Chapter 1

EPIDEMIOLOGICAL APPROACHES TO POPULATION HEALTH

Stephen Bezruchka

Introduction

Epidemiology is the study of health and its determinants in specified populations with the often unstated goal of improving health. The root word, "epidemic," derives its origin from a study of the causes of diseases. The word has been so used for the last 125 years, and epidemiology as a discipline is mainly concerned with illness or disease rather than health and well-being. This chapter traces the historical roots of epidemiology's evolution, its main concepts, and discusses how the way it is practised limits its potential to improve the health of populations. This chapter considers what health means at various biological and social levels, and the sources of health in populations. It is argued that the gap between rich and poor in a society is the key factor in producing health. The gap likely matters most in early life, somewhere between conception and age five. Discussion of various natural experiments will help the reader to grasp this concept.

Early Epidemiology

The origins of epidemiology and a classic example of its approach come from John Snow, who studied people who succumbed to cholera in London 150 years ago (Gordis 1996). By plotting the incidence of death on maps, he discovered an association between deaths in various districts and the sources of drinking water. He went door to door, counting deaths and asking about those homes' water sources. He hypothesized that the scourge was spread by contaminated water from evacuations of infected people. Once these sources were identified, Snow removed the offending pumps' handles even though he did not understand that it was bacteria that spread the disease. Subsequently, deaths declined.

As Snow demonstrated, if we wish to produce health, we can do so without understanding all the links between the causes and outcomes of disease. When Snow's study is discussed in standard textbooks, the action he undertook to control the epidemic is rarely mentioned. This lack of concern with improving health once the causes of disease are identified is all too common in the practice of epidemiology today. Epidemiologists mostly conduct studies and report results. Action is

not usually considered part of the discipline's domain. This reality can be equated with going to the doctor to find out what is wrong with you and then finding a non-physician (who was often a barber in medieval Europe) to provide treatment. We need a more positive and action-oriented approach to producing health.

Another health official in London at that time, William Farr, the registrar-general in London, recognized that poverty was an important contributor to poor health (Farr 2000). Others, before and since, have remarked on this, and usually consider that the factors responsible for poor health are the behaviours and environmental exposures associated with poverty. In this chapter, we scientifically develop the concept that there is something intrinsic about poverty or deprivation, both material and relative, that is unhealthy. This approach is also missing from many standard public health texts. Curricula in medical schools and specialty training programs almost entirely neglect this perspective. If studies demonstrate the critical importance of relative and absolute deprivation, but there is no action by epidemiologists, we may wonder why there is no equivalent response to removing the pump handle.

Health as a Concept Differs on the Level Being Considered

This section considers health from a cellular level, then at an individual human level, and finally at the population level to give a perspective on how health can be produced within a society. Consider a human being and ask of what an individual consists. In biology classes we looked at cells under a microscope and saw small structures with nuclei and chromosomes in which DNA resided. There were also cell walls that contained proteins and energy sources. Cells come in many varieties: heart muscle cells, brain cells, lung cells, blood cells, and so on. As a medical student, I spent considerable time learning the different features of those cells, and how to identify them.

In one sense, you and I are nothing more than a community of different kinds of cells grouped together in various organ systems. These organs include our nervous system, which makes our limbs move when and how we want them to; our digestive system, which extracts and stores nutrients from food; our respiratory system, which extracts oxygen from the atmosphere to allow our cells to breathe; our cardiovascular system, which moves oxygen and energy to various parts of our body, and scavenges waste; our musculoskeletal system, which allows us to maintain our shape and move, and so on. Our bodies consist of cells arranged in these various communities, along with water and some other biochemical material.

Suppose we isolate one of these cells, such as a heart muscle cell, and ask what that cell would need to be healthy. Cell biologists would say that a cell needs nutrients and oxygen. Glucose is the key nutrient or energy substance in our blood that powers cells. Oxygen is necessary as well as a few trace elements. The same is true for other cells. If your heart cells do not get enough oxygen or glucose because of a faulty nutrient-delivery system, these cells die and you will have a heart attack. The same is true for any cell in the body. If it is not nourished properly, the cell

will not work as it should. Such cells will not be healthy and premature death may occur. Later we will review evidence suggesting that cells in poorer people are not as healthy as cells in those with higher incomes and status.

The argument could be made that since human beings are but an assembly of cells that need oxygen and glucose plus some trace elements, then humans need just what their cells need to be healthy. If cells benefit from oxygen and glucose, then the more of these we get, the better our health will be. We should consume as much food as possible to get as much glucose as we can, and breathe as much oxygen as we can. Then since each one of our cells will be healthy, so should we.

But stuffing ourselves full of food is folly as our increasing obesity rates demonstrate. Healthy adults breathing high concentrations of oxygen over long periods get lung disease, and babies given pure oxygen go blind. The logic of doing what is best for our component parts—our cells—and generalizing this prescription to the community of cells that comprise a human being may not be the best health advice for us as humans.

At the individual level—the community of cells that comprise each of us—our health is improved by following all the dos and don'ts such as eating healthy foods, exercising, not smoking, wearing a seat belt, using a condom, and getting a good night's sleep. That is good health advice for an individual human. None of those recommendations make any sense to one of your cells. You cannot ask cells to exercise, not smoke, wear a seat belt, get a good night's sleep, and so on. That isn't what cells can choose to do. There are no cellular-relevant versions of health advice for individuals.

If you follow health advice for individuals, your cells should be healthy as a by-product. If you exercise, eat right, and don't smoke, then your heart muscle cells should be healthier than if you didn't follow those behaviours. If you do what is best for an individual human to produce health, your cells will be healthier than if you don't. Individual health advice is for individual humans, cellular health advice is for cells, and we should keep them separate because humans are a community of cells and how the cells are organized (pun intended) must be considered.

What about other levels of organization such as communities, states/provinces, or nations? These locations contain populations of humans. Is it logical to assume that what is the best advice for the constituents of that population—namely, you and I—would be the best health advice for the population? Our health advisers tell us that we should exercise, eat properly, not smoke, wear seat belts, use condoms, and our population will be healthy. Are they making the same mistake that I pointed out in applying health advice for a cell to an individual human? Looking at Japan's population suggests that there may be considerable reason for rethinking our health advice to populations of all rich countries. The Japanese smoke the most, yet they lead the world in good health (Bezruchka et al. 2008). We have all learned how bad smoking is for our health, but compared to other factors that affect a population's health, the effect of smoking may be secondary.

There are population-level health-producing factors that have no individual-level counterparts, just as health advice for individuals has no cellular-level counterparts. If the population factors are right, then what individuals in that population do or don't do for their own health may not matter as much. They are healthy as a by-product of the way the jurisdiction is organized, just as our cells are healthy if we do what's right for us as individuals. If this is the case, then we can produce the population factors in a particular society and obtain health, or we may decide to organize society in such as way that the population will not be healthy. Canada as a nation has more of this population health framework than the U.S., for example, although citizens in Canada as elsewhere tend to be unaware of how population-level factors impact their health. The task of epidemiologists and others working for health is to make them aware.

Associations of cells as organs and the factors that produce disease in these organs are the primary concern of most epidemiologists. They study the incidence and prevalence of diseases such as heart disease, lung cancer, and Alzheimer's and attempt to identify the precipitating factors that lead to these afflictions. This focus leads the discipline to consider risk factors in an individual that produce unhealthy organs. A risk factor is a behaviour or other characteristic that is associated with the condition studied. Such a focus may not be more effective than looking at the health of a cell. Removing the pump handle as John Snow did affected a population. Such population-level actions may be preferable to trying to get individuals in London to modify their risk factors that affect intestinal (or-gan) health (cholera), such as boiling their water, or walking to another pump. It is increasingly apparent that we need to look for the equivalent of removing a pump handle in modern society.

The Cause of the Cause
There is an Indian story—Clifford Geertz, the famous anthropologist, recounts hearing it as a story from India—about an Englishman who, having been told that the world rested on a platform on the back of an elephant, which rested in turn on the back of a turtle, asked what the turtle rested on. Another turtle. And that turtle? "Ah Sahib, after that it is turtles all the way down."

In any discussion of disease and the causes of disease, we can look at the cause of the cause of the cause—that is, we need to go back to the source of the problem. This can be difficult since discussion of disease and its causes is often limited by various societal norms and understandings as to the appropriate way to identify and deal with a problem. There are six questions to ponder. What are the facts? What is the interpretation of the facts? What are the presuppositions that frame a discussion? What questions are you not supposed to ask? In looking at the health of populations, what are the basic foundations of health? What is the turtle at the bottom of the pile of turtles?

Population Health Epidemiology

John Snow went door to door in what is called "shoe leather epidemiology" to collect information on water sources and deaths. Such observational data form the backbone of epidemiologic investigations. For a disease-focused approach, one needs to know whether or not someone has the disease, and then obtain a variety of supplemental information to discern what is going on. Suppose one studied lung cancer in a population where everyone smoked. It would be very difficult to identify smoking as a cause of lung cancer if you studied the disease in a population where everyone smoked since you could not compare the incidence of disease between smokers and non-smokers. Smoking as a risk factor for lung cancer would not be apparent. The kinds of questions asked to study health in a population depend on the characteristics of that population and the questions themselves. If you ask the wrong question, or study the wrong population, you will be led astray as suggested by our smoking example. Today the term "social epidemiology" reflects the population or societal level of analysis.

One could ask why "turtles all the way down" are not the focus in epidemiology today. Epidemiologists have graduate training (usually in public health schools) and work in public health departments at various levels. Their employers tend to have a narrow focus, and their projects are short term and focused on behavioural interventions. These foci may not be the most effective in producing health. Much research is done by private businesses or federal agencies with close ties to private business. Many consider public–private partnerships to be the best way of addressing problems in society. Despite the global economic collapse brought about by bankers in the U.S., credence is still given to the business model and so-called free markets in facilitating positive social and health change. The theme is often to create a product, a drug, or an instrument for a procedure or a communications campaign. The focus is likely to be on individuals or their organs. The outcome is usually something an individual should do or purchase: Ask a doctor about a drug. Eat this food. Use this exercise appliance. There are severe limitations with this illness or disease focus (Schwartz et al. 1999).
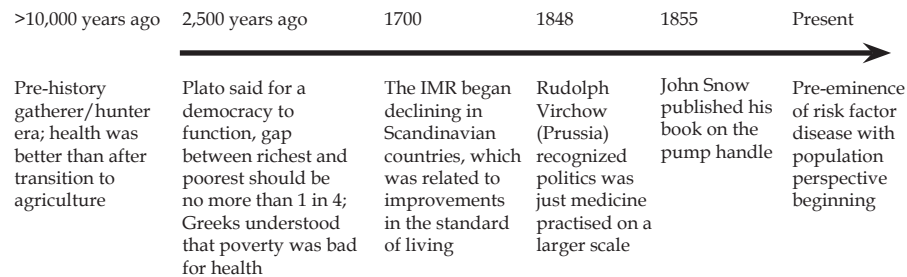
Another explanation for the kind of work done by epidemiologists relates to the development of powerful computers. This allows analysis of complicated studies of individual diseases. The focus on the individual and the ability to process vast amounts of data keep many researchers stuck in the individual risk factory. At the same time studies demonstrate how difficult it is to change individual behaviours, especially by telling people what they should do. We should not neglect basic treatments of populations comparable to removing the pump handle.

A common approach in modern epidemiology limits the validity of discoveries. In most contemporary studies of diseases there is a problem similar to studying lung cancer in a society where everyone smokes. Unless you look at people who are similar in important respects, you won't find what you are looking for. They must

have similar incomes, or education, or wealth, or status in society. In the jargon of epidemiology, you have to control for socio-economic status in a study, or you won't find an effect. Controlling means that you factor out the importance of that variable in the analysis. Then you cannot ask questions about the variable. Hence socio-economic status must be very important in producing health. If it wasn't, then one wouldn't need to control for socio-economic status in studying other factors. How you frame the question profoundly impacts what answer you get.

Defining a disease can be very political (Illich 1976). Homosexuality used to be labelled a disease in medical textbooks in the U.S., and it still is in some countries. On the other hand, in Canada formal unions among gays are sanctioned, and it is no longer considered a disease here. Fibromyalgia and chronic fatigue syndrome are conditions that haven't yet appeared on the universally recognized disease stage, but are termed "contested illnesses." A disease focus may provide much useful information in treating individuals, but this schema may not help produce health in populations (Evans and Stoddard 1990). The Lalonde Report, named after the then minister of health in Canada and published in 1974, was the first government publication that drew awareness to the distinction between health and health care.

Figure 1.1: Time-line

>10,000 years ago	2,500 years ago	1700	1848	1855	Present
Pre-history gatherer/hunter era; health was better than after transition to agriculture	Plato said for a democracy to function, gap between richest and poorest should be no more than 1 in 4; Greeks understood that poverty was bad for health	The IMR began declining in Scandinavian countries, which was related to improvements in the standard of living	Rudolph Virchow (Prussia) recognized politics was just medicine practised on a larger scale	John Snow published his book on the pump handle	Pre-eminence of risk factor disease with population perspective beginning

## Learning from Health Data on Populations

To understand what produces health in a population we need to define health. The World Health Organization states that "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." A more measurable definition might be asking individuals how healthy they consider themselves on a scale from very unhealthy to very healthy. This is termed "self-assessed health" (SAH). For a population, consider the average length of life (life expectancy), or the infant mortality rate (IMR). Out of 1,000 infants born, the IMR measures how many die in their first year of life. These can give us numbers, allowing us to ask what may maximize health. SAH measures mirror mortality

measures when measured in a culturally similar population, and is often used to study factors affecting the health of populations.

IMR is a more sensitive measure than others since early life is so critical to adult health considered broadly. The U.S. Central Intelligence Agency monitors countries' IMRs because if that measure is increasing, it portends political instability (Esty et al. 1998). To determine the life expectancy of a population, one needs the dates of births and deaths to calculate age-specific death rates in a given year. One then constructs a table in which a hypothetical population would die at those rates and determine the average length of life. The number of person years lived by the population gives you this number. Life expectancies are computed for all countries recording vital events, births, and deaths.

The United Nations' annual *Human Development Report* is a convenient data source (UNDP 2007). The top 30 countries are shown in Figure 1.2. For the data reported in 2007, estimating life expectancy for 2005, the range is from 82.3 years for Japan to 40.5 for Zambia, the least healthy in our list of 185 countries. We understand vital signs of individuals, the measures that are taken when we visit a medical clinic. Often someone measures our pulse, blood pressure, and temperature. If those numbers are far from what is considered normal, they can indicate the need to act

Figure 1.2: Health Olympics 2005
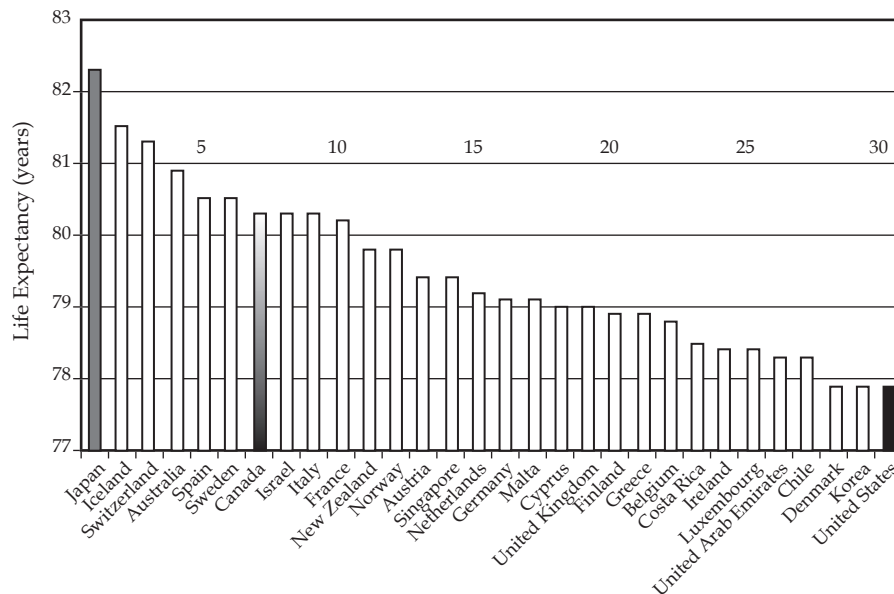
Source: UNDP, *Human Development Report* (New York: United Nations Development Programme): Table 1.

quickly. If someone tells me in the ER that a patient's blood pressure is 60/30 and has a pulse of 200, I'm there in a heartbeat. If the blood pressure is 120/70 with a pulse of 60 and a temperature of 37°C, I can take my time. We are not so familiar with life expectancy as a health measure for a population.

To get a sense of what small differences mean, consider calculating life expectancy in the United States in 2001 with and without the 3,000 deaths of September 11. It would make only a 0.01 year difference. New York City did this exercise for that jurisdiction alone and found a difference of 0.2 years for men and 0 for women. Tiny differences in life expectancies can translate to huge disparities in deaths. The U.S. is undoubtedly the world's richest and most powerful country with almost half of all billionaires and vast military might, yet it is far from being the healthiest. Canada is much healthier and Japan leads the world. The U.S. is only 4.5 years behind Japan, which seems insignificant. Another perspective is that if the U.S. eliminated heart disease as a cause of death, its number one killer, it still wouldn't be the healthiest country. The 4.5-year health gap is huge! No U.S. doctor could envisage curing heart disease.

Fifty-five years ago, best estimates would put the U.S. in the top five, and Japan would be considerably below the 30th ranking enjoyed by the U.S. in 2005, so there has been a profound deterioration in health in the U.S. compared to other countries. Figure 1.3 presents life expectancy trends for five countries from 1960 to 1982, demonstrating how Japan's health improved faster in comparison to other rich countries, and how the U.S. became last in that cohort.

Imagine how excited John Snow must have been to draw his revealing maps. Our graphs of the "Health Olympics" provide similar insight. The U.S. and Japan have more than changed places. Why? Epidemiologists can collect other data such as measures of health care, air pollution, smoking rates, economic growth, dietary habits, education, etc., to see if there is some association between those data and our measure of health. This is termed looking for confounders or other explanations. Consider health care. An easy measure is the per-capita expenditure. The U.S. spends half of the world's health care budget, about U.S. $7,200 per person in 2006, in total as much as every other country combined and more than double what Canada spent.

The U.S. is clearly not buying health with its health care dollars. We naturally assume that health and health care are synonymous, but they are not. We must ask: "Do you want health or health care?" We will later consider a study from Winnipeg for insight. Similar analyses demonstrate that none of the usual factors explain why the U.S. is so unhealthy. We discovered that men in Japan smoke the most of all the countries shown in Figure 1.2! The U.S. has the lowest prevalence of male smoking among those countries (Shafey et al. 2003). You could conclude that smoking is what makes Japan so healthy. Another interpretation is that although smoking is not good for your health, other factors are worse and they supersede the bad effects of smoking. Richard Wilkinson is an economic historian and epidemiologist

Figure 1.3: Life Expectancy Trends of Selected Countries: 1960–1982
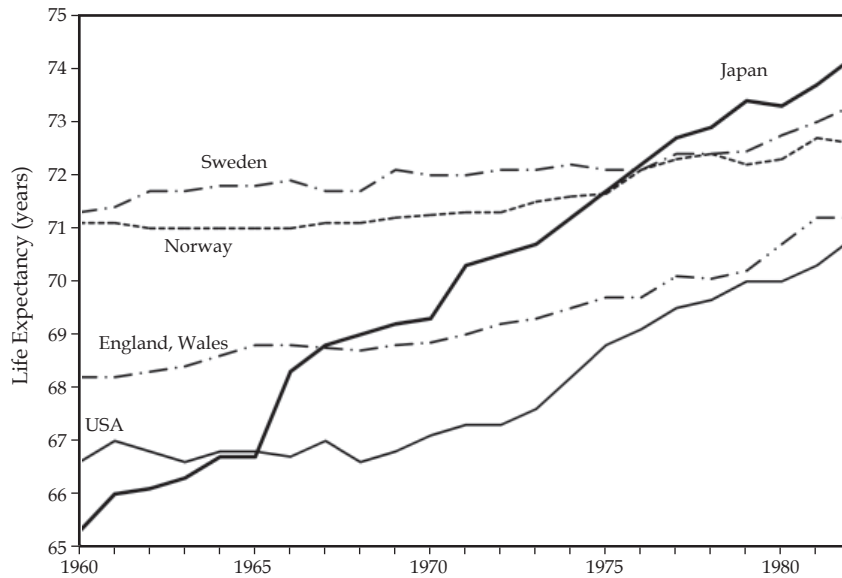
Source: S. Bezruchka et al., "Improving Economic Equality and Health: The Case of Postwar Japan," *American Journal of Public Health 98*(4) (2008): 589–594.

who has been studying the health of countries for decades, trying to determine the factors related to their health. He demonstrated that the usual factors did not offer satisfactory explanations. By 1986 he had found that the gap between the rich and poor in a country appeared to be correlated with the population's health. This was not something commonly considered, but by 1992, his findings were published in the *British Medical Journal*.

Figure 1.4 presents his study with life expectancy data for 1981 for 11 countries. You can see how well a country's health lines up with how much income the bottom 70 percent of households earn. This paper helped spawn the study of population health today. Association does not assume causation. How do we interpret the studies that epidemiologists produce? Guidelines have existed for at least 50 years, and were summarized in the U.S. surgeon general's report of 1964 linking smoking and bad health.

To consider a finding to be causative, there would have to be many studies on different populations, by different investigators, on different time periods that demonstrated the association. There must be a dose–response relationship—that is, more of one should produce more of the other. The chicken-and-egg dilemma

Figure 1.4: Income Distribution and Life Expectancy
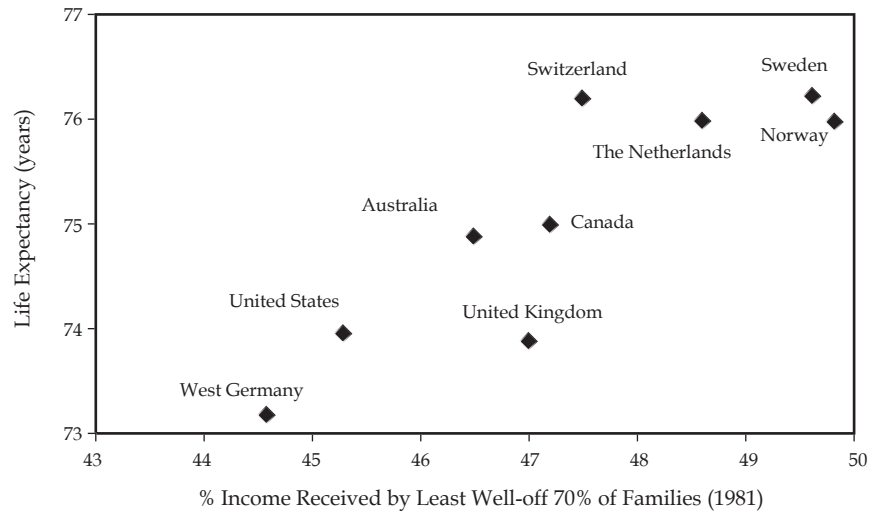
Source: R.G. Wilkinson, "Income Distribution and Life Expectancy," *BMJ 304*(6820): 165–168.

needs to be determined. Which direction does the cause operate? And finally, there had to be some pathologic mechanism through which the effect could occur.

The ensuing period has found researchers investigating the health hierarchy hypothesis. At this point, the conclusions are extremely suggestive of being causal. Research demonstrates findings that could lead us to the equivalent of removing the handle on the pump if our goal is to produce health without knowing everything about the disease of cholera and its causes.

To summarize the findings, relative poverty is bad for your health. That is, for almost any condition, being lower in the socio-economic ladder is bad for you. Poverty has an effect that is not just related to personal behaviours engaged in by poorer or richer people. The Institute of Medicine in the U.S., a branch of the National Academy of Sciences that operates under a congressional charter to advise the federal government, issued a report stating that "more egalitarian societies (i.e., those with a less steep differential between the richest and the poorest) have better average health, because a dollar at the bottom 'buys' more health than a dollar at the top" (Institute of Medicine 2003: 59).

This is a well-established rule of thumb common in many Health Canada documents as well (http://www.phac-aspc.gc.ca/ph-sp/determinants/index-eng.php). Relative deprivation or relative poverty has been found to be an important aspect of inequality that impacts health. What matters for health in rich countries appears

to be how individuals perceive themselves to be economically deprived relative to their peers (Eibner and Evans 2004: 5; Kondo et al. 2008).

There has been an academic debate as to whether materialist or the psychosocial issues of relative poverty or deprivation predominate. Poorer people in rich countries tend to have material possessions that science fiction detective Dick Tracy didn't even imagine 50 years ago. Invidious comparisons drive psychosocial issues more than a lack of goods. This has been strengthened by the recent research mentioned above. A dialectic prevails transcending Eastern and Western thought that suggests both mechanisms are at work to varying extents. The gap between the rich and poor in society represents how much the society cares for and shares with its members. The U.S. has the highest child poverty rate among rich countries, despite having so many billionaires.

Canada has a better profile than the U.S., but fares much worse than do many European nations (see chapters 6 and 9 in this volume). A CEO in the U.S. makes about 500 times what an average worker does, while the figure is 20 for Canada and 10 for Japan. Back in 1980, when the U.S. was considerably healthier compared to other countries, the pay gap was about 40 to one. There is a dose–response relationship. Many studies support the concept that for the most part, you get sick if you are poor, rather than the other way around.

Biological plausibility for the pathological mechanisms relating to inequality is present and described later. These mechanisms are programmed early in life, and some are present at birth. Universal access to health care is not very important for producing health in a society. I've always looked for studies demonstrating this isn't so. Few studies ask that basic question, and there are none published that I am aware of that show benefits.

The best study looking at the impact of health care services in advancing health was done in Winnipeg, Manitoba, by looking at mortality outcomes related to cuts in health care services (Roos et al. 2006). The more that was cut, the better the improvements in mortality. Their last paragraph was: "To conclude, a universal health care system is definitely the right policy tool for delivering care to those in need, and for this it must be respected and supported. However, investments in health care should never be confused with, or sold as, policies whose primary intent is to improve population health or to reduce inequalities in health. Claims to that effect are misleading at best, dangerous and highly wasteful at worst." (page 125)

In developed nations such as Canada then, medical care is not as important in producing health in a population as are these other factors. For the non-specialist and specialist doctors and the general public, this is the most difficult concept to grasp. The conclusion of the chapter on medical care and health from the *Oxford Textbook of Public Health* is "The impact of personal medical services on the health and survival of individuals seems readily apparent. With modern investigations and treatments, patients are now regularly saved and make very good recoveries from

infections, injuries, and a variety of other conditions that were almost uniformly fatal even a few years ago. Surprisingly it is more difficult to demonstrate conclusively the impact of these medical advances on the health of whole communities" (Jamrozik and Hobbs 2002: 238). A major reason for this difficulty is in part because whenever medical care has been studied, it has been found to be a leading cause of death (Davis 2004; Starfield 2000). Whereas health care definitely helps some, it harms others, and for populations, whenever it has been studied, there appears to be little or no net benefit. Recognizing this is very difficult for most people. I write this as a practising emergency physician.

Inequality in Society Is Bad for Your (Our) Health

The most commonly used measure of inequality is that of income differences. This is so since these data appear regularly in the census and other sources. Income is a flawed measure—especially among countries—because there are a variety of behind-the-scenes redistribution mechanisms in different countries. Through taxes, transfers, and other payments, Sweden reduces its poverty rate based on income over 80 percent in comparison to about 40 percent for Canada and less than 20 percent for the U.S. Some countries provide health care, education, and other benefits that people in countries like the U.S. and Canada have to purchase directly. There may be a threshold of disparity for income inequality to have an effect. Canada has less income inequality than the U.S. because of various social and economic policies. The relationship between income distribution and health among Canadian provinces is less pronounced than the situation among U.S. states (see Figure 1.5.) On the other hand, in Chile, which has a large gap between the rich and poor, there is a relationship between health and income inequality.

The geographic level at which income distribution is measured affects the health outcome. In a small neighbourhood, most people are similar economically. It would be unlikely that a small income gap in a small area would be related to health. In the U.S. we see the relationship at the city and state level throughout the country, but not at the county level within a state. Other studies have demonstrated that even the rich in the United States are not as healthy as poorer counterparts in Europe (Avendano et al., 2009).

Epidemiologists speak of the ecological fallacy for population findings that may mislead what happens with individuals. For example, the finding that populations with more poverty have worse health than populations with less poverty implies that poorer people will have poorer health, but this must be demonstrated; it could be the opposite, namely, that rich individuals have worse health and where there are more poor, there are also more rich.

We have studies on individuals using self-assessed health (SAH) that refute the fallacy limitation. Some studies suggest that the rich may be more affected by inequality than the poor, while others suggest the poor are more impacted. No matter, everyone does better with a smaller economic gap.

Figure 1.5: Working-Aged Male Mortality by Proportion of Income Belonging to the Less Well-Off Half of Households, U.S. States (1990) and Canadian Provinces (1991)

Working-Aged Male (25–64) Mortality by Median Share U.S. States and Canadian Provinces
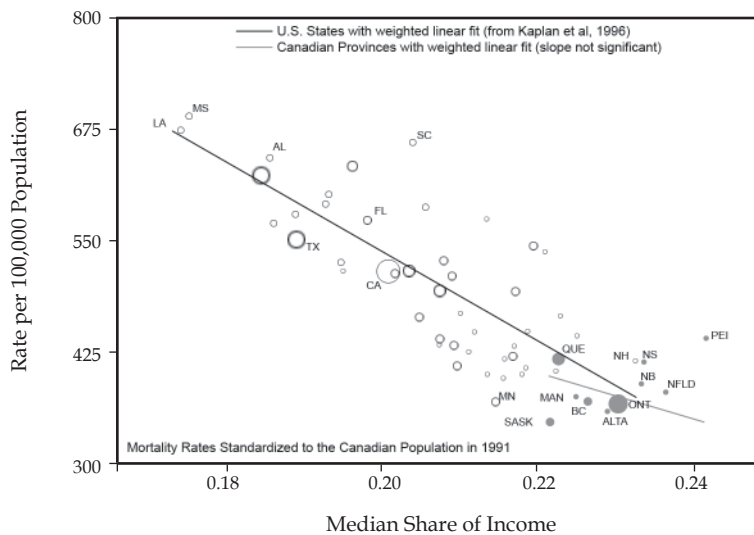
Source: N.A. Ross, M. Wolfson, J. Dunn, J.M. Berthelot, G. Koplan, and J. Lynch, "Relation between Income Inequality and Mortality in Canada and in the United States: Cross-sectional Assessment Using Census Data and Vital Statistics," *BMJ 320*(7239): 898–902.

Basic Needs

The nature of caring and sharing in a society determines its health. Can we generalize from what we discovered in rich countries? Are egalitarian societies always healthier than those with a big gap between the rich and poor? Let's look at Nepal, where I have spent 10 of the last 40 years, much of it in providing and teaching about health care. The health–hierarchy relationship is difficult to study in such a primarily rural agrarian society that does not record births and deaths. Reported life expectancies are crude estimates. Determining how many infants die in the first year of life is a little easier. How to measure hierarchy is also problematic for such a population, since few people fill out survey forms, and shoe-leather epidemiology will wear out many pairs of shoes in this markedly roadless nation.

Nevertheless, in Nepal the highest infant mortality rate is found in districts with the most egalitarian structure. These districts have significant food deficits

and everyone is uniformly poor and starving. Having enough food and clean water and shelter takes precedence over economic justice. One finds that for countries with a low gross domestic product (GDP) (a few hundred dollars up to a couple of thousand dollars per person per year), life expectancy estimates tend to increase with increasing GDP, which can indicate that everyone is getting the basic necessities of life and living standards are improving. For such countries, providing food, water, and shelter for everyone takes priority. Once countries exceed this threshold, the level of hierarchy or economic justice present matters more in producing health. There is a critical threshold relating economic growth, to further improvements in population health and other measures of well-being this is reached about $10,000 per capita GDP (or GNP; the two terms are the same for our purposes). Above that level, further economic growth does not by itself lead to longer lives, increases in happiness or well-being, or other measures of a good society.

Today there are the richest and poorest people who have ever lived. Countries in sub-Saharan Africa have seen their life expectancies and other mortality measures of health get worse over the last decades, and they have not seen economic growth to benefit their societies for the most part. Hunger and poverty are rampant there and in South Asia, yet India has more of the 10 richest people in the world than any other country. What is needed is more global caring and sharing—providing the basics of food, water, and shelter—rather than continuing the plundering that is at least partly responsible for this situation.

Box 1.1: What Produces Health in a Population

- Provision of the basic needs (food, water, shelter, security)
- Provision of caring and sharing, especially in early life, which is typically measured by the distribution of wealth, resources, income, political power, status of women
- Access to basic health care services
- Cultural elements of reciprocity, social harmony, and vigilant sharing
- Focus on early life: Early life lasts a lifetime.

Early Life Lasts a Lifetime

If we ask how much of our health as adults is determined early in life, the answer is a lot! Certainly by age two or three, research shows that as much as half of our health as adults is already programmed. This is long before we make any conscious choices about behaviours to make us healthy. How can such life course views be studied epidemiologically?

One way is to follow a group of people from before they were born until they die, which is termed a cohort study. There are huge challenges in such research, including the need to follow people for longer than the lifespan of the investigator, as well

as the huge costs involved. Studies in countries that have kept detailed records at birth that can be followed have found that in the trajectory from the womb to the tomb, the womb may be more important than the home as far as chronic diseases in adulthood are concerned.

David Barker's initial studies have spawned great understanding of the importance of early life conditions. Significant stress during pregnancy can be linked to worse health later in a child's life. John Bowlby, studying orphans after the Second World War, demonstrated the importance of having a single caregiver present soon after birth and for the first year of a child's life. Such conditions were more likely to lead to secure attachment, meaning the infant felt more comfortable in exploring surroundings. Better mental health, physical health, and healthy behaviours are more likely to result than when the newborn is unattended for much of the early part of his or her life.

Now there are many studies demonstrating the impact of early life, especially conditions of poverty, on adult health. Societies that foster more time for a less stressful pregnancy and for early life parenting have better health outcomes than countries that neglect these. The United States stands with Swaziland, Liberia, and Papua-New Guinea as the only countries without a paid maternity/paternity leave law. An updated version of Wilkinson's graph linking life expectancy and income inequality was published in 2005, reflecting 2001 data with more nations, and demonstrated quite a spread of health outcomes at the more equal end (Figure 1.6). Japanese live the longest, and Danish the shortest of those nations with a small income gap.

Something is rotten in the state of Denmark. Denmark is the only more egalitarian and rich country that has health outcomes comparable to the United States, namely, that people die younger. In 1994, the Danish government published a report mentioning that for the past two decades, life expectancy had been stagnating there rather than growing as in all the other OECD (Organisation for Economic Co-operation and Development) nations (Bjerregaard and Hermann 1994). In 1970 life expectancies of both Danish men and women were far higher than in the United States and close to those of Norway and Sweden, but by 1990, they were equal for U.S. and Danish men with U.S. women outliving Danish women. The report noted that Danish women entered the labour market in large numbers during the period 1960–1968, which was earlier than women in other neighbouring countries such as Norway and Sweden, and that they typically began working when they had young children.

Their jobs were mostly temporary, unskilled, and low-paying, and in the 1970s and 1980s unemployment soared, especially in comparison to the other nations. Women's mortality increased as a result, while the welfare practices typical of other Scandinavian countries were not as comprehensive in Denmark. The resultant stresses led to high rates of women smoking, and later these women developed the highest lung cancer mortality of all European nations.

Figure 1.6: Income Distribution and Life Expectancy, 2000

Gini coeffecient (1990–1998)
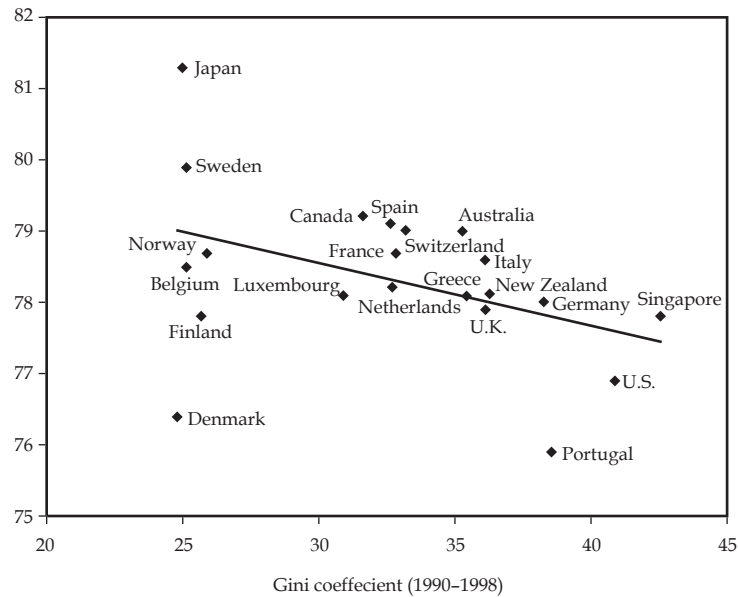
Source: R. De Vogli et al., "Has the Relation between Income Inequality and Life Expectancy Disappeared? Evidence from Italy and Top Industrialised Countries," *Journal of Epidemiology and Community Health 59*(2) (2005): 158–162.

The report was published before there was increased awareness of the importance of the conditions of early life for good health in adulthood. The impact of the family situation on the children born to these women certainly was part of the lack of health improvement seen during that period. Denmark has learned from the conditions producing health deprivation, and life expectancy is again increasing at a substantial rate. It will likely outpace health in the United States in the ensuing decades.

Biology of Inequality

Most of us go through life with a rudimentary understanding of biology and specific aspects of physiology and pathology. Our previous discussion of cells, organs, individuals, and populations leads us to consider what it would mean to have a biological explanation of health impacts on large human groups. Understanding proceeds from hypotheses that are tested by experiments that are further refined and elaborated in different settings. Cells can be studied in cultures, and their components can be extracted and measured. Organs can be perfused in an artificial environment.

Whole creatures can be manipulated in captivity and in the wild. From this we infer mechanisms that control the various functions we ascribe to biology. Experiments on populations are rarely carried out on humans for ethical reasons, but various natural experiments occur throughout history. Early life issues have been extensively studied in rats and sheep. Dog labs were settings for gaining much understanding of human physiology. Primate labs and alfresco experiments help understanding of our closer relatives. Heritability can be studied in various ways.

General statements can be made about inequality in human societies and their impact on health. Many aspects of the early environment matter tremendously in producing the health of offspring. Stresses during pregnancy affect the health of children and adults. Growth in the uterus is determined by many factors, and early child development has a profound effect on adult health. Generally, those lower in socio-economic position in society have worse health outcomes that are independent of the effects of personal behaviours. Poverty in infancy can be considered a brain toxin from which later complete recovery is highly unlikely. The social environment in early life is determined to a significant degree by the economic and political environment. Chronic stress, beginning in pregnancy, can be shown to impact the biological responsiveness of inflammatory cells in adults in their 20s who appear to be healthy. The acute stress response, activated when one is faced with a threat or danger, allows energy to be mobilized and directed to the organs that will save one's life.

Cortisol and adrenaline are key effectors. Turning the response on for a few minutes to get out of the path of a car has a marked survival benefit, but if it is turned on all the time — for example, when one is stuck in traffic and late for an appointment, or worrying about being evicted, or whether a significant other will be violent at the next encounter — may not have death-avoiding advantages. Evidence is accumulating that overworking the stress system may be maladaptive and have lasting repercussions on the ability to mount a swift survival response when it is needed.

Those lower down the socio-economic ladder tend to be more affected by chronic stress in measured ways. This includes a likelihood of obesity, adult-onset diabetes, and cardiovascular disease. Mechanisms that produce chronic stress in society have received considerable research attention (Sapolsky 2004). The production of cortisol from the adrenal gland, which is regulated by the hippocampus in the brain, is an important pathway leading to worse health when higher cortisol levels are sustained. The placenta stimulates production of cortisol in the mother, which also affects the fetus and helps fetal organs in case of a premature birth because of maternal stress. In addition to many individual studies, there are population data that demonstrate this (Kristenