reported elsewhere;⁸⁻¹³ a brief overview of the strategy for comparative risk assessment is provided below.

For each disease, injury, and risk factor, GBD estimates the relative risk and risk factor exposure frequencies by collecting and analyzing a continuous stream of the most up-to-date data available from over 20,000 randomized controlled trials, cohorts, household surveys, census data, vital registration data, satellite data, and other resources.¹⁴ The GBD analytic team extracts data into centralized databases to model specific diseases, injuries, and risk factors. The Canadian data are pooled from over 600 sources of data, of which 133 were used for the risk factors assessment (listed in Supplementary Table 1). Details of the statistical models used to pool data, adjust for bias, and incorporate covariates have been published elsewhere.¹⁴ The GBD study is compliant with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER), a set of guidelines that promote best practices in reporting health estimates.¹⁵ Figures are generated using the GBD Compare data visualization tool, which is publicly available (http://vizhub.healthdata.org/gbd-compare).¹⁶ Burden estimates are accompanied by 95% uncertainty intervals that incorporate both sampling error and error from model estimation.

Measurement of burden

This paper measures and reports health loss through three well-established metrics previously described:^{9,11} (1) a summation of premature death and disability (disability-adjusted life years [DALYs]); (2) death (total deaths); and (3) disability (years of life lived with disability [YLDs]¹⁷⁻¹⁹). One DALY is equivalent to one year of healthy life (free of disease, injury, or disability) lost.⁹

Selection of risk factors

In the GBD study, a risk is an attribute, behaviour, exposure, or another factor causally associated with an increased probability of developing a disease or experiencing an injury. The GBD risk factors team evaluated 2,579 studies to establish causality for 481 risk-outcome pairs that met the World Cancer Research Fund evidence grading criteria for evidence¹⁵ that is biologically plausible and shows consistent associations between exposure and disease, with little or no evidence to the contrary. The primary sources of evidence were independent prospective studies, such as randomized controlled trials, non-randomized interventions, and cohort studies.¹⁵

We used a comparative risk assessment (CRA) conceptual framework that employs a causal web in which the risks that are responsible for the health outcomes are organized into four hierarchical, mutually exclusive and collectively exhaustive levels.^{20,14} Level 1 includes three categories of risk factors (behavioural, environmental and occupational, and metabolic) that distribute into 17 Level 2 risk factors as either single risks or risk clusters (**Supplementary Table 2**). While not included within the scope of this present paper, Levels 3 and 4 have 50 and 67 risk factors, respectively.

Attributable burden estimation

The calculation of attributable burden for a risk factor has four components: exposure levels for the risk, the relative risk of a health outcome related to the risk exposure, a counterfactual (in this case, optimal) level of risk factor exposure, and the burden metric (DALYs, number of deaths, or YLDs).¹⁴ For example, to estimate the burden of diabetes due to high body-mass index (BMI), the exposure level will be the mean, standard deviation, and shape of BMI distribution by age, sex, country, and year. The relative risk is the incidence and mortality due to diabetes per level increase in BMI. The counterfactual level of the risk factor exposure is the optimal BMI exposure level that minimizes risk for everyone in the population, called theoretical minimum risk exposure level (TMREL). These input data are used to estimate the population attributable fraction (PAF), which is the proportion of the disease burden that could have been prevented if the BMI was at the TMREL or optimal level. The PAF is then multiplied by the disease-specific burden metric to obtain attributable disease burden for each). . . risk-outcome pair.

Decomposition analysis

To explain the drivers of our observed trends in Canada's risk-attributable disease and injury burden, we conducted a decomposition analysis to examine the percentage change in Canada's risk-attributable DALYs over time due to (1) population growth; (2) population aging; (3) risk-deleted mortality rates (the expected mortality that would be observed if all risk factors included in GBD 2016 were removed); and (4) exposure to all risk factors included in GBD 2016. Methods were based on those of Das Gupta²¹ and adapted for GBD as described elsewhere.¹²

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2 3 4	113	
5 6	114	RESULTS
7 8	115	In Canada 39.6% (36.9–42.3) of DALYs, 56.0% (53.6–58.2) of deaths, and 24.2% (22.7–
9 10 11	116	25.8) of YLDs could be attributed to risk factors assessed in 2016.
12 13	117	
14 15	118	Top 10 risk factors for attributable DALYs
16 17	119	In 2016, the 10 leading risk factors in Canada contributing to DALYs (% of total DALYs
18 19 20	120	[95% UI]) were tobacco (10.6% [9.4–11.9]), dietary risks (9.4% [7.7–11.2]), high BMI (9.0%
21 22	121	[6.2–11.8]), high FPG (7.3% [5.8–9.2]), high systolic blood pressure (SBP, 7.1% [6.0–8.2]),
23 24	122	alcohol and drug use (6.9% [5.8–8.1]), occupational risks (4.8% [4.4–5.3]), high total cholesterol
25 26 27	123	(3.7% [2.9–4.6]), impaired kidney function (2.1% [1.9–2.3]), and air pollution (1.3% [1.0–1.7])
28 29	124	(Figure 1). Women and men were similar in the leading risk factors related to DALYs, except
30 31	125	for alcohol and drug use (ranked higher for men) and high SBP (ranked higher for women).
32 33 34	126	Stratification by age group also revealed differences in risk factor attribution (Supplementary
35 36	127	Figures 7 and 8).
37 38	128	
39 40	129	Top five risk factors for attributable deaths and YLDs
41 42 43	130	In terms of total deaths in Canada, the five leading attributable risk factors (% of total
44 45	131	deaths [95% UI]) were dietary risks (17.6% [14.7-20.5]), tobacco (17.5% [16.6-18.5]), high
46 47	132	SBP (14.7% [12.3–17.2]), high FPG (11.2% [7.9–15.3]), and high BMI (10.8% [6.9–15.0])
48 49 50	133	(Figure 2). Dietary and tobacco risk factors were the largest contributors to deaths in Canada,
50 51 52	134	responsible for 47,947 (95% UI: 39,935–56,181) and 47,737 (44,704–51,114) deaths,
53 54		
55 56		
57 58 59		Page 7
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respectively. High BMI was the top risk factor contributing to YLDs in Canada (7.3% [5.1–9.4]), followed by high FPG (5.5% [4.8–6.3]) and alcohol and drug use (5.4% [4.5–6.5]) (Figure 3). *Trends from 1990 to 2016 for DALYs, deaths, and YLDs*Since 1990, exposure to tobacco has continued to be the leading risk factor for DALYs even though a 26% decline in the attributable all-age DALY rate and a 47% decline in the age-

standardized DALY rate were observed over the last 26 years (Figure 4). High BMI and high FPG have both increased in ranking to become the third and fourth leading risk factors. Alcohol and drug use attributable all-age and age-standardized DALY rates have increased by 13% and 9% since 1990. The all-age attributable DALY rate for high SBP and high cholesterol have decreased by 34% and 44% since 1990, leading to improvements in their respective rankings. Among the leading risk factors contributing to total deaths, the only risk factor contributing to a substantial increase in the death rate from 1990 to 2016 was high BMI, which increased by 22% (Figure 5). Alcohol and drug use ranked ninth as an attributable risk for deaths, but its contribution to the all-age and age-standardized death rates has risen by 66% and 36%, respectively, since 1990. The risk factors contributing to YLDs have changed from 1990, with high BMI and high FPG becoming the top two risk factors, reflecting a 61% and 40% increase in the all-age attributable YLD rates associated with these risk factors (Figure 6).

5 153

154 Drivers of observed trends in risk-attributable DALYs

Our decomposition analysis separated out the relative contributions of risk factors from those of population growth, aging, and risk-deleted mortality rate, revealing that risk factor exposure related to communicable and non-communicable diseases is on the decrease in Canada,

while the percentage of injuries due to risk factor exposure is increasing (Figure 7). For all ages
together, exposure to risk factors is accountable for a decreasing percentage of health burden in
Canada. However, stratification by age group reveals that exposure to risk factors is accountable
for an increasing percentage of health burden in Canadians aged 5-9 and 20-39 years.

163 INTERPRETATION

Of the risk factors included in our GBD study data, the top two risk factors related to health burden in Canada are tobacco and diet. We observed that this ranking has remained relatively unchanged since 1990, despite simultaneously detecting a substantial decline in burden due to diet and especially tobacco in the last 26 years. Although still a leading risk factor, tobacco exposure as a burden for DALYs was much lower in Canadians younger than 49 years, which is consistent with historical patterns of tobacco use and the longer latency period of lung cancer and other tobacco-related diseases.^{22,23} Dietary risk has remained the second highest risk factor over the last two decades, contributing to large amounts of DALYs caused by ischemic heart disease, stroke, and diabetes in Canada,¹⁶ and relating to intermediary risk factors including high BMI and high FPG,¹² which are now the third and fourth most significant causes of health loss. High SBP and high total cholesterol have decreased, but they remain important risk factors, along with alcohol and drug use.

