

## GLOBAL STATUS OF EPIDEMIOLOGY

# Burden of disease, health indicators and challenges for epidemiology in North America

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**Background** Commissioned by the International Epidemiological Association, this article is part of a series on burden of disease, health indicators and the challenges faced by epidemiologists in bringing their discoveries to provide equitable benefit to the populations in their regions and globally. This report covers the health status and epidemiological capacity in the North American region (USA and Canada).

**Methods** We assessed data from country-specific sources to identify health priorities and areas of greatest need for modifiable risk factors. We examined inequalities in health as a function of social deprivation. We also reviewed information on epidemiological capacity building and scientific contributions by epidemiologists in the region.

**Findings** The USA and Canada enjoy technologically advanced healthcare systems that, in principle, prioritize preventive services. Both countries experience a life expectancy at birth that is higher than the global mean. Health indicator measures are consistently worse in the USA than in Canada for many outcomes, although typically by only marginal amounts. Socio-economic and racial/ethnic disparities in indicators exist for many diseases and risk factors in the USA. To a lesser extent, these social inequalities also exist in Canada, particularly among the Aboriginal populations. Epidemiology is a well-established discipline in the region, with many degree-granting schools, societies and job opportunities in the public and private sectors. North American epidemiologists have made important contributions in disease control and prevention and provide nearly a third of the global scientific output via published papers.

**Conclusions** Critical challenges for North American epidemiologists include social determinants of disease distribution and the underlying inequalities in access to and benefit from preventive services and healthcare, particularly in the USA. The gains in life expectancy also underscore the need for research on health promotion and prevention of disease and disability in older adults. The diversity in epidemiological subspecialties poses new challenges in training

and accreditation and has occurred in parallel with a decrease in research funding.

**Keywords** North American region, burden of disease, health indicators, epidemiology

### Preamble

This article is part of a series commissioned by the International Epidemiological Association to bring into focus the role of the epidemiology profession in addressing burden of disease and in providing new tools and new evidence for health promotion and disease prevention, while defining itself as a key public health discipline. Each article in the series covers a different region, as defined by the World Health Organization (WHO). The present report covers the WHO North American region, which includes Canada and the USA. The current status of epidemiology training, opportunities and challenges for the future are also the focus of the foregoing analysis.

### Main health problems in North America

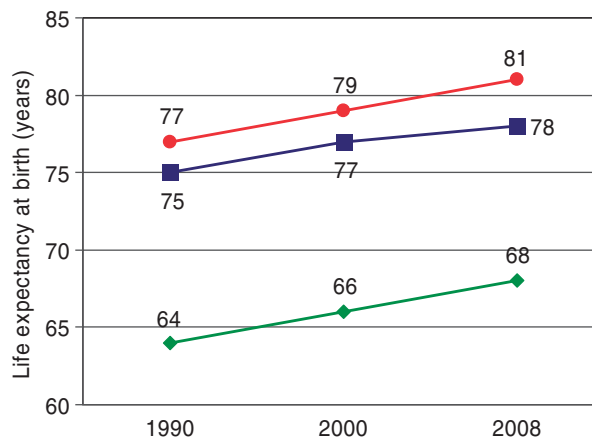
In this section, we present three aspects of the epidemiological profile of North America: (i) trends and current levels of on-average rates of morbidity and mortality, (ii) trends and current levels of on-average exposure to major risk factors contributing to trends in health outcomes and (iii) social inequalities in health and their social determinants, which together shape the observed on-average rates routinely presented in national reports. We believe all three aspects merit mention, for purposes of comparability to other countries, overall and in relation to health inequities.

#### Morbidity and mortality

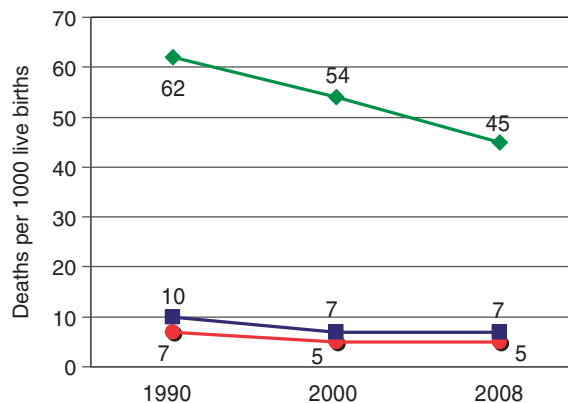
As high-resource countries, the USA and Canada enjoy technologically advanced health care systems that, at least in principle, give a high priority to preventive services as indicated by these countries' leading public health agencies.<sup>1,2</sup> Nevertheless, the number of primary care physicians (who have primary responsibility for provision of preventive healthcare) in the USA remains inadequate<sup>3</sup> and the number and proportion of people without health insurance in the USA is on the rise, in 2009 equalling 16.7% of the population, or nearly 51 million people.<sup>4</sup> Both countries experience an estimated on-average life expectancy at birth that is higher than the global mean of 68 years (Figure 1). In 2008, life expectancy at birth for the US population reached 78 years, up from 75 in 1990. The gap in life expectancy between men and women decreased from 7 years in 1990 to 5 years in 2008. In 2008, life

expectancy at birth for the Canadian population reached 81 years, up from 77 in 1990. The gap in life expectancy between men and women decreased from 6 years in 1990 to 4 years in 2008.<sup>5</sup>

As shown in Figure 2, although there has been a global decline in infant mortality rates from 1990 to 2008, Canada and the USA continue to have substantially lower rates than the global average of 45 per 1000 live births. As is well known, although data on national rates are important, there is considerable heterogeneity in rates by social group within any given country, such that informative summaries



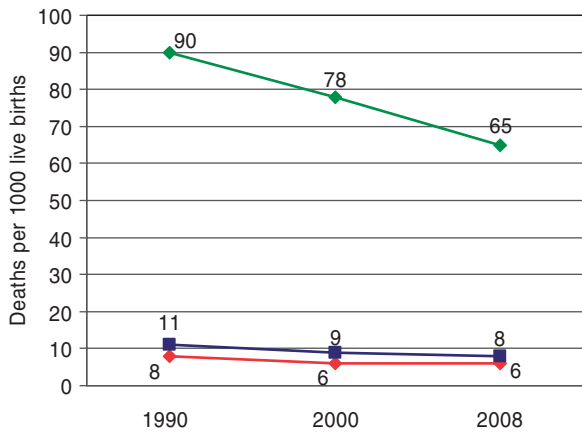
**Figure 1** Life expectancy at birth in North America and in the World. Canada: red line with circles; USA: blue line and squares; Global: green line with diamonds. Source: WHO's World Health Statistics 2010<sup>5</sup>



**Figure 2** Infant mortality rates in North America and in the World. Canada: red line with circles; USA: blue line and squares; Global: green line with diamonds. Source: WHO's World Health Statistics 2010<sup>5</sup>

require attention to both overall levels and social inequalities in health (discussed below).<sup>6–9</sup> In 2008, the infant mortality rate in Canada was 5 per 1000 live births, 29% lower than in 1990. The infant mortality rate in the USA in 2008 was 7 per 1000 live births, 30% lower than in 1990. The global infant mortality rate decreased from 62 per 1000 live births in 1990 to 45 per 1000 live births in 2008, a 27% decrease.<sup>5</sup>

The under-age-5 years (0–<5 years) (under-5) mortality rates for Canada and the USA are also

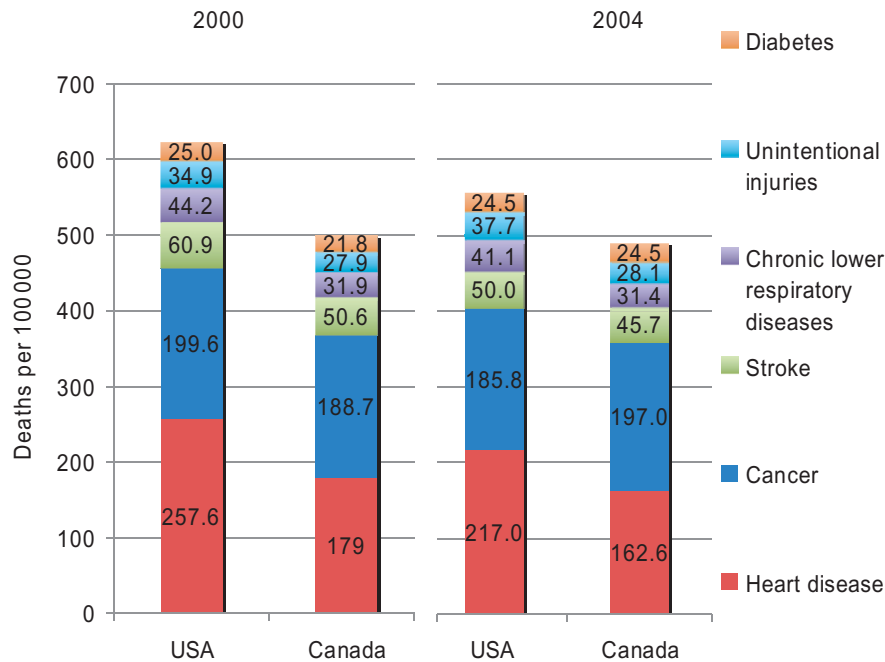


**Figure 3** Mortality rates among children under the age of 5 years in North America and in the World. Canada: red line with circles; USA: blue line and squares; Global: green line with diamonds. *Source:* WHO’s World Health Statistics 2010<sup>5</sup>

significantly lower than the global rate, estimated to be 65 per 1000 live births in 2008 (Figure 3). The under-5 mortality rate in Canada was 6 per 1000 live births in 2008, a 25% decrease from 1990. The under-5 mortality rate in the USA was 8 per 1000 live births in 2008, a 27% decrease from 1990. The global under-5 mortality rate decreased from 90 per 1000 live births in 1990 to 65 per 1000 live births in 2008, a 28% decrease.<sup>5</sup>

The leading causes of death are comparable between Canada and the USA, with the exception of the differences noted for all malignant neoplasms. In 2004, heart disease was the number one cause of death in both Canada and the USA, followed by cancer, stroke, chronic lower respiratory diseases, unintentional injuries and diabetes (Figure 4). The death rates for all leading causes of death were higher in the USA than Canada in 2004, except the death rate due to cancer, which was 5.7% higher in Canada and mortality due to diabetes, which was similar between countries.<sup>10,11</sup> The death rate due to heart disease—the leading cause of death in both Canada and the USA—declined 9% from 2000 to 2004 in Canada and 16% from 2000 to 2004 in the USA.<sup>10,11</sup> The death rate due to cancer—the second leading cause of death in both countries—increased 4% from 2000 to 2004 in Canada and declined 7% from 2000 to 2004 in the USA.<sup>10,11</sup>

In terms of proportional mortality burden in 2004, as a group of diseases, cancer was one of the leading causes of death worldwide. Ischaemic heart disease, stroke and other cerebrovascular diseases, lower



**Figure 4** Rates of leading Causes of Death in Canada and the US 2000 vs 2004 (per 100 000). Data for the US are taken from the National Center for Health Statistics Health in the US 2009 report.<sup>11</sup> Data for Canada are taken from Statistics Canada measurements of health online database<sup>10</sup>

**Table 1** Estimated mortality according to leading causes of death in 2004 (in thousands): World and North American region

Category	World		Canada		USA	
	Frequency	%	Frequency	%	Frequency	%
Total deaths	58 772	100	225	100	2467.60	100
Ischaemic heart disease	7198	12.20	41.80	18.60	489.50	19.80
Stroke and other cerebrovascular diseases	5712	9.70	15.50	6.90	160.10	6.50
Lower respiratory infections	4177	7.10	0.20	0.09	63.10	2.60
COPD	3025	5.10	9.80	4.40	122.50	5
Diarrhoeal diseases	2163	3.70	0.60	0.30	4.60	0.20
HIV/AIDS	2040	3.50	0.40	0.20	13.40	0.50
Tuberculosis	1464	2.50	0.10	0.04	0.80	0.03
Malignant neoplasms	7424	12.60	66.90	29.70	575.10	23.30
Trachea, bronchus, and lung cancers	1323	2.30	17.60	7.80	163.90	6.60
Road traffic accidents	1275	2.20	2.70	1.20	45.60	1.80
Prematurity and low birthweight	1179	2	0.30	0.10	7.30	0.30
Unintentional injuries	3906	6.60	9.10	4.00	116.40	4.70
Diabetes mellitus	1141	1.90	8.10	3.60	76.10	3.10

Note: Cancers of the trachea, bronchus and lung are a subset of all malignant neoplasms, shown for comparison purposes. COPD: Chronic obstructive pulmonary disease; HIV: Human immunodeficiency virus; AIDS: Acquired immunodeficiency syndrome.

Source: WHO's Global Burden of Disease 2004.<sup>12</sup>

**Table 2** Burden of selected infectious diseases (in thousands of new cases) in 2004–05: North American region and other World Health Organization regions

Type	Disease	Canada	USA (2005)	World	WHO regions					
					Africa	Americas	Eastern Mediterranean	Europe	South-East Asia	Western Pacific
General infectious diseases	Tuberculosis	1.6	15	7782	1360	365	584	563	2830	2076
	Salmonella	5	45.3	–	–	–	–	–	–	–
	Diphtheria	–	0	34	18	1	1	0	13	1
	Malaria	0.4	1.5	2 41 340	2 03 710	2858	8533	13	23 263	2634
Sexually transmitted infections	Syphilis	1.4	33.3	–	–	–	–	–	–	–
	HIV	2.5	33.5	2805	1935	185	63	236	246	138
	Hepatitis A	0.5	4.5	–	–	–	–	–	–	–
	Hepatitis B	0.8	5.1	–	–	–	–	–	–	–
	Hepatitis C	13.4	0.7	–	–	–	–	–	–	–
Childhood diseases	Chlamydia	59.3	976.4	–	–	–	–	–	–	–
	Gonorrhoea	8.6	339.6	–	–	–	–	–	–	–
	Measles	0.01	0.06	27 118	5264	0	972	162	17 397	3292
	Meningitis	0.2	1.2	668	254	53	71	35	170	84
	Mumps	0.03	0.3	–	–	–	–	–	–	–
	Rubella	0.01	0.01	–	–	–	–	–	–	–

Source: WHO's Global Burden of Disease 2004 Report.<sup>12</sup> Data for the US: 2009 Health in the US Report,<sup>11</sup> MMWR Summary of Notifiable Diseases 2004<sup>13</sup> and the CDC's HIV/AIDS Surveillance Report 2004.<sup>14</sup> Data for the world, Canada, and the WHO regions are for the year 2004. Data for the US are for the year 2005, except the Malaria and HIV incidence data, which are for 2004.

respiratory infections, unintentional injuries, chronic obstructive pulmonary disease (COPD) and diarrhoeal diseases were also prominent among the causes (Table 1).<sup>12</sup> On the other hand, infectious diseases continue to present a much greater risk to the global population than to high-income countries such as Canada and the USA (Table 2).<sup>13,14</sup> Tuberculosis, for example, was the cause of 2.5% of total deaths globally in 2004, although only accounting for 0.04% and 0.03% of deaths in Canada and the USA populations, respectively.<sup>12</sup>

### Risk factors

Table 3 shows the prevalence, globally and for Canada and the USA, of three selected risk factors: obesity, tobacco smoking and alcohol consumption. These exposures, all strongly socially patterned (though in diverse ways), are important contributors to aetiological pathways leading to individuals' health status and to both overall population rates of disease and health inequalities.<sup>7,15-17</sup>

Obesity increases the risk of heart disease, diabetes, stroke and cancer, all of which are leading causes of death in North America. Canada and the USA both have a higher overweight and obese population compared with the global mean. In 2004, the percentage of the global population reported as being overweight or obese was 42% and the percentage reported as obese was 12%.<sup>12</sup> Canada had an overweight and obesity rate of 49.4% and an obesity rate of 15.3% in 2004.<sup>10</sup> In contrast, 59.2% of the US population was considered overweight or obese in 2004 and 24% were obese.<sup>18</sup> Canadian men were 28% more likely to be overweight or obese than Canadian women in 2004, and the equivalent figure for the

USA was 24%.<sup>10,18</sup> The increased rate for male obesity in Canada and the USA is contrary to the global population pattern in which women have a 7% greater likelihood of being overweight or obese.<sup>12</sup>

Cigarette smoking increases the risk of cancers of the respiratory tract and other sites, heart disease, COPD and chronic lower respiratory infections, all of which are leading causes of death in North America. Canada and the USA have both seen rates of tobacco use decline dramatically since mid-century, and both countries currently have lower rates of tobacco use than the global population. In 2004, 26% of the global population aged  $\geq 12$  years were current smokers, with 43% of men and 10% of women reported as current smokers.<sup>12</sup> In Canada, 15.3% of people aged  $\geq 18$  years were reported as current smokers in 2004.<sup>10</sup> In 2004, 24% of the US population aged  $\geq 12$  years reported being current smokers. Following the global trend, the percentage of smokers among men was higher than among women in both Canada and the USA in 2004.<sup>18</sup>

Chronic and binge use of alcohol increases the risk for several chronic diseases and accidental injuries.<sup>19</sup> The global population and the US population had comparable percentages of current drinkers in 2004 with a reported 44% and 47.1%, respectively.<sup>12</sup> Men were more likely to be current drinkers than women, both globally and in the USA.<sup>12,18</sup> Comparable data on current drinkers for Canada are not available; however, 17.3% of the Canadian population reported 'binge drinking', defined as drinking at least five or more drinks on one occasion, at least once per month in 2004. In Canada, the percentage of binge drinkers among men was much higher than among women at 25.3% and 9.6%, respectively.<sup>20</sup>

**Table 3** Prevalence of selected risk factors by sex: World and North American region

Risk Factor	Statistic	World			USA			Canada		
		Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female
Body mass index (BMI)	Mean (kg/m <sup>2</sup> )	24.5	24.3	24.6	–	–	–	–	–	–
	Overweight and obese (BMI > 25) (%)	42	40	43	59.2	67.2	50.9	49.4	57.3	41.3
	Obese (BMI > 30) (%)	12	9	15	24	23.9	23.7	15.3	16	14.5
Tobacco use	Current smokers (%)*	26	43	10	21	23	19	23	25	21
Alcohol use	Proportion consuming alcohol (%)**	44	55	34	47.1	56.5	38.3	17.3	25.3	9.6
	$\geq 40$ g alcohol/day (%)	13	22	3	–	–	–	–	–	–
	Average per capita consumption (grams alcohol per day)	14	21	6	–	–	–	–	–	–

Prevalence rates are given as the percentage of the total population. Data for the world population are taken from the WHO's Global Burden of Disease 2004.<sup>12</sup> Data for the US is taken from the NHIS Survey.<sup>18</sup> Data for Canada are taken from the Stats Canada database<sup>10</sup> information about selected risk factors. All prevalence rates are for the year 2004, except rates for Canada, which are for the year 2005.

\*Data for the world and US populations are reported for people aged  $\geq 12$  years. Data for Canada are reported for adults aged  $\geq 18$  years.

\*\*Data for the world and US populations are for current drinkers. Data for Canada are for heavy drinkers and reports the percentage of the population aged  $\geq 12$  years who reported consuming at least 5 or more drinks on one occasion per month in the past 12 months.



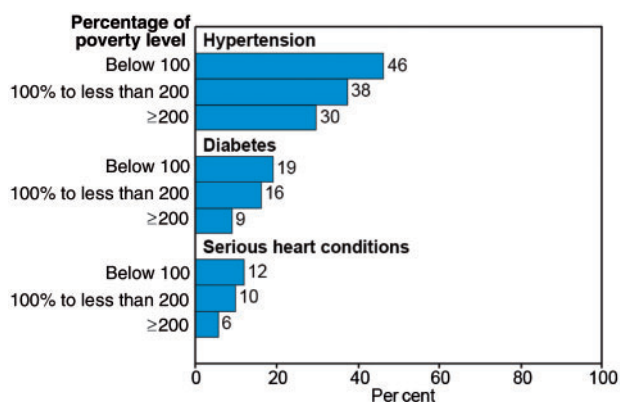
### Social inequalities in health

Health indicator measures are consistently worse in the USA than in Canada for many health outcomes, although typically by only marginal amounts. As mentioned above, life expectancy, infant mortality and the under-5 mortality rate are slightly worse in the USA relatively to Canada, whereas Canada has higher rates of cancer mortality.<sup>5</sup> These measures of health are consistent with levels of mean reported health (i.e. utility) documented in the 2002 Joint Canada–USA Survey of Health, which reported the US population as slightly less healthy than the Canadian population.<sup>21</sup> Both countries experience an association between socio-economic position and health; however, health disparities between high- and low-income populations are more pronounced in the USA.<sup>22</sup> Americans in the poorest socio-economic groups are more likely to report poor or

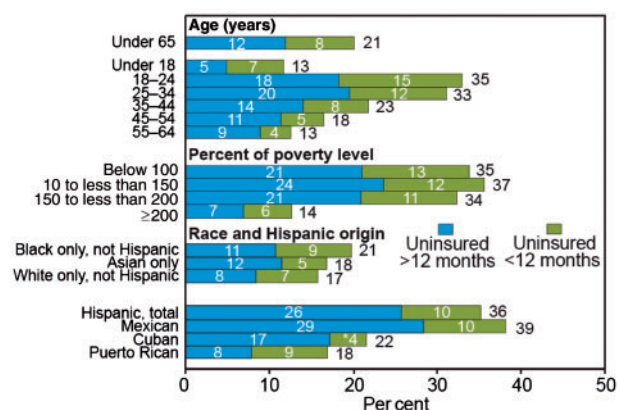
fair health, obesity and severe mobility impairment than Canadians in the same category of socio-economic status. No significant differences in health between the Canadian and US populations exist at the higher end of the socio-economic scale.<sup>21</sup>

Illustrating aspects of health inequities in the USA, Figure 5 shows data on US socio-economic disparities in selected chronic conditions (hypertension, diabetes and serious heart conditions) among the US adult population aged 45–64 years in 2007; Figure 6 displays data also from 2007 on the length of time persons in the USA <65 years have lacked medical insurance, in relation to socio-economic position, race/ethnicity and age.<sup>11</sup> The magnitude of US health inequities, moreover, has varied over time, as shown in Figure 7, which presents trends in US rates of premature mortality (top graph) and infant death (bottom graph) from 1960 to 2002 by county income quintile and race/ethnicity. Rates in all county income quintiles declined, for both Whites and populations of colour, between the mid-1960s and 1980 and inequities in these outcomes shrank, but starting after 1980, they widened and stagnated.<sup>23</sup> Canadian socio-economic inequities in life expectancy at age 25 years, for the period 1991–2001, are in turn provided in Figure 8.<sup>24</sup>

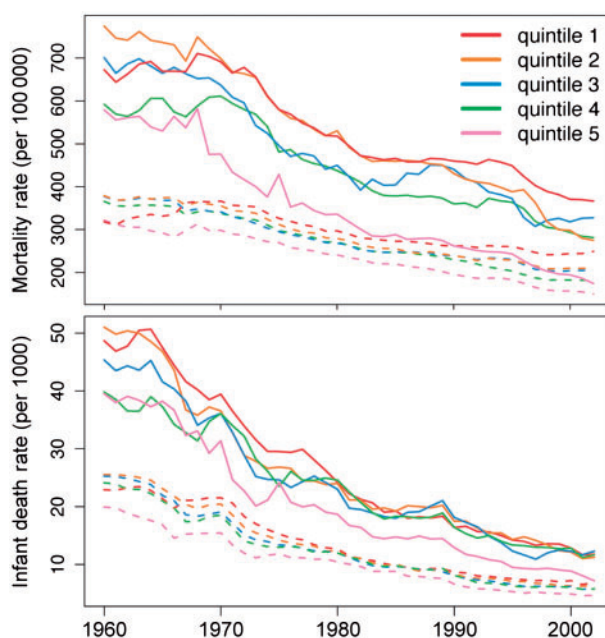
Racial/ethnic inequities in socio-economic position contribute to, but do not fully explain, the marked racial/ethnic inequities long documented in the



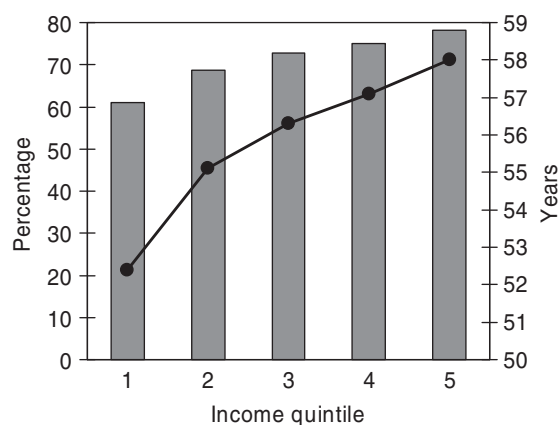
**Figure 5** Socio-economic inequalities in health in the US (2007): proportions of chronic conditions among adults 45–64 years old, by income category. *Source:* National Center for Health Statistics (2010) Health United States 2009,<sup>11</sup> National Health Interview Survey<sup>18</sup>



**Figure 6** Length of time uninsured for adults under 65 years of age in the US (2007), according to age, income level and race/ethnicity. *Source:* National Center for Health Statistics (2010) Health United States 2009,<sup>11</sup> Data from the National Health Interview Survey<sup>18</sup>



**Figure 7** Premature mortality rates (deaths <65 years) (top graph) and infant death rates (deaths under the age of 1 year) (bottom graph), United States, 1960–2002, stratified by county median family income quintile and racial categories (Whites: dashed lines; persons of colour: solid lines). Quintile 1 is for the lowest and quintile 5 for the highest income counties. Adapted from Krieger *et al*<sup>23</sup>



**Figure 8** Socio-economic inequalities in life expectancy among adults aged >25: Canada, 1991–2001. Remaining life expectancy (in years) at age 25 (line) and percentage expected to survive to aged 75 years (bars) by income quintile. *Source:* Wilkins *et al.* The Canadian census mortality follow-up study, 1991–2001.<sup>24</sup>

USA.<sup>7,25–29</sup> In 2009, the proportion of the US population below poverty was 9.4% among White non-Hispanics vs 12.5% among Asian Americans, 25.3% among Hispanic Americans, 25.8% among Black Americans<sup>4</sup> and in 2006–2008 it was 25.3% for American Indian and Alaska Natives.<sup>30</sup> The proportion without health insurance in 2009 was 12.0% among White non-Hispanics vs 17.2% among Asian Americans, 21.0% among Black Americans and 32.4% among Hispanic Americans,<sup>4</sup> and in 2007 it was 33% among American Indians and Alaska Natives.<sup>31</sup>

New research is documenting how racial discrimination harms health within and across socio-economic strata, as well as contributes to racial/ethnic inequities in socio-economic deprivation, adverse neighbourhood and workplace exposures and inadequate health care.<sup>26,27,32–35</sup> In the USA, populations of colour—especially African Americans and American Indians and Alaska Natives, and some (but not all) sub-populations of Hispanics and of Asian and Pacific Islanders—experience poorer health than White Americans, even at the same socio-economic level. In 2006, a gap of 6 years existed between the life expectancy of White men and Black men in the USA, and a 4-year gap in life expectancy existed for women. Similarly, infant mortality rates in 2006 were highest among non-Hispanic Black mothers. Overall mortality was 25% higher for Black Americans than for White Americans in 2007. Age-adjusted death rates for the Black population were 48% higher for stroke, 31% higher for heart disease, 21% higher for cancer, 113% higher for diabetes and 786% higher for HIV disease than the White population in 2006.<sup>11</sup> Additional research is grappling with the complex patterns linking race/ethnicity, immigration and health status, whereby growing evidence

indicates that although first generation immigrants to the USA exhibit what is known as the ‘healthy immigrant’ effect, by the second or third generation, their health status, especially if of colour, tends to be worse than that of White Americans.<sup>36,37</sup>

Similar to the USA, Canadian racial/ethnic inequities in health exist within and across socio-economic strata, and also involve immigrant status,<sup>38–40</sup> albeit with the most severely disadvantaged populations in Canada being the First Nations and Inuit.<sup>21,41–43</sup> In 2001, the average income of Aboriginal men and women was 58 and 72%, respectively, that of non-Aboriginal men and women, with these disparities greater for the Aboriginal population living on reserves (40 and 61%, respectively).<sup>8</sup> In 2004, fully 33% of the Aboriginal population experienced food insecurity, as compared with only 8.2% of the non-Aboriginal population. Although estimates vary depending on source of data, on average life expectancy among the Aboriginal population is 5–14 years less than for the non-Aboriginal population and their infant mortality rates are 1.5–4 times higher.<sup>8</sup>

New analyses from the 2005/2006 Canadian Community Health Survey, based on data for Aboriginal persons not living on reserves (proportions by region: 100% in Nunavut, 90% in Yukon, 29% in Northwest Territories and 71% in Southern Canada) compared with the non-Aboriginal population, provided additional evidence of health inequalities, with the gaps between the Aboriginal vs non-Aboriginal populations greater in Southern as compared with Northern Canada.<sup>43</sup> For example, in Southern Canada the prevalence of selected risk factors and chronic conditions for the off-reserve Aboriginal as compared with non-Aboriginal populations were: 25.3% vs 15.6% for obesity, 36.2% vs 17.6% for daily smoking and 10.7% vs 7.8% for asthma, respectively. In Northern Canada, the corresponding proportions were: 25.4% vs 21.1%, 50.2% vs 23.5% and 6.3% vs 8.6%. This report further noted that disease burdens may vary among First Nation, Inuit and Métis peoples, but did not have data stratified by these groups.<sup>43</sup>

Social deprivation is also at the root cause of violence, an important contributor to premature mortality, particularly among communities subjected to economic and social deprivation, especially affecting US populations of colour. In 2007, the rate of homicides involving White victims was 3.3 per 100 000, whereas that with Black victims was 20.9 per 100 000 (with Black males as victims: 40.6 per 100 000).<sup>44</sup> In Canada, the homicide rate in 2008 was 1.8 per 100 000. Although the Canadian data are not provided by racial or ethnic group, the variation among provinces suggests that regions with a high proportion of Aboriginal communities are affected the most, e.g. Nunavut: 12.7 per 100 000, Northwest Territories: 6.9 per 100 000).<sup>20</sup>

Epidemiological research has also brought into view additional health inequalities that exist along side

with, and are often modified by, socio-economic position and race/ethnicity. These include health inequalities in relation to gender, sexuality, disability and other social divisions involving adverse discrimination and/or economic and social deprivation.<sup>9,45–49</sup> Although it is beyond the scope of this article to review these dimensions of health and social position, it is important to stress that epidemiological research on and monitoring of these types of health inequalities, singly and in combination, is on the rise.

## Current status of epidemiology training and resources in North America

### Academic institutions and training

A systematic review of university websites revealed a total of 150 academic institutions in Canada and the USA offering graduate training in epidemiology (Table 4). In Canada, there are 16 public institutions, and in the USA 88 public and 46 private institutions offering epidemiology training. Epidemiologists within North America typically possess one or a combination of the following four degrees:

#### Master of Public Health

The Master of Public Health (MPH) is the foundational degree in professional public health, and the most common degree in public health offered by academic institutions throughout the USA and Canada. Although only a subset of these programmes offer a concentration in epidemiology, all MPH programmes include training in basic epidemiologic concepts and methods. The MPH degree typically takes 2 years of full-time study to complete and often requires completion of an independent research project or thesis.

In addition to epidemiology, MPH programmes provide training in the other four domains of public health including: Biostatistics, Environmental Health Sciences, Health Policy and Social and Behavioural Sciences. Many programmes allow students to concentrate their studies within one of the five core disciplines, whereas others emphasize a particular

population of interest. The MPH prepares students to enter a variety of positions in the public health field including research, health policy, public health practice and health services management.

#### Doctor of Public Health

The Doctorate of Public Health (DrPH) degree, granted exclusively by US institutions (as of this writing), is an advanced professional degree aimed at educating future leaders in public health practice. Most programmes require a prior degree in public health, as well as practical work experience in the public health field for admission. On average, the DrPH takes 3–4 years of full-time study to complete.

Typical DrPH degree programmes aim to integrate and advance the five core fields of public health and focus on solving problems at state, regional, national or global levels. The DrPH differs from the PhD by emphasizing the development of advocacy, communication and management and leadership skills to enhance the students' abilities to act as effective leaders. The DrPH degree prepares one to become a high-level health policy-related researcher, policy-maker or practitioner capable of addressing complex public health issues.

#### Master of Science in epidemiology

The Master of Science (MSc) in epidemiology is the foundation academic degree in epidemiology and is aimed at those who seek to become research and clinical epidemiologists. On average the MSc takes ~2 years of full-time study to complete and often requires the completion of an independent research project or thesis report.

The typical MSc in epidemiology degree provides training in the causes, distribution, control and prevention of diseases in populations. The MSc differs from the MPH in that it focuses solely on epidemiological theory and methods and does not require study of the general public health field. The MSc in epidemiology prepares students to become researchers, clinical investigators and educators in academia, the government, the private sector and also in non-government organizations (NGOs) and community-based organizations (CBOs).

**Table 4** Number of academic institutions offering degrees in epidemiology in North America

Country	Type	Professional degrees		Academic degrees		Other*
		MPH/MSPH	DrPH	MSc	PhD	
Canada	Public	10	0	12	8	–
United States	Private	41	9	13	21	6
	Public	81	20	25	37	3
Total		132	29	50	66	9

Numbers reflect the results of a systematic search of academic institutions in the US and Canada.

\*Other includes programmes outside the typical MSc or MPH in epidemiology, which include substantial study of epidemiology theory and methods, e.g. MSc in Clinical and Translational Science.



**Doctor of Philosophy in epidemiology**

The PhD in epidemiology is an advanced academic degree typically pursued after completion of the MSc or MPH. The PhD degree takes ~4–5 years of full-time study to complete, and requires the completion of a doctoral dissertation involving an independent research, consisting of collection, processing and analysis of original data. The PhD degree furthers students' knowledge of the causes (whether social, behavioural, microbiological, environmental or genetic determinants), distribution, control and prevention of disease in populations, and prepares students to become high-level epidemiologists in academia, the government, research institutions and the private sector, as well as in NGOs and CBOs. A similar degree, offered by some US institutions (e.g. the Harvard School of Public Health), is the ScD; the distinction largely has to do with whether or not universities allow professional schools to award PhDs.

Although a graduate degree is traditionally required to enter the field of public health, a number of academic institutions throughout Canada and the USA have developed undergraduate programmes in public health. Medical schools have also laid a greater emphasis on epidemiology over the past few decades. Many medical schools now offer joint MD/MPH programmes, and all of the 131 schools accredited by the American Association of Medical Colleges include 'preventive medicine' in their curriculum, of which epidemiology is typically a major component.<sup>50</sup>

Beyond academic institutions, federal, provincial and state agencies play the largest role in training epidemiologists. Federal institutions such as the Centres for Disease Control and Prevention (CDC), National Institute of Health (NIH) and Health Canada offer a number of internship and fellowship programmes in epidemiology. The CDC, for example, offers postgraduate training with the Epidemic Intelligence Service (EIS) and a fellowship programme with the Council for State and Territorial Epidemiologists (CSTE). Many state and provincial public health offices offer similar training programmes.

**Research institutions**

Universities and government agencies are the primary health research institutions employing epidemiologists in both Canada and the USA. Universities that offer graduate-level degree programmes in epidemiology typically have extensive research departments staffed by faculty, support personnel and students. Federal public health agencies such as the NIH and Health Canada also have intramural research departments, which often work in conjunction with academic institutions. Some provincial and state health departments also operate their own intramural research programmes, typically with oversight from federal institutions.

**National, regional and state/provincial institutions**

Neither Canada nor the USA has a single, defined national institute of epidemiology; however, both countries operate epidemiology-focused branches within their national health institutes. A systematic review of each country's government website revealed that the following institutes either conduct, utilize or monitor epidemiology research programmes.

**US National agencies with epidemiology components**

The major federal agency concerned with healthcare and public health in the USA is the Department of Health and Human Services (HHS). Within the HHS there are four subsidiary agencies that include strong epidemiology components.

**Agency for Health Care Research and Quality (AHRQ).**

The AHRQ is the health services research arm of the HHS and is responsible for sponsoring, conducting and disseminating healthcare research at a national level. The mission of the AHRQ is to improve the overall quality of healthcare research via systematic and continued evaluation of scientific evidence. It is considered a sister agency to the HHS's biomedical research arm, the NIH.

**CDC.** The CDC is the major health surveillance arm of the HHS and also the main agency tasked with public health prevention. The CDC's mission is to monitor and sustain the nation's health through strategies of detection, investigation, policy, education and leadership; it also supports research to evaluate and guide public health interventions. The CDC operates a total of nine national centres each specializing in an area of public health, including the National Center for Health Statistics, which is the nation's principal health statistics agency. The Council for State and Territorial Epidemiologists also operates under the CDC's jurisdiction, and provides a specialized taskforce for state, national and international epidemiology matters.

**Food and Drug Administration (FDA).** The FDA is the branch of the HHS responsible for sustaining public health through the regulation of food, drugs, medical devices, cosmetics and tobacco products. The FDA operates six product centres and one research centre, which utilize epidemiological methods to test and monitor the safety and efficacy of products.

**NIH.** The NIH is the arm of the HHS charged with overseeing biomedical research at a national level; although largely geared to clinical and basic science research, the mission does include aspects of public health research as well. The NIH is composed of 27 institutes and centres, each specializing in a particular domain of research based on diseases or organ systems, e.g. the National Cancer Institute (NCI), the National Heart, Lung and Blood Institute

(NHLBI) and the National Institute of Allergy and Infectious Diseases (NIAID). However, only two focus on health in relation to different periods of the life course, i.e. the National Institute of Child Health and Development (NICHD) and the National Institute of Aging (NIA). The National Institute of Environmental Health Sciences (NIEHS) focuses on environmental health, whereas both the NIH Office of Behavioral and Social Science Research (OBSSR) and the NIH National Institute for Minority Health and Health Disparities are charged with focusing on social determinants of disease distribution. Each NIH Institute and Centre maintains epidemiological information regarding its specific area of interest.

Additionally, outside the DHHS, two additional federal agencies with important health responsibilities that include epidemiology components are the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA). Each agency is involved with epidemiological monitoring and analysis of occupational and environmental exposures, respectively.

#### *US regional, state and local agencies with epidemiology components*

The US HHS Department also oversees 10 regional offices (Boston, New York, Philadelphia, Atlanta, Chicago, Dallas, Kansas City, Denver, San Francisco, Seattle) responsible for monitoring the health of their respective districts. Additionally, each of the 50 states and the District of Columbia operates a Department of Public Health, which employs an official state epidemiologist and a number of 'lead epidemiologists' depending on the size and need of the state.<sup>51</sup> State departments of health are responsible for monitoring the health and controlling disease outbreaks of the respective state populations. Many states also have county health departments that include epidemiology units, as do some of the larger city health departments (e.g. the New York City Department of Health and Mental Hygiene).<sup>52</sup>

#### **Canadian national institutions with epidemiology components**

Canada's primary federal agency for public health information and surveillance is Health Canada. Within Health Canada, the Public Health Agency of Canada (PHAC) is Canada's primary epidemiology institute. Statistics Canada and the Canadian Institute for Health Information (CIHI) are also essential sources of health-related information for epidemiologists.

**Health Canada.** As Canada's primary federal department of health, Health Canada acts a leader, regulator, funder, educator and producer of health research and information.

**PHAC.** PHAC is a subsidiary agency of Health Canada and is primarily concerned with public health research and policy. PHAC is responsible for monitoring, preventing and controlling disease on the national level.

**Statistics Canada.** In addition to being mandated to conduct the population census every 5 years, this federal agency produces many different surveys on virtually all aspects of Canadian life, many of which related to health.

**CIHI.** Funded by federal, provincial and territorial governments, CIHI is an independent, not-for-profit organization that provides essential information on the Canadian health system and the health of Canadians to stakeholders in government, policy-making and academia.

#### **Canadian regional and provincial institutions with epidemiology components**

Health Canada operates seven regional offices (British Columbia, Alberta, Manitoba and Saskatchewan, Ontario, Quebec, Atlantic, Northern) responsible for monitoring and promoting the health of populations in their respective districts. Each of Canada's 10 provinces and 3 territories operates its own department of health, commonly called the Department of Health and Social Services. Most provinces also have governmental disease control institutes, committees or taskforces, which are responsible for preventing and controlling disease outbreaks among their populations.

#### *Funding for epidemiological research*

Federal public health institutions are the largest source of funding for epidemiology research in both Canada and the USA. The principal funding source in Canada is the CIHR, which is a branch of Health Canada. The Canadian Public Health Association also offers funding opportunities, as well as many of Canada's provincial public health departments. NIH and CDC are the principal funding sources in the USA, whereas their umbrella department, HHS, also offers substantial funding opportunities for epidemiology research.

Charitable organizations represent the second major funding source for epidemiological research in the USA and Canada. Notable organizations in the USA include the American Cancer Society, American Association for Cancer Research, Alzheimer's Association, American Diabetes Association, American Heart Association and the Robert Wood Johnson Foundation among many others. A number of similar funding sources exist in Canada including the Heart and Stroke Foundation of Canada, Multiple Sclerosis Society of Canada, Canadian Cancer Society and the Canadian Diabetes Association.

### *Integration of training, research and public health activities*

Epidemiology training and research are inherently integrated in Canada and the USA due to the fact that academic institutions are among the largest producers of epidemiology research in North America. Academic institutions offering training in epidemiology typically possess wide-ranging research groups and centres staffed by both faculty and students, which publish thousands of journal articles annually. National and state/provincial public health institutes maintain close ties with academic institutions as they often contribute funding to academic research. It is not uncommon for epidemiology graduate students to conduct field work via cooperative arrangements with a government agency under the co-supervision of one or more scientists from that agency. Typically, these individuals also serve as members of the thesis or dissertation advisory committees for the students who are engaged in such university-agency arrangements. The NIH and CDC, in the USA, provide pre-doctoral and post-doctoral fellowships for intramural research in collaboration with selected universities.

### *Links to institutions outside the North American region*

North American epidemiology departments and academic programmes have multiple ties to institutions outside the USA and Canada. Nearly every large epidemiology department in Canada and the USA maintains staff devoted to global health studies. In fact, global health as an academic and research activity has attained a prominent status in many universities in North America, which maintain dedicated offices linked to the faculties of medicine and public health. Institutions such as Harvard, in the USA and McGill University, in Canada, maintain vigorous research programmes in Africa, Latin America and other resource-poor regions. North American universities and government agencies also play a prominent role worldwide in providing graduate training for foreign scientists.

International professional societies such as the International Epidemiological Association (IEA) and the International Genetic Epidemiology Association (IGES) and the International Society for Environmental Epidemiology (ISEE) provide professionals from all over the globe, a means of communications and avenue to distribute their scientific findings. Many professional organizations hold annual conferences, which allow for professional partnerships to be forged across continents.

Government agencies such as the CDC, NIH and Health Canada also have extensive global linkages. These links may take the form of subsidiary institutes such as the CDC's National Center for Emerging and Zoonotic Infectious Diseases, which provides international leadership in infectious disease epidemiology or specific campaigns such as CDC's Global AIDS Programme, which offers financial and

technical assistance to communities, governments and national organizations around the world.

A few notable academic institutions also emphasize the importance of global communication to further the field of public health. Columbia University's Mailman School of Public Health, for example, is one of the five international partners in the Centre for the AIDS Programme of Research in South Africa (CAPRISA), an NIH-funded Comprehensive International Programme of Research on AIDS (CIPRA), which conducts and disseminates epidemiological research in South Africa. Likewise, many US and Canadian universities have strong partnership commitments with sister institutions abroad to advance the mission of global health via research, policy-making and teaching.

## **Human resources for epidemiology**

### **Availability and job outlook**

In 2008, the United States Department of Labour estimated the number of currently employed epidemiologists to be 4800. The most common places of employment for epidemiologists include academic institutions, federal and state public health institutes, private sector research firms, pharmaceutical companies and charitable organizations that conduct health research. Median annual earnings for epidemiologists in the USA were approximately \$61360 in 2008.<sup>53</sup>

The US Department of Labour reported a better than average job outlook for epidemiologists in 2008, with a projected growth rate of 15% over the next decade.<sup>53</sup> This is consistent with the 2006 Epidemiology Capacity Survey conducted by the Council of State and Territorial Epidemiologists, in which the majority of state-employed epidemiologists reported a need for additional epidemiologists at the state level.<sup>51</sup> Reasoning for the projected growth rate includes the public's heightened awareness of bioterrorism, rare infectious diseases and the increased public health concern that surrounded the recent H1N1 outbreak in North America.

Although specific statistics on employment for epidemiologists in Canada are not available, the job opportunities for epidemiologists have been strong, based on the Canadian authors' observations. Admissions to degree programmes have increased and graduates invariably are able to secure employment in government, academia or in the private sector. Funding for health research has declined slightly in recent years, both in the USA and in Canada. However, this has not translated into an apparent shortage of opportunities for epidemiologists to further their careers.

### **Professional societies**

A systematic review of professional societies for epidemiology identified approximately 16 professional



**Table 5** Professional societies of epidemiology with a basis in North America

Country	Society	Established	Members	Primary Journal
Canada	Association of Public Health Epidemiologists in Ontario	1991	75	–
	Canadian Public Health Association	1910	1298 (46 Epidemiologists)	–
	Canadian Society for Epidemiology and Biostatistics	1990	–	–
USA	Saskatchewan Epidemiology Association	–	–	–
	American Academy of Pediatrics – Section on Epidemiology	1988	500	–
	American College of Epidemiology	1979	–	<i>Annals of Epidemiology</i>
	American College of Preventive Medicine	1954	2400	<i>American Journal of Preventive Medicine</i>
	American Diabetes Association Council on Epidemiology & Statistics	–	–	–
	American Epidemiological Society	1927	400	–
	American Public Health Association	1872	30 000	<i>American Journal of Public Health</i>
	American Statistical Association(ASA), Section on Statistics in Epidemiology	1992	–	–
	Association for Professionals in Infection Control and Epidemiology	1972	13 000	<i>American Journal of Infection Control</i>
	Society for Epidemiologic Research	1968	–	<i>American Journal of Epidemiology</i>
	Society for Healthcare Epidemiology of America	1980	1800	<i>Infection Control and Hospital Epidemiology</i>
Society for Pediatric and Perinatal Epidemiology	1988	223	–	
Society for Analysis of African-American Public Health Issues	–	–	–	

Data based on a systematic search of professional societies' websites. International professional societies were not included. Major publications included academic publications authored, sponsored or published by the respective professional society.

societies located in Canada and the USA (Table 5). These societies play an important role in epidemiology education, professional standards, research collaboration and in dissemination of research findings to the greater scientific community. Most societies hold annual conferences and training sessions to promote professional development and provide continuing education. Many organizations sponsor prestigious epidemiology journals, whereas some publish their own independent newsletters. In addition to regional societies, a number of international epidemiology societies, such as the International Epidemiological Association, exist in which Canadian and American epidemiologists play an active role.

## Scientific productivity by epidemiologists

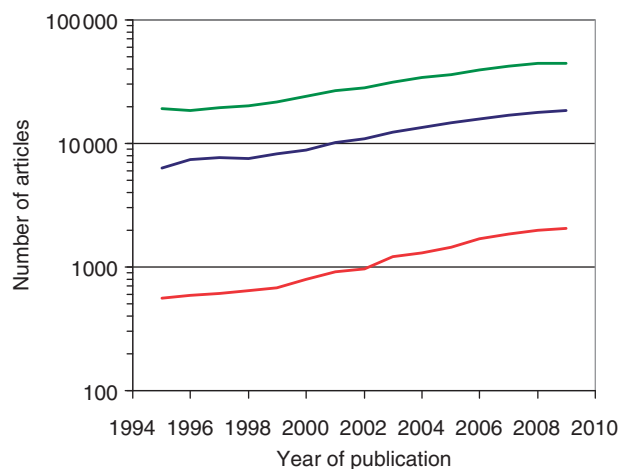
### Bibliometric analysis

We conducted a systematic search of Medline combining the search terms 'exp Epidemiology',

'epidemiol\*.tw.' and 'epidemiology.fs.' with the logical operand 'OR'. This search revealed all Medline-indexed journal articles containing 'epidemiology' as a MeSH term, text word or floating subheading. The search was then limited by year of publication for the years 1995–2009. The resulting counts were recorded as the total number of epidemiology papers published worldwide for the years 1995–2009. To determine the number of epidemiology papers published in the USA, the initial search was rerun and combined with the search limitation '(USA or United States).in.', which determined all journal articles whose first author is associated with an American institution. To determine the number of epidemiology papers published in Canada, the search limitation 'Canada.in.' was added, which determined all journal articles whose first author is associated with a Canadian institution. These searches were then systematically rerun for the years 1995–2009.

In all, the above analysis (Figure 9) revealed that US and Canadian sources have collectively produced 29.8% of the total number of epidemiology





**Figure 9** Number of epidemiology papers indexed on Medline 1995–2009. Canada: red line (bottom); USA: blue line (middle); Rest of the world: green line (top)

publications on average since 1995. US sources account for 27.2%, whereas Canadian sources were responsible for 2.6%. In relative terms, the percentage of articles from US sources increased from 24.1% in 1995 to 28.6% in 2009, whereas those from Canadian authors went from 2.1% in 1995 to 3.2% in 2009. The number of epidemiology journal articles indexed on Medline increased from 26 175 in 1995 to 64 972 in 2009, a 150% increase. The number of epidemiology publications from US primary authors increased 194% during this period, whereas publications from Canadian universities increased 267%. It should be noted that although widely used for bibliometric analyses, Medline is a North American database and thus our results may overemphasize the number of North American journals relative to the rest of the world.

### Role in prevention and control

North American epidemiologists have played prominent roles in elucidating the causes of important diseases. Possibly, the most recognizable contribution by epidemiologists in the region is that of the causal relation between smoking and lung cancer. In the first half of the 20th century, two pioneer epidemiological studies were conducted in the USA, by Ernst Wynder and Evarts Graham, of Washington University and by Morton Levin and colleagues, from the Roswell Park Memorial Institute. The successful eradication of smallpox in the late 80s and the nearly complete eradication of poliomyelitis (caused by poliovirus type 2) stems from a global effort that included teams of epidemiologists and policymakers from the North American region working on behalf of federal agencies in the USA and in Canada and at the Pan American Health Organization.<sup>54</sup>

During the later part of the 20th century there was a shift in epidemiological study focus from the

aetiology and transmission of infectious diseases to chronic diseases and the identification of both diverse risk factors and the social determinants of health.<sup>55</sup> This shift, however, was challenged by the onset of the AIDS epidemic in 1981 and growing attention to other emerging infectious diseases, along with growing recognition of the role of infection in the aetiology of cancer and other chronic diseases. Advances in scientific technology and epidemiological methods and theories have allowed epidemiologists to address more diverse questions and broaden their scope to include social, behavioural, environmental (physical, chemical and biological) and genetic risk factors.<sup>27,50,56</sup> North American epidemiologists have made key methodological and substantive contributions since the mid-1950s.<sup>57</sup>

Among epidemiology's most impressive accomplishments of the past decades are the discoveries that hepatitis B (and also hepatitis C) viruses are causally associated with liver cancer and genital infection with certain oncogenic genotypes of human papillomavirus (HPV) as a cause of cervical and other anogenital cancers, as well as of oral cancer. These discoveries led to major advances in the control of these common cancers globally. For women worldwide, the identification of HPV as a necessary cause of cervical cancer led to the development of HPV vaccination and new molecular methods to screen for this disease. Although a Nobel prize was awarded to the scientist who conducted the prominent basic biological work on HPV, epidemiologists (many from North America) played a major role in that discovery.<sup>58</sup>

Social epidemiologists in both the USA and Canada have also contributed, substantively, methodologically and theoretically, to work revealing the existence—and also recent widening—of health inequalities and to research elucidating the social determinants of health, including how they operate over the lifecourse and at multiple levels.<sup>9,59–61</sup> The first two textbooks focused on social epidemiology<sup>59</sup> and its methods<sup>60</sup> were published in North America in the first decade of the 21st century; the first textbook to offer a comprehensive account of epidemiological theories of disease distribution, past and present, and their implications for understanding population health and addressing health inequities, is likewise of North American origin.<sup>9</sup> Underscoring the contributions of social epidemiology to shaping public health priorities, in 2000 the US Healthy People objectives, for the first time since their inception in 1979,<sup>62</sup> drew on social epidemiological findings to set as the twin objectives both (i) improving population health overall (the overall goal of all prior reports) and (ii) reducing health inequalities,<sup>63</sup> objectives that are further elaborated in the proposed Healthy People 2020 goals.<sup>63</sup> Initiatives to monitor health inequalities and to promote health equity are also increasingly prominent in the activities of US state and local health departments.<sup>52,64</sup>

## Main challenges for epidemiologists in the future

Among the main challenges facing epidemiologists in the future, and others in public health and medicine, as well, is the continued identification and control of critical risk factors, pre-disposing biological characteristics and the broader societal determinants of health which influence their distribution, and thereby shape population health overall. Although tobacco use has been identified as a leading risk factor for lung cancer and heart disease, much still remains to be done to decrease smoking prevalence rates—and social inequalities in these rates—among the Canadian and US populations (in 2004 these rates were 23 and 21%, respectively), with highest rates among those most subjected to economic and social deprivation.<sup>10,15,18,65</sup> Similarly, the marked increases in overweight and obesity in North American populations must continue to be addressed, including their overrepresentation among those with the least resources.<sup>15,66</sup> In 2004, these at-risk groups represented 49 and 59% of the Canadian and US populations, respectively.<sup>10,15</sup> The aforementioned social differential that may explain the high homicide rates for certain racial groups or communities (e.g. Blacks in the US and First Nations in Canada) is also a key challenge for epidemiologists in the region.

One critical determinant for epidemiologists to address in the coming decades is age. The median age of the world's population is expected to significantly increase in the coming decade due to increases in life expectancy, declines in fertility and the ageing of the 'baby boom' generation born following World War II. Whereas the increase in life expectancy speaks of the success of past public health interventions, it also presents future challenges such as the increased burden of chronic illnesses, injuries and disability among older adults. In all, the latter conditions as well as cognitive and physical impairments pose a major threat to the overall quality of life among the elderly. In order to address these impending problems public health agencies will need to expand their research initiatives to include health promotion and prevention (and care) of disease and disability in older adults with a focus on quality of extended life.<sup>67,68</sup>

A second major challenge facing the epidemiology profession in the coming decade is effectively utilizing the rapid advances in scientific technology. Scientific advances have provided increasingly complex and specialized technologies and subspecialties, such as molecular, genetic and pharmaco-epidemiology. Whereas these subspecialties hold immense promise in terms of furthering public health initiatives, the subspecialized nature of these groups may give rise to a resource problem. Many of epidemiology's most promising subspecialties are likely to face a capacity crisis in the coming decade due to the extensive and

complex training necessary to conduct the type of high-quality research expected by North American epidemiologists.

Epidemiology's emerging subspecialties also highlight the future challenge of standardizing educational competencies. Partly due to the fact that epidemiological methods are continuously evolving, there still remains to be a consensus on the fundamental training methods of epidemiology graduate programmes across North America.<sup>69</sup> There is also growing awareness of the need to improve epidemiologists' training in the concepts, as well as methods, required to analyse determinants of health, including societal determinants, across the lifecourse and at multiple levels.<sup>9,27,59,60</sup> Heterogeneity in epidemiological training highlights the increasingly diversified nature of the epidemiology field, and raises concerns regarding the fundamental competencies of the profession. Ensuring a baseline of commonly understood concepts and methods in epidemiology education and training, therefore, presents another challenge that must be faced by the profession in the coming decades.<sup>70</sup> In part, this is being addressed by the new certification in public health examination advanced by the National Board of Public Health Examiners for graduates of Council for Education in Public Health accredited schools of public health both in North America and other countries. Epidemiology is one of the five core areas in this examination.

In practical terms, funding for epidemiological research has also become a primary concern. Not uncommonly, case-control studies can cost several hundred thousand dollars and cohort studies typically incur multi-million dollar budgets. Specialized exposure collection instruments and obtaining biomarker data can represent the greatest cost items for epidemiologists and imply assembling large multi-disciplinary research teams. Genome-wide association studies require complex and costly high-throughput gene sequencing technologies and frequently involve multi-phase studies that include thousands of cases and controls. For adequate statistical power and cost efficiency, such studies often need to be done by consortia of teams worldwide. Because of their prohibitive costs, very few single agencies are capable of funding such initiatives.

Although great achievements have been made in North American epidemiology over the past several decades, these achievements have not completely translated into equitable benefits to the global community—nor all residents of North America. In addition to persistent and in some cases growing health inequalities within both Canada and the USA, the advances of the public health movements in the global North have often meant that public health problems are spread and disproportionately shifted from high-resource countries to low-resource countries, and from rich populations to poor populations. The gains in regulating and curbing tobacco use in

countries of the global North, for example, has encouraged the tobacco industry to move much of its marketing to the global South, with the consequence that more people are exposed to tobacco today than ever before. Similar shifts have occurred for certain occupational carcinogens and hazards associated with certain industries. Although the source of these disparities are primarily political and is a concern to professionals from all health-related disciplines, North American epidemiologists must recognize the global responsibility, inherent in their scientific advances and discoveries. This is especially true considering that population health research suffers from the same 90/10 paradigm that we see in

pharmaceutical research—only about 10% of the world's health research funding is allocated to the 90% of the world's health problems, which occur in populations in the global South.<sup>71</sup>

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### KEY MESSAGES

- Relative to the rest of the world, the USA and Canada have high average life expectancy at birth; with non-communicable diseases representing a major component in proportional mortality.
- Health indicator measures are consistently worse in the USA than in Canada for many outcomes, although typically by only marginal amounts.
- There are socio-economic and racial/ethnic disparities in health indicators and risk factors in the USA and, to a lesser extent, these social inequalities also exist in Canada.
- North American epidemiologists are faced with challenges in studying social determinants of disease distribution and the underlying inequalities in access to preventive services and healthcare.

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