177 Comparison to previous studies

Few previous studies have undertaken the task of identifying the top attributable risk factors to disease burden in Canada, and those that did focused primarily on mortality as an outcome. For example, the results of the present study are comparable to recently published

findings from the Mortality Population Risk Tool (MPoRT), which reported that 50% of deaths in Canada could be attributed to the four behavioural risk factors they assessed (smoking, unhealthy alcohol consumption, physical inactivity, and poor diet).¹ Similar to results from our analysis, smoking was the leading unhealthy behaviour contributing to deaths for men, despite a continuing decrease in the prevalence of smoking in Canada.¹ Steensma *et al.* also demonstrated significant health loss in the Canadian population associated with high BMI.²⁴ A 2006 analysis reported that alcohol is a major contributor to mortality in Canada,²⁵ as we also observed in the present study, and as was reported in a previous (2005) GBD analysis of the premature mortality attributable to alcohol consumption in Canada.²⁶ Recent analyses of the American GBD study data⁵ and UK GBD study data⁶ also reported that the two leading risk factors contributing to health burden were tobacco and dietary factors.⁵

Limitations

A study of this size and scope has several limitations, many of which have been previously addressed in other GBD publications.^{2,17} The present analysis used Canadian data from numerous sources across the country; however, important sources of data may not have been included in the GBD study yet. Our aim is that this current analysis will be the first in an ongoing assessment of the burden of disease in Canada and that with each iteration, our analysis will benefit from newly identified or collected data sources. One major limitation to the interpretation of our study's findings is that we could not incorporate data on the social determinants of health (such as housing, income, ethnicity, and education) that strongly influence risk factors^{27,28} and differ vastly by community.^{29,30} Obtaining such adequately detailed data is a future goal of ours, given that social determinants of health have been shown to be crucially

important to population health.^{31,32,33} There may also be other risk factors that are important but not included in the GBD, including psychosocial factors such as social isolation and loneliness.^{34,35} Another limitation is that some diseases, such as depression and migraines, have high burden and prevalence, but little to no risk factor attributions in the present analysis. The present study did not assess why risk factors rose or fell in their rankings, which could represent a worsening scenario or an improvement in other areas.

Conclusion and future directions

The present GBD Canada study, with its multiple countrywide data sources and comprehensive analysis of both disability and premature death on the same scale in relation to risk factors, provides a unique assessment and ranking of the risk factors attributable to health loss in Canada. Modifiable metabolic and behavioural risk factors such as tobacco and diet have remained the leading risk factors in Canada for the last 26 years, identifying opportunities for reducing Canada's health burden. These findings stand despite some substantial declines in risk factor exposure, indicating that risk factors can influence the population for a substantial length of time, and that decreasing health burden for Canadians requires a long-term commitment to risk reduction. Future analyses are warranted that focus on specific risk factors, detailing their complexities. For example, our present analysis did not specify the precise dietary factors (such as lack of fruit, excess sweetened beverages) that contribute to health burden and could be a target for new policy. Another area of high burden where a future detailed analysis could lead to enhanced action for population health benefits is drug use, especially given the recent opioidrelated burden and incoming cannabis legalization. Canadian GBD data provide inimitable insight into the relative magnitude of many important risk factors' contribution to health loss and

1 2		
2 3 4	227	can guide decision-makers as they identify the priorities and opportunities for reducing
5 6	228	premature death and disability burden among Canadians.
7 8 9	229	
10 11	230	Acknowledgments
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14 15	232	Study (GBD), led by the Institute for Health Metrics and Evaluation. The GBD study was
16 17 18	233	partially funded by the Bill & Melinda Gates Foundation; the funders had no role in the study
19 20	234	design, data analysis, data interpretation, or writing of the report. Samiah Alam was the recipient
21 22	235	of an Experiential Learning fund through the Direct Skills Link program with the Department of
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25 26		Labour and Advanced Education, Government of Nova Scotia, Canada.
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5 6		(DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195
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FIGURE TITLES

Please note: Figures 1-3 share the same set-up and legend and work well as one 3-part figure to save considerable space and have a nice visual comparison (this figure would be entitled 'Burden of disease attributable to leading risk factors for all Canadians in 2016 expressed as a percentage of (A) disability-adjusted life years (DALYs), (B) total deaths, and (C) years lived with disability (YLDs)'. Similarly, figures 4-6 share the same set-up and legend and could nicely be made as 1 figure with parts A, B, and C to save space and have a visual comparison. We have these figures listed separately as 6 figures in this version so that you can match the corresponding supplementary figures which are stratified into men and women. However, we could have less figures and less supplementary figures, if you would prefer.

Figure 1. Burden of disease attributable to leading risk factors for all Canadians in 2016 expressed as a percentage of disability-adjusted life years (DALYs).

Figure 2. The burden of disease attributable to leading risk factors for Canadians in 2016 expressed as a percentage of total deaths.

Figure 3. The burden of disease attributable to leading risk factors for Canadians in 2016 expressed as a percentage of years lived with disability (YLDs).

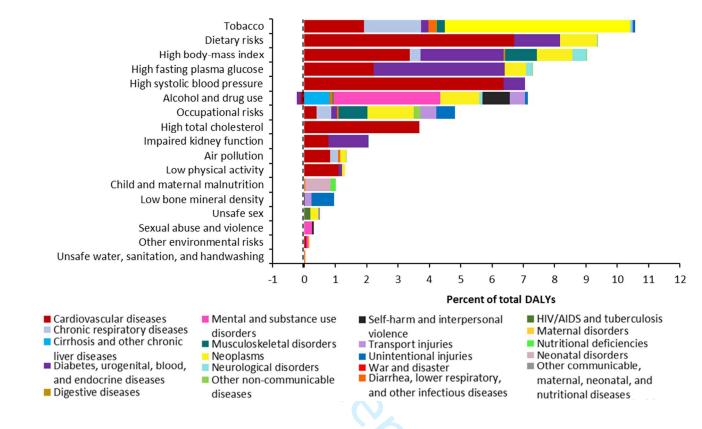
Figure 4. Rank changes in disability-adjusted life years (DALYs) attributable to leading risk factors and percent change in all-age and age-standardized DALY rates in Canada from 1990-2016.

Figure 5. Rank changes of total deaths attributable to leading risk factors and percent change in all-age and age-standardized death rates in Canada between 1990-2016 for females and males combined.

Figure 6. Rank changes of years lived with disability (YLDs) attributable to leading risk factors and percent change in all-age and age-standardized YLD rates in Canada between 1990-2016 for females and males combined.

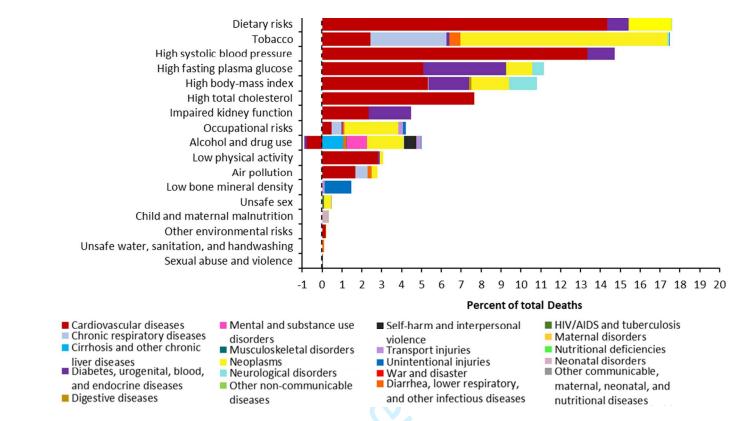
Figure 7. Drivers of percent changes in Canada's risk-attributable disease and injury burden from 2006 to 2016 due to population growth, population aging, risk-deleted mortality, and exposure to risk factors expressed as (A) disability-adjusted life years (DALYs) for all ages, (B) deaths for all ages and (C) DALYs by age group.

Figure 1. Burden of disease attributable to leading risk factors for all Canadians in 2016 expressed as a percentage of disability-adjusted life years (DALYs)



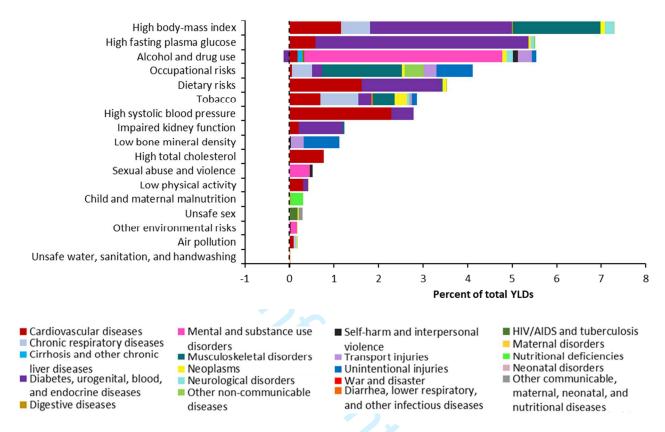
One DALY is equivalent to one year of healthy life (free of disease, injury, or disability) that has been lost.

Figure 2. The burden of disease attributable to leading risk factors for Canadians in 2016 expressed as a percentage of total deaths



The negative percentage for alcohol is the protective effect of mild alcohol use on risk of cardiometabolic disease.

Figure 3. The burden of disease attributable to leading risk factors for Canadians in 2016 expressed as a percentage of years lived with disability (YLDs)



The negative percentage for alcohol is the protective effect of mild alcohol use on risk of cardiometabolic disease.

Figure 4. Rank changes in disability-adjusted life years (DALYs) attributable to leading risk factors and percent change in all-age and age-standardized DALY rates in Canada from 1990 to 2016

			% change all-age a DALY rate	% change nge-standardise DALY rate
Risk factors by attributable DALYs 1990		Risk factors by attributable DALYs 2016	(1990-2016)	(1990-2016)
1. Tobacco		1. Tobacco	-25.7%	-47.4%
2. Dietary risks	<u> </u>	2. Dietary risks	-33.3%	-53.2%
3. High systolic blood pressure		3. High body-mass index	19.7%	-12.2%
4. High body-mass index	K'y	4. High fasting plasma glucose	1.67%	-27.9%
5. High fasting plasma glucose	· `	5. High systolic blood pressure	-34.4%	-55.3%
6. High total cholesterol		6. Alcohol and drug use	13.3%	8.53%
7. Alcohol and drug use	1×	7. Occupational risks	-4.0%	-20.2%
8. Occupational risks		8. High total cholesterol	-44.5%	-62.1%
9. Impaired kidney function		9. Impaired kidney function	-0.09%	-31.3%
10. Air pollution		10. Air pollution	-31.8%	-52.3%
11. Low physical activity		11. Low physical activity	-27.9%	-51.7%
12. Child and maternal malnutrition		12. Child and maternal malnutrition	-38.2%	-20.2%
13. Unsafe sex		13. Low bone mineral density	44.8%	-5.92%
14. Low bone mineral density		14. Unsafe sex	-50.1%	-54.9%
15. Sexual abuse and violence		15. Sexual abuse and violence	-0.75%	1.59%
16. Other environmental risks		16. Other environmental risks	-24.5%	-39.9%
17. Unsafe water, sanitation, and handwashing		17. Unsafe water, sanitation, and handwashing	75.6%	33.9%

Behavioural risks

Metabolic risks

Environmental/occupational risks

One DALY is equivalent to one year of healthy life (free of disease, injury, or disability) that has been lost.

% change

% change

Figure 5. Rank changes of total deaths attributable to leading risk factors and percent change in all-age and age-standardized death rates in Canada between 1990 and 2016 for females and males combined

			% change	% change
			-	ge-standardis death rate
Risk factors by attributable deaths 1990)	Risk factors by attributable deaths 2016	death rate (1990-2016)	(1990-2016)
1. Dietary risks		1. Dietary risks	-29.4%	-56.4%
2. Tobacco		2. Tobacco	-14.3%	-43.3%
3. High systolic blood pressure		3. High systolic blood pressure	-27.3%	-56.2%
4. High total cholesterol	~	4. High fasting plasma glucose	0.19%	-37.4%
5. High fasting plasma glucose	· ·	5. High body-mass index	22.3%	-21.8%
6. High body-mass index	~.	6. High total cholesterol	-36.1%	-61.8%
7. Occupational risks		7. Impaired kidney function	8.89%	-37.7%
8. Impaired kidney function		8. Occupational risks	-1.07%	-28.4%
9. Low physical activity	- /	9. Alcohol and drug use	66.4%	36.4%
10. Air pollution	1-	10. Low physical activity	-19.2%	-52.6%
11. Alcohol and drug use		11. Air pollution	-21.2%	-50.3%
12. Unsafe sex	~	12. Low bone mineral density	88.1%	0.76%
13. Low bone mineral density		13. Unsafe sex	-43.7%	-56.8%
14. Child and maternal malnutrition		14. Child and maternal malnutrition	-41.7%	-23.2%
15. Other environmental risks		15. Other environmental risks	-32.5%	-58.8%
16. Sexual abuse and violence		16. Unsafe water, sanitation, and	255%	103%
17. Unsafe water, sanitation, and	X	handwashing	14.50/	24.2%
handwashing		17. Sexual abuse and violence	-14.5%	-21.2%

Behavioural risks

Metabolic risks

Environmental/occupational risks

Figure 6. Rank changes of years lived with disability (YLDs) attributable to leading risk factors and percentage change in all-age and age-standardized YLD rates in Canada between 1990 and 2016 for females and males combined

% change

% change

			% change	% change
			•	ge-standardis
			YLD rate	YLD rate
Risk factors by attributable YLDs 1990		Risk factors by attributable YLDs 2016	(1990-2016)	(1990-2016)
1. Alcohol and drug use	./	1. High body-mass index	61.0%	24.3%
2. High body-mass index		2. High fasting plasma glucose	40.2%	2.92%
3. High fasting plasma glucose	``	3. Alcohol and drug use	11.2%	16.0%
4. Occupational risks		4. Occupational risks	16.3%	3.97%
5. Tobacco		5. Dietary risks	14.7%	-15.4%
6. Dietary risks	~	6. Tobacco	-17.8%	-37.4%
7. High systolic blood pressure		7. High systolic blood pressure	6.81%	-26.0%
8. Impaired kidney function		8. Impaired kidney function	39.3%	1.90%
9. High total cholesterol	~/	9. Low bone mineral density	45.2%	-1.93%
10. Low bone mineral density	~	10. High total cholesterol	-1.01%	-31.1%
11. Sexual abuse and violence		11. Sexual abuse and violence	6.07%	8.73%
12. Low physical activity		12. Low physical activity	29.0%	-11.3%
13. Child and maternal malnutrition		13. Unsafe sex	31.2%	24.6%
14. Unsafe sex	~	14. Child and maternal malnutrition	-6.61%	10.2%
15. Air pollution	~	15. Other environmental risks	62.9%	49.0%
16. Other environmental risks	~	16. Air pollution	30.7%	-6.73%
17. Unsafe water, sanitation, and handwashing		17. Unsafe water, sanitation, and handwashing	-19.7%	-15.2%

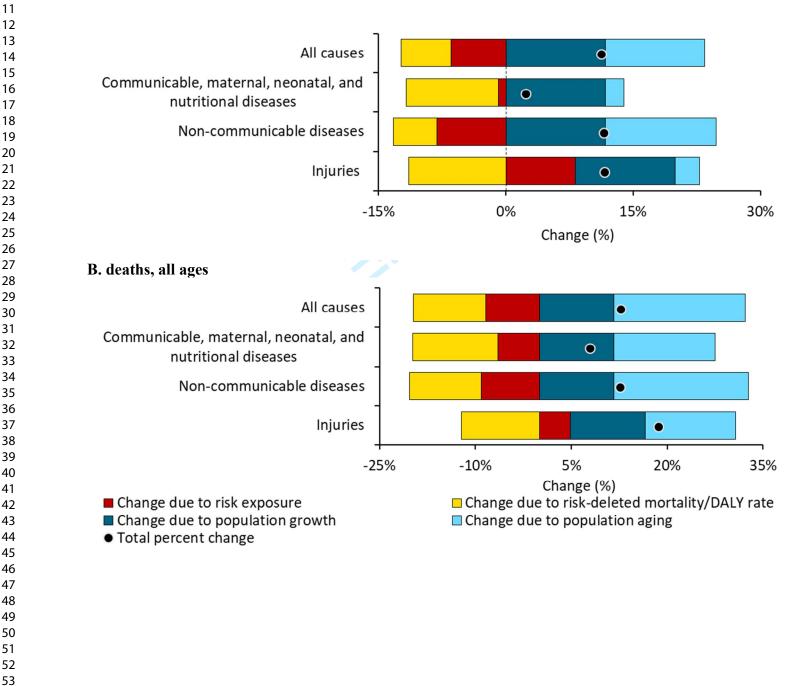
Behavioural risks

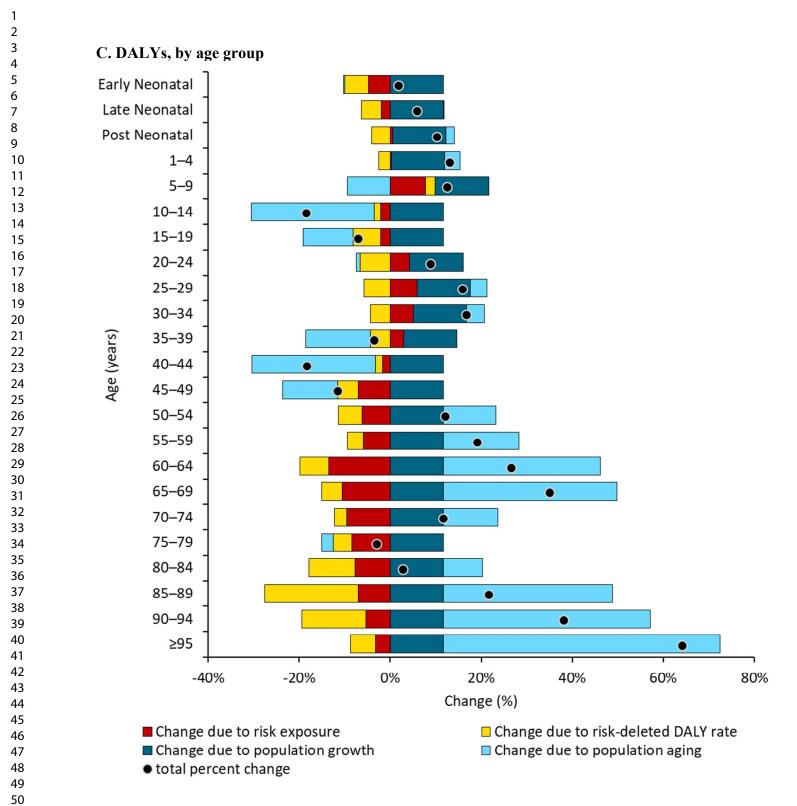
Metabolic risks

Environmental/occupational risks

Figure 7. Drivers of percentage changes in Canada's risk-attributable disease and injury burden from 2006 to 2016 due to population growth, population aging, risk-deleted mortality, and exposure to risk factors expressed as (A) disability-adjusted life years (DALYs) for all ages, (B) deaths for all ages, and (C) DALYs by age group

A. DALYs, all ages





One DALY is equivalent to one year of healthy life (free of disease, injury, or disability) that has been lost.

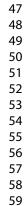
Supplementary Table 1. Canadian dataset records used in the Global Burden of Disease Study 2016, organized by type of data

Data type	Number of records	Examples of type of record
Administrative records	25	Canada Discharge Abstract Database 1994 to 2010
		Canada National ambulatory care reporting system 2002–2010
		The Canadian Neonatal Network Annual Report 2014
Census	7	Canada Population Estimates 2012, 2014
		Canada population and housing census 2011
		Canada Census 1991, 2001
Disease registry	163	Canada-BC/Alberta Congenital Anomalies Surveillance System Data
		Canadian Organ Replacement Register Annual Statistics 2001–2017
		Provincial cancer registry since 1991
Epi surveillance	49	WHO Global Health Observatory Interactive Graph – Number of Cases of Cutaneous
-		Leishmaniasis Reported 1998 to 2015
		WHO Global Health Observatory Interactive Graph – Number of Cases of Visceral
		Leishmaniasis Reported 1998 to 2015
		Zika cases – 2016
		HIV in Canada: Surveillance Summary Tables, 2014–2015
		Number of Reported Cases of Dengue and Severe Dengue (SD) in the Americas, by
		Country 2006 to 2014
		Canada Reported Cases of Syphilis by Age and Sex
		Canada Reported Cases of Gonorrhea by Age and Sex
		Canada Reported Cases of Chlamydia by Age and Sex
Financial record	16	Canada Rotary Committee for International Development Financial Statement 2006 to
		2008
		World University Service Canada Annual Report 2005 to 2007
		Center for International Studies and Cooperation Annual Report 2000 to 2007
Natural phenomena	3	SPARTAN Global Particulate Matter Network Chemical Speciation Data
-		Canada National Air Pollution Surveillance Network PM _{2.5} Data 2013
		Canada Air Quality Annual PM _{2.5} and PM ₁₀ Data 1990, 1995, 2000, 2005, 2010, 2012
Other publications	2	Operation Iraqi Freedom – Iraq Coalition Casualties: Fatalities By Year

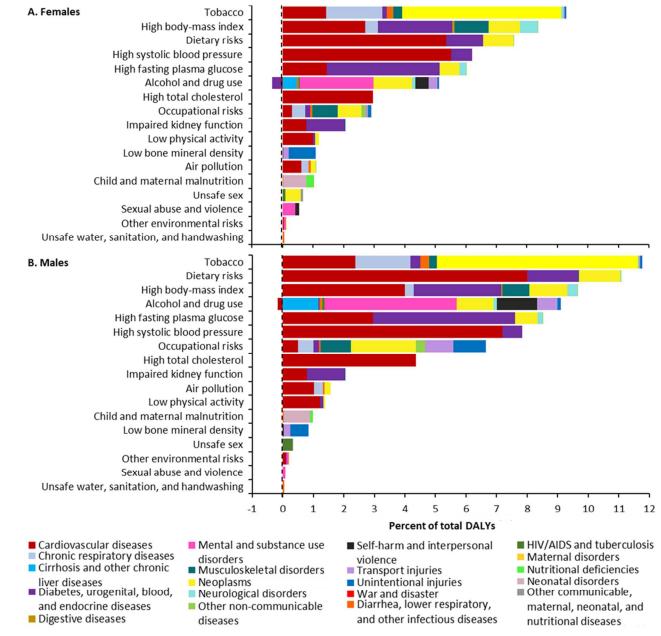
		Operation Enduring Freedom – Coalition Deaths by Year
Report	28	Canada UNGASS Country Progress Report 2012
		Social Determinants of Health and Well-being Among Young People: Health Behaviour i
		School-aged Children (HBSC) Study: International Report from the 2001–2, 2005–6,
		2009–10 Survey
		Canadian Neonatal Network Annual Report 2005, 2009
		Canada Evaluation of Progress in Drug Control 2005–2006
		Canada Community Health Survey Findings – Adult Obesity in Canada: Measured Heigh
		and Weight 2004
		Canada: Alcohol and Partner Physical Aggression in the 10 Provinces
		Violence Against Women: An International Perspective
		Canada – Trends in Breastfeeding Practices in Canada (2001 to 2009–2010)
		Canadian National Report on Immunization 2006
		Canada – Homicide in Canada, 2001 to 2010
		World Taxation and Price Guide 1994
		OECD Regions at a Glance 2011
		Canada – Family Violence in Canada: A Statistical Profile 2007
Scientific literature	403	A 2015 global update on folic acid-preventable spina bifida and anencephaly
		Income adequacy and education associated with the prevalence of obesity in rural
		Saskatchewan, Canada
		A preliminary investigation into diet adequacy in senior residents of Newfoundland and
		Labrador, Canada: a cross-sectional study
		Prevalence of Hearing Loss Among a Representative Sample of Canadian Children and
		Adolescents, 3 to 19 Years of Age
Surveys	117	Canada Tobacco Use Monitoring Survey 2012
·		Canada Health Measures Survey 2012–2013
		Canada Community Health Survey – Mental Health 2012 Major Depressive Disorder and
		Bipolar Disorder Tabulations
		Canada Childhood National Immunization Coverage Survey 2011
		Canada Alcohol and Drug Use Monitoring Survey 2011
		Canada Progress in International Reading Literacy Study 2010–2011
		Canada Program for International Student Assessment 2015
Vital registrations	45	Canada Vital Registration – Deaths 1990 to 2012

		Canada Vital Registration Late Fetal Death Data 1997 to 2011 Canada CANSIM Database – Live Births, by Weeks of Gestati Provinces and Territories, Annual Canada Vital Registration Birth Data 1990	on and Sex, Canada,
TOTAL	868		
			Page 3
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Level 0	Level 1	Level 2
All risk	Behavioural risks	Alcohol and drug use
factors		Dietary risks
		Low physical activity
		Malnutrition
		Sexual abuse and violence
		Тоbacco
	C	Unsafe sex
	Environmental/occupational risks	Air pollution
		Occupational risks
	0	Other environmental risks
		Unsafe water, sanitation, and
		handwashing
	Metabolic risks	High body-mass index (BM
		High fasting plasma glucos
		(FPG)
		High systolic blood pressu
		(SBP)
		High total cholesterol
		Impaired kidney function
		Low bone mineral density

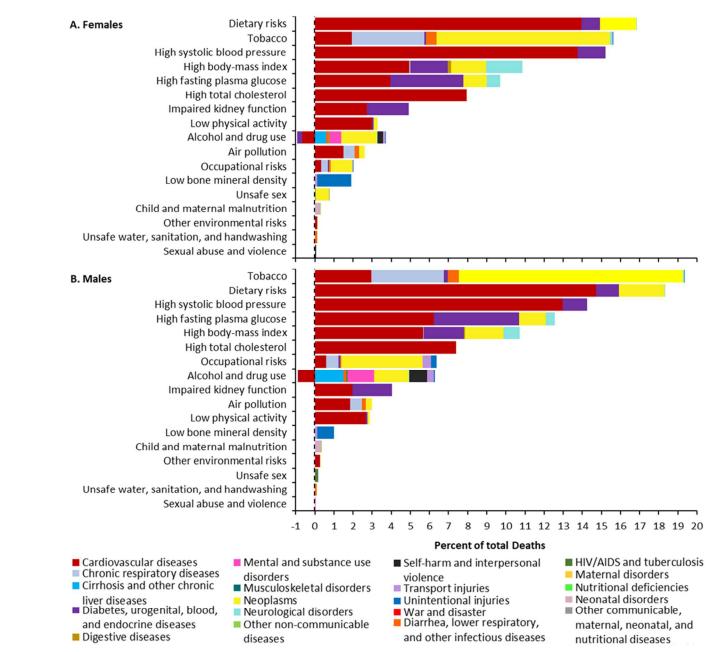


Supplementary Figure 1. Burden of disease attributable to leading risk factors for Canadians in 2016, expressed as a percentage of total disability-adjusted life years (DALYs) for (A) females (B) males.



One DALY is equivalent to one year of healthy life (free of disease, injury, or disability) that has been lost. The negative percentage for alcohol is the protective effect of mild alcohol use on risk of cardiometabolic disease.

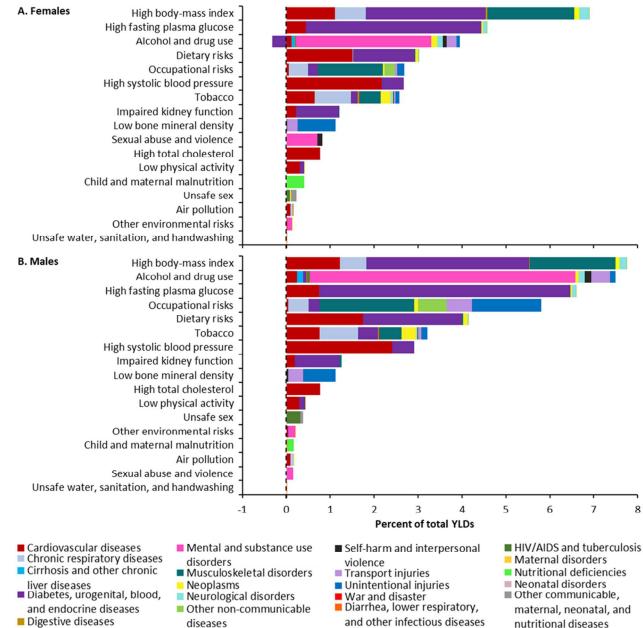
Supplementary Figure 2. The burden of disease attributable to leading risk factors for Canadians in 2016, expressed as a percentage of total deaths for (A) females (B) males



The negative percentage for alcohol is the protective effect of mild alcohol use on risk of cardiometabolic disease.

59	
60	

Supplementary Figure 3. The burden of disease attributable to leading risk factors for Canadians in 2016, expressed as a percentage of years lived with disability (YLDs) for (A) females (B) males



The negative percentage for alcohol is the protective effect of mild alcohol use on risk of cardiometabolic disease.

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Supplementary Figure 4. Rank changes in disability-adjusted life years (DALYs) attributable to leading risk factors and percent change in all-age and age-standardized DALY rates in Canada between 1990 and 2016, for (A) women and (B) men

				DALY ra
Risk factors by attributable DALYs 1990		Risk factors by attributable DALYs	(1990-2016)	
1. Dietary risks		1. Tobacco	-7.89%	-32.9%
2. Tobacco	r'y	2. High body-mass index	19.4%	-10.4%
3. High systolic blood pressure	\mathcal{A}	3. Dietary risks	-33.3%	-51.9%
4. High body-mass index		4. High systolic blood pressure	-30.9%	-52.4%
5. High fasting plasma glucose		5. High fasting plasma glucose	-3.46%	-28.7%
6. High total cholesterol	·./	6. Alcohol and drug use	21.7%	14.4%
7. Alcohol and drug use		7. High total cholesterol	-41.0%	-59.8%
8. Occupational risks		8. Occupational risks	27.3%	5.77%
9. Impaired kidney function		9. Impaired kidney function	1.64%	-28.19
10. Low physical activity		10. Low physical activity	-25.0%	-48.79
11. Child and maternal malnutrition	ŀ,	11. Low bone mineral density	50.6%	-0.43%
12. Air pollution		12. Air pollution	-23.2%	-44.8%
13. Unsafe sex	ŀ/`	13. Child and maternal malnutrition	-32.1%	-13.79
14. Low bone mineral density	· ``	14. Unsafe sex	-8.03%	-19.5%
15. Sexual abuse and violence]	15. Sexual abuse and violence	-4.92%	-2.319
16. Other environmental risks		16. Other environmental risks	2.00%	-13.29
		10. Other environmental fisks	2.00%	-13.27
17. Unsafe water, sanitation, and handwashing B. Males]	17. Unsafe water, sanitation, and handwashing	82.4% % change	34.79 % chang e-standar DALY ra
handwashing		17. Unsafe water, sanitation, and	82.4% % change all-age ag	34.79 % chang e-standar DALY ra
handwashing B. Males))	17. Unsafe water, sanitation, and handwashing	82.4% % change all-age ag DALY rate	34.79 % chang e-standa DALY ra (1990-20
handwashing B. Males Risk factors by attributable DALYs 1990)]	17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs	82.4% % change all-age ag DALY rate (1990-2016)	34.79 % chang e-standar DALY ra (1990-20 -56.09
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco	82.4% % change all-age ag DALY rate (1990-2016) -35.1%	34.79 % chang e-standar DALY ra (1990-20 -56.09 -54.99
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3%	34.79 % change-standar DALY ra (1990-20 -56.09 -54.99 -14.49
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0%	34.7% % chanțe e-standai DALY ra (1990-20 -56.0% -54.9% -14.4% 6.04%
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45%	34.7% % chanţ e-standal DALY ra (1990-20 -56.0% -54.9% -14.4% 6.04% -29.3%
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43%	34.79 % chang e-standar DALY ra
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8%	34.7% % chanţ e-standai DALY ra (1990-20 -56.0% -54.9% -14.4% 6.04% -29.3% -58.0%
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose 7. High body-mass index		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure 7. Occupational risks	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8% -12.9%	34.79 % chanţ e-standaı DALY ra (1990-20 -56.09 -54.99 -14.49 -29.39 -14.49 -29.39 -58.09 -58.09 -58.09 -63.89
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose 7. High body-mass index 8. Occupational risks		17. Unsafe water, sanitation, and handwashing 18. Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure 7. Occupational risks 8. High total cholesterol	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8% -12.9% -46.5%	34.79 % chanţ e-standau DALY ra (1990-20 -56.09 -54.99 -14.49 6.04% -29.39 -58.09 -29.09 -63.89 -35.29
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose 7. High body-mass index 8. Occupational risks 9. Air pollution		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure 7. Occupational risks 8. High total cholesterol 9. Impaired kidney function	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8% -12.9% -46.5% -1.66%	34.79 % chanţ e-standai DALY ra (1990-20 -56.09 -54.99 -14.49 6.04% -29.39 -14.49 6.04% -29.39 -58.09 -58.09 -58.09 -55.29 -57.19
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose 7. High body-mass index 8. Occupational risks 9. Air pollution 10. Impaired kidney function		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure 7. Occupational risks 8. High total cholesterol 9. Impaired kidney function 10. Air pollution	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8% -12.9% -46.5% -1.66% -36.5%	34.79 % chang e-standar DALY ra (1990-20 -56.09 -54.99 -14.49 -29.39 -14.49 -29.39 -58.09 -63.89 -35.29 -57.19 -54.69
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose 7. High body-mass index 8. Occupational risks 9. Air pollution 10. Impaired kidney function 11. Low physical activity		17. Unsafe water, sanitation, and handwashing 18. Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure 7. Occupational risks 8. High total cholesterol 9. Impaired kidney function 10. Air pollution 11. Low physical activity	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8% -12.9% -46.5% -166% -36.5% -30.1%	34.79 % chanţ e-standai DALY ra (1990-20 -56.09 -54.99 -14.49 6.04% -29.39 -58.09 -29.09 -63.89 -35.29 -57.19 -54.69 -25.59
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose 7. High body-mass index 8. Occupational risks 9. Air pollution 10. Impaired kidney function 11. Low physical activity 12. Child and maternal malnutrition		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure 7. Occupational risks 8. High total cholesterol 9. Impaired kidney function 10. Air pollution 11. Low physical activity 12. Child and maternal malnutrition	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8% -12.9% -46.5% -1.66% -36.5% -30.1% -43.2%	34.79 % chanţ e-standai DALY ra (1990-20 -56.09 -54.99 -14.49 6.04% -29.39 -14.49 6.04% -29.39 -58.09 -29.09 -63.89 -35.29 -57.19 -54.69 -25.59 -25.59 -11.09
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose 7. High body-mass index 8. Occupational risks 9. Air pollution 10. Impaired kidney function 11. Low physical activity 12. Child and maternal malnutrition 13. Unsafe sex		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure 7. Occupational risks 8. High total cholesterol 9. Impaired kidney function 10. Air pollution 11. Low physical activity 12. Child and maternal malnutrition 13. Low bone mineral density	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8% -12.9% -46.5% -36.5% -30.1% -43.2% 38.3%	34.79 % chanţ e-standai DALY ra (1990-20 -56.09 -54.99 -14.49 6.04% -29.39 -58.09 -58.09 -29.09
handwashing B. Males Risk factors by attributable DALYs 1990 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. Alcohol and drug use 5. High total cholesterol 6. High fasting plasma glucose 7. High body-mass index 8. Occupational risks 9. Air pollution 10. Impaired kidney function 11. Low physical activity 12. Child and maternal malnutrition 13. Unsafe sex 14. Low bone mineral density		17. Unsafe water, sanitation, and handwashing Risk factors by attributable DALYs 1. Tobacco 2. Dietary 3. High body-mass index 4. Alcohol and drug use 5. High fasting plasma glucose 6. High systolic blood pressure 7. Occupational risks 8. High total cholesterol 9. Impaired kidney function 10. Air pollution 11. Low physical activity 12. Child and maternal malnutrition 13. Low bone mineral density 14. Unsafe sex	82.4% % change all-age ag DALY rate (1990-2016) -35.1% -33.3% 20.0% 9.45% 5.43% -36.8% -12.9% -46.5% -30.1% -30.1% -43.2% 38.3%	34.79 % chang e-standar DALY ra (1990-20 -56.09 -54.99 -14.49 -29.39 -14.49 -29.39 -58.09 -29.09 -63.89 -35.29 -57.19 -54.69 -25.59 -11.09 -74.19

Behavioural risks Metabolic risks Environmental/occupational risks

Supplementary Figure 5. Rank changes in total deaths attributable to leading risk factors and percent change in all-age and age-standardized death rates in Canada between 1990 and 2016, for (A) women and (B) men

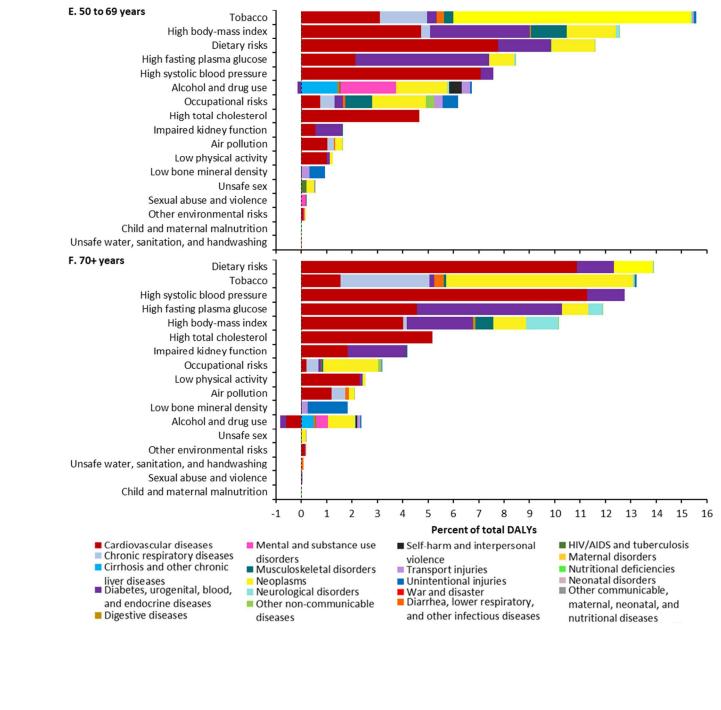
A. Females			% change	% change ge-standardis
			death rate	death rate
Risk factors by attributable deaths 199	0	Risk factors by attributable deaths	(1990-2016)	
1. Dietary risks	<u> </u>	1. Dietary risks	-27.7%	-56.3%
2. High systolic blood pressure		2. Tobacco	12.3%	- 24.4%
3. Tobacco	Y.	3. High systolic blood pressure	-22.3%	-54.3%
4. High total cholesterol	k. /	4. High body-mass index	26.9%	-20.8%
5. High fasting plasma glucose	ŀ≁	5. High fasting plasma glucose	-3.47%	-40.0%
6. High body-mass index	Y`	6. High total cholesterol	-30.8%	-60.1%
7. Impaired kidney function		7. Impaired kidney function	11.9%	-36.6%
8. Low physical activity	<u> </u>	8. Low physical activity	-15.0%	-51.2%
9. Air pollution	h. /	9. Alcohol and drug use	120%	56.3%
10. Occupational risks	1/	10. Air pollution	-11.1%	-43.9%
11. Alcohol and drug use	Y ``	11. Occupational risks	34.6%	-0.78%
12. Low bone mineral density		12. Low bone mineral density	91.4%	3.33%
13. Unsafe sex	<u> </u>	13. Unsafe sex	-2.51%	-27.1%
14. Child and maternal malnutrition	Ī—	14. Child and maternal malnutrition	-37.5%	-17.6%
15. Other environmental risks		15. Other environmental risks	-17.5%	-51.0%
16. Sexual abuse and violence		16. Unsafe water, sanitation, and	292%	126%
16. Sexual abuse and violence 17. Unsafe water, sanitation, and handwashing B. Males	X	16. Unsafe water, sanitation, and handwashing17. Sexual abuse and violence	-26.1% % change all-age	-28.5% % change ge-standardis
17. Unsafe water, sanitation, and handwashing		handwashing	-26.1% % change	-28.5% % change ge-standardi: death rate
17. Unsafe water, sanitation, and handwashing B. Males		handwashing 17. Sexual abuse and violence	-26.1% % change all-age death rate	-28.5% % change ge-standardis death rate
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths	-26.1% % change all-age a death rate (1990-2016)	-28.5% % change ge-standardi: death rate (1990-2016
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 195 1. Tobacco 		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths 1. Tobacco	-26.1% % change all-age a death rate (1990-2016) -27.8%	-28.5% % change ge-standardis death rate (1990-2016 -54.1%
17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths 1. Tobacco 2. Dietary risks	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8%	-28.5% % change ge-standardi: death rate (1990-2016 -54.1% -57.4%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths 1. Tobacco 2. Dietary risks 3. High systolic blood pressure	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -31.8%	-28.5% % change ge-standardi: death rate (1990-2016 -54.1% -57.4% -58.4%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High fasting plasma glucose	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -31.8% 3.16%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -58.4% -37.2%
17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 5. High fasting plasma glucose		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High fasting plasma glucose 5. High body-mass index	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -30.8% -31.8% 3.16% 18.0%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -58.4% -37.2% -24.0%
17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 5. High fasting plasma glucose 6. High body-mass index		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High fasting plasma glucose 5. High body-mass index 6. High total cholesterol	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -31.8% 3.16% 18.0% -41.0%	-28.5% % change ge-standardii death rate (1990-2016 -54.1% -57.4% -58.4% -37.2% -24.0% -63.7%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 5. High fasting plasma glucose 6. High body-mass index 7. Occupational risks 		handwashing17. Sexual abuse and violenceRisk factors by attributable deaths1. Tobacco2. Dietary risks3. High systolic blood pressure4. High fasting plasma glucose5. High body-mass index6. High total cholesterol7. Occupational risks	-26.1% % change all-age (1990-2016) -27.8% -30.8% -31.8% 3.16% 18.0% -41.0% -8.63%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -57.4% -37.2% -24.0% -63.7% -36.9%
17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 5. High fasting plasma glucose 6. High body-mass index 7. Occupational risks 8. Air pollution		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High fasting plasma glucose 5. High body-mass index 6. High total cholesterol 7. Occupational risks 8. Alcohol and drug use	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -30.8% -31.8% 3.16% 18.0% -41.0% -8.63% 48.0%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -58.4% -37.2% -24.0% -63.7% -36.9% 30.4%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 5. High fasting plasma glucose 6. High body-mass index 7. Occupational risks 8. Air pollution 9. Impaired kidney function 		handwashing 17. Sexual abuse and violence Risk factors by attributable deaths 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High fasting plasma glucose 5. High body-mass index 6. High total cholesterol 7. Occupational risks 8. Alcohol and drug use 9. Impaired kidney function	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -31.8% 3.16% 18.0% -41.0% -8.63% 48.0% 5.55%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -58.4% -37.2% -24.0% -63.7% -36.9% 30.4% -39.6%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 Tobacco Dietary risks High systolic blood pressure High total cholesterol High fasting plasma glucose High body-mass index 7. Occupational risks 8. Air pollution Impaired kidney function 10. Low physical activity 		handwashing17. Sexual abuse and violenceRisk factors by attributable deaths1. Tobacco2. Dietary risks3. High systolic blood pressure4. High fasting plasma glucose5. High body-mass index6. High total cholesterol7. Occupational risks8. Alcohol and drug use9. Impaired kidney function10. Air pollution	-26.1% % change all-age (1990-2016) -27.8% -30.8% -31.8% 3.16% 18.0% -8.63% 48.0% 5.55% -28.2%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -58.4% -37.2% -24.0% -63.7% -36.9% 30.4% -39.6% -55.3%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 5. High fasting plasma glucose 6. High body-mass index 7. Occupational risks 8. Air pollution 9. Impaired kidney function 10. Low physical activity 11. Alcohol and drug use 		handwashing17. Sexual abuse and violenceRisk factors by attributable deaths1. Tobacco2. Dietary risks3. High systolic blood pressure4. High fasting plasma glucose5. High body-mass index6. High total cholesterol7. Occupational risks8. Alcohol and drug use9. Impaired kidney function10. Air pollution11. Low physical activity	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -30.8% -31.8% 3.16% 18.0% -41.0% -8.63% 48.0% 5.55% -28.2% -23.4%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -58.4% -37.2% -24.0% -63.7% -36.9% 30.4% -39.6% -55.3% -54.6%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 5. High fasting plasma glucose 6. High body-mass index 7. Occupational risks 8. Air pollution 9. Impaired kidney function 10. Low physical activity 11. Alcohol and drug use 12. Unsafe sex 		handwashing17. Sexual abuse and violenceRisk factors by attributable deaths1. Tobacco2. Dietary risks3. High systolic blood pressure4. High fasting plasma glucose5. High body-mass index6. High total cholesterol7. Occupational risks8. Alcohol and drug use9. Impaired kidney function10. Air pollution11. Low physical activity12. Low bone mineral density	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -31.8% 3.16% 18.0% -41.0% -8.63% 48.0% 5.55% -28.2% -23.4% 82.3%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -58.4% -37.2% -24.0% -63.7% -36.9% 30.4% -39.6% -55.3% -54.6% -1.89%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 Tobacco Dietary risks High systolic blood pressure High total cholesterol High fasting plasma glucose High body-mass index 7. Occupational risks 8. Air pollution Impaired kidney function 10. Low physical activity Alcohol and drug use Unsafe sex 13. Child and maternal malnutrition 		handwashing17. Sexual abuse and violenceRisk factors by attributable deaths1. Tobacco2. Dietary risks3. High systolic blood pressure4. High fasting plasma glucose5. High body-mass index6. High total cholesterol7. Occupational risks8. Alcohol and drug use9. Impaired kidney function10. Air pollution11. Low physical activity12. Low bone mineral density13. Child and maternal malnutrition	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -31.8% 3.16% 18.0% -8.63% 48.0% -8.63% 48.0% 5.55% -28.2% -28.2% 82.3% -44.8%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -58.4% -37.2% -24.0% -63.7% -36.9% 30.4% -39.6% -55.3% -54.6% -1.89% -27.3%
 17. Unsafe water, sanitation, and handwashing B. Males Risk factors by attributable deaths 199 1. Tobacco 2. Dietary risks 3. High systolic blood pressure 4. High total cholesterol 5. High fasting plasma glucose 6. High body-mass index 7. Occupational risks 8. Air pollution 9. Impaired kidney function 10. Low physical activity 11. Alcohol and drug use 12. Unsafe sex 13. Child and maternal malnutrition 14. Low bone mineral density 		handwashing17. Sexual abuse and violenceRisk factors by attributable deaths1. Tobacco2. Dietary risks3. High systolic blood pressure4. High fasting plasma glucose5. High body-mass index6. High total cholesterol7. Occupational risks8. Alcohol and drug use9. Impaired kidney function10. Air pollution11. Low physical activity12. Low bone mineral density13. Child and maternal malnutrition14. Other environmental risks	-26.1% % change all-age a death rate (1990-2016) -27.8% -30.8% -30.8% -31.8% 3.16% 18.0% -41.0% -8.63% 48.0% 5.55% -28.2% -23.4% 82.3% -44.8% -38.1%	-28.5% % change gge-standardis death rate (1990-2016 -54.1% -57.4% -37.2% -24.0% -63.7% -36.9% 30.4% -39.6% -55.3% -54.6% -1.89% -27.3%

Behavioural risks Metabolic risks Environmental/occupational risks

Supplementary Figure 6. Rank changes in years lived with disability (YLDs) attributable to leading risk factors and percent change in all-age and age-standardized YLD rates in Canada between 1990 and 2016 for (A) females (B) males

5 6	between 1990 and	2016 for (A) females (B)	male	es				
0 7	Supplementary F	igure 7. The burden of dis	sease	e attributable to leading ris	sk f	actors	in 2	2016 for
8	Canadians,	-		_	9	% change	2	% change
9	expressed as a	A. Females				all-age YLD rate	-	-standardised YLD rate
10	percentage of	Risk factors by attributable YLDs 1990		Risk factors by attributable YLDs 2016		990-2016)		1990-2016)
11		1. High body-mass index	<u> </u>	1. High body-mass index		53.0%		20.4%
12	A. Under 5	2. High fasting plasma glucose		2. High fasting plasma glucose		28.1%		-2.34%
13 14	Child and maternal Impaired kid			3. Alcohol and drug use	İΓ	11.4%	F	17.3%
14	High bod			4. Dietary risks	ίĒ	6.44%	Ē	-18.6%
16		5. Dietary risks	X	5. Occupational risks	ίĒ	32.8%	Γ	19.3%
17	Unsafe water, sanitation, and	6. High systolic blood pressure	X	6. High systolic blood pressure	i F	5.76%		-24.8%
18	High fasting pl		/ `\	7. Tobacco	i F	-16.0%		-34.4%
19	High systolic bl				iF	34.8%		
20	Other enviro	8. Impaired kidney function		8. Impaired kidney function	╏┢			1.50%
21	Alcohol Sexual abuse	9. Sexual abuse and violence	/	9. Low bone mineral density		50.4%	Ļ	4.13%
22	High tota		1.	10. Sexual abuse and violence	ļĻ	3.28%	Ļ	5.75%
23		11. Low bone mineral density		11. High total cholesterol	ΙĻ	3.49%	Ļ	-26.1%
24	Occu	12. Child and maternal malnutrition		12. Low physical activity	ΙL	27.7%	L	-8.54%
25	Low ph	13. Low physical activity	~	13. Child and maternal malnutrition		-3.48%		11.7%
26	Low bone m	14. Unsafe sex	<u> </u>	14. Unsafe sex		25.2%		25.5%
27		15. Air pollution	10	15. Air pollution	-	33.3%		-1.47%
28	B. 5 to 14 years High boo	16. Other environmental risks	10	16. Other environmental risks	ר ו	68.7%	ŕĒ	54.2%
29 30	Child and materna Alcohol	17. Unsafe water, sanitation, and		17. Unsafe water, sanitation, and handwashing	ן ב	-18.0%	Ē	-15.3%
31	High fasting pl			nanuwashing	1			
32					i i	% change all-age		% change -standardised
33		Tobacco				YLD rate	-	YLD rate
34		nRissonadtaiskby attributable YLDs 1990		Risk factors by attributable YLDs 2016	(1	990-2016)	(1	1990-2016)
35	Sexual abuse Unsafe water, sanitation, and	1. Alconor and drug use	·./	1. High body-mass index	ΙL	70.3%	L	28.5%
36	Unsale water, sanitation, and	2. Occupational risks	1	2. Alcohol and drug use		11.2%		15.0%
37		3. High body-mass index	Y'	3. High fasting plasma glucose		51.2%		6.35%
38	High systolic b	4. High fasting plasma glucose		4. Occupational risks	İΓ	8.92%	Ē	-3.05%
39	Occu	5 Tobacco		5. Dietary risks	ίĒ	22.9%	Г	-13.4%
40	High tot	6. Dietary risks	X	6. Tobacco	i F	-19.4%		-40.9%
41	Low ph			7. High systolic blood pressure	i F	7.97%		-27.8%
42	Low bone m	8. Impaired kidney function		8. Impaired kidney function	ĻĻ	44.7% 1		1.64%
43 44	C. 15 to 49 years Alcohol			9. Low bone mineral density		44.7761		
44 45	Occu	national risks	\times	,		39.5%	F	-7.5%
46	High boo	10. Low bone mineral density		10. High total cholesterol	ļĻ	-5.9%	Ļ	-36.3%
47		11. Low physical activity		11. Low physical activity	ļĻ	30.4%	Ļ	-15.4%
48	High facting n	12. Unsafe sex	-	12. Unsafe sex	ΙĽ	36.0%	Ľ	24.4%
49	High fasting pl High systolic b	1.3. Child and maternal mainutrition	/	13. Other environmental risks		58.7%		42.1%
50	High tot	4 4 4 1 H 4	1	14. Child and maternal malnutrition		-14.9%		6.29%
51		15. Other environmental risks	1	15. Air pollution	ΙΓ	28.1%	Γ	-12.9%
52	Sexual abuse	16. Sexual abuse and violence	i	16. Sexual abuse and violence	ίĒ	26.6%	Ē	30.6%
53	Impaired ki	17. Unsafe water, sanitation, and	i i	17. Unsafe water, sanitation, and	ίF	-21.9%		-15.0%
54	Low ph	handwashing		handwashing		21.570		10.070
55		ineral density						
56		aBrebaritionnal risks 🚺 📃 Metabolic	risks	Environmental/occupational risks	5			
57		nmental risks						
58	Unsafe water, sanitation, and	handwashing					,	
59		-1 0 1 2 3			11	12 13	1	.4 15 16)
60		For Pe	er Re	eview Pencemit of total DALYs				

total disability-adjusted life years (DALYs) stratified by age group



Supplementary Figure 8. Rank changes of disability-adjusted life years (DALYs) attributable to leading risk factors and percent change in DALY rates and number of DALYs in Canada between 1990 and 2016, in age categories

A. Under 5

Risk factors by attributable DALYs 1990	Risk factors by attributable DALYs 2016	(1990-2016)	(1990-201
1. Child and maternal malnutrition	1. Child and maternal malnutrition	-24.2	-22.2
2. Tobacco	2. Impaired kidney function	39.9	43.5
3. Impaired kidney function	3. High body-mass index	28.8	32.1
4. High body-mass index	4. Tobacco	-54.9	-53.7
5. Air pollution	5. Unsafe water, sanitation, and	8.30	11.1
6. Unsafe water, sanitation, and	handwashing		
handwashing	6. Air pollution	-57.0	-55.9
7. High fasting plasma glucose	7. High fasting plasma glucose	-37.8	-36.1
8. High systolic blood pressure	8. High systolic blood pressure	-2.43	0
9. Other environmental risks	9. Other environmental risks	140	146
10. Alcohol and drug use	10. Alcohol and drug use	59.1	63.2
11. Sexual abuse and violence	11. Sexual abuse and violence	18.29	21.2

% change in % change DALY rate number of DALYs)16)

39.9	43.5
28.8	32.1
-54.9	-53.7
8.30	11.1
-57.0	-55.9
-37.8	-36.1
-2.43	0
140	146

B. 5-14 years

Risk factors by attributable DALYs 1990		Risk factors by attributable DALYs 2016	(
1. High body-mass index		1. High body-mass index	
2. Child and maternal malnutrition		2. Child and maternal malnutrition	
3. Alcohol and drug use		3. Alcohol and drug use	
4. High fasting plasma glucose		4. High fasting plasma glucose	
5. Tobacco	h	5. Impaired kidney function	
6. Impaired kidney function	· ·	6. Tobacco	
7. Other environmental risks		7. Other environmental risks	
8. Unsafe water, sanitation, and		8. Sexual abuse and violence	
handwashing	1	9. Unsafe water, sanitation, and	
9. Sexual abuse and violence	r	handwashing	
10. Air pollution		10. Air pollution	
11. Unsafe sex		11. Unsafe sex	
12. High systolic blood pressure		12. High systolic blood pressure	
13. Occupational risks		13. Occupational risks	

% change in % change DALY rate number of DALYs 0-2016) (1990-2016)

/	
16.6	11.6
14.0	9.20
-9.04	-12.9
-12.7	-16.4
-18.2	-21.7
-43.9	-46.3
-8.50	-12.4
17.6	12.7
-16.1	-19.7

-56.2	-58.0
-50.8	-52.9
-13.6	-17.2
-3.36	-7.44

Behavioural risks

Metabolic risks

Environmental/occupational risks

% change in

% change

C. 15-49 years

Risk factors by attributable DALYs 1990		Ris
1. Alcohol and drug use		1
2. Occupational risks		2
3. Tobacco	. /	3
4. Dietary risks	X	4
5. High body-mass index		5
6. High total cholesterol		6
7. High systolic blood pressure	A	7
8. Unsafe sex	1	8
9. High fasting plasma glucose	- /	9
10. Sexual abuse and violence	./	1
11. Air pollution		1
12. Impaired kidney function		1
13. Low physical activity		1
14. Low bone mineral density	~/	1
15. Child and maternal malnutrition		1
16. Other environmental risks		1
17. Unsafe water, sanitation, and handwashing		1 h

isk factors	by attributable	DALYs 2016

Sk lactors by attributable DALIS 2010
1. Alcohol and drug use
2. Occupational risks
3. High body-mass index
4. Dietary risks
5. Tobacco
6. High fasting plasma glucose
7. High systolic blood pressure
8. High total cholesterol
9. Unsafe sex
10. Sexual abuse and violence
11. Impaired kidney function
12. Air pollution
13. Low physical activity
14. Low bone mineral density
15. Child and maternal malnutrition
16. Other environmental risks
17. Unsafe water, sanitation, and handwashing

DALY rate number of DALYs (1990-2016) (1990-2016)			
1.14	13.9		
-15.7	-5.09		
1.55	14.3		
-36.4	-28.4		
-49.4	-43.1		
0.60	13.3		
-42.7	-35.5		
-46.7	-40.0		
-64.2	-59.7		
1.58	14.4		
-7.94	3.65		
-44.9	-38.0		
-33.3	-24.9		
-1.12	11.3		
6.94	20.4		
17.7	32.5		
-1.83	10.5		

D. 50-69 years

Risk factors by attributable DALYs 1990

1. Tobacco	[
2. Dietary risks	
3. High systolic blood pressure	×1
4. High body-mass index	\sim
5. High total cholesterol	<u>/`</u> [
6. High fasting plasma glucose	N /
7. Occupational risks	HX.
8. Alcohol and drug use	
9. Air pollution	
10. Low physical activity	
11. Impaired kidney function	
12. Low bone mineral density	[
13. Unsafe sex	<u> [</u>
14. Other environmental risks	
15. Sexual abuse and violence	
16. Unsafe water, sanitation, and handwashing	
17. Child and maternal malnutrition	

Risk factors by	v attributable	DALYs 2016

1. Tobacco
2. High body-mass index
3. Dietary risks
4. High fasting plasma glucose
5. High systolic blood pressure
6. Alcohol and drug use
7. Occupational risks
8. High total cholesterol
9. Impaired kidney function
10. Air pollution
11. Low physical activity
12. Low bone mineral density
13. Unsafe sex
14. Sexual abuse and violence
15. Other environmental risks
16. Child and maternal malnutrition
17. Unsafe water, sanitation, and handwashing

% change % change in DALY rate number of DALYs (1990-2016) (1990-2016)

()	
-52.3	-1.10
-20.4	64.8
-56.4	-9.71
-31.7	41.5
-60.0	-17.1
10.5	129
-26.2	53.0
-65.8	-29.1
-37.4	29.8
-57.4	-11.7
-56.4	-9.67
-13.9	78.4
-26.4	52.5
-0.43	106
-59.8	-16.8
80.4	274
41.2	193

Behavioural risks

Metabolic risks

Environmental/occupational risks

E. 70+ years

Risk factors by attributable DALYs 1990	Risk factors by attributable DALYs 2016	% change DALY rate nu (1990-2016)	% change in umber of DALYs (1990-2016)
1. Dietary risks	1. Dietary risks	-52.0	-9.96
2. High systolic blood pressure	2. Tobacco	-38.0	16.2
3. Tobacco	3. High systolic blood pressure	-50.6	-7.35
4. High fasting plasma glucose	4. High fasting plasma glucose	-29.5	32.2
5. High total cholesterol	5. High body-mass index	-5.35	77.4
6. High body-mass index	6. High total cholesterol	-57.1	-19.6
7. Impaired kidney function	7. Impaired kidney function	-26.6	37.6
8. Low physical activity	8. Occupational risks	-19.5	50.8
9. Occupational risks	9. Low physical activity	-46.5	0.20
10. Air pollution	10. Air pollution	-46.7	-0.02
11. Low bone mineral density	11. Low bone mineral density	16.9	119
12. Other environmental risks	12. Alcohol and drug use	1220	2375
13. Unsafe sex	13. Unsafe sex	-29.6	31.9
14. Alcohol and drug use	14. Other environmental risks	-46.1	0.98
15. Sexual abuse and violence	15. Unsafe water, sanitation, and	130	332
16. Unsafe water, sanitation, and	handwashing		
handwashing	16. Sexual abuse and violence	-10.5	67.8
17. Child and maternal malnutrition	17. Child and maternal malnutrition	7.89	102
Rehavioural ricks	Environmental/occupational ricks		

990-2016)	(1990-2016)
-52.0	-9.96
-38.0	16.2
-50.6	-7.35
-29.5	32.2
-5.35	77.4
-57.1	-19.6
-26.6	37.6
-19.5	50.8
-46.5	0.20
-46.7	-0.02
16.9	119
1220	2375
-29.6	31.9
-46.1	0.98
130	332
-10.5	67.8

-10.5	07.
7.89	10

Behavioural risks Metabolic risks Environmental/occupational risks

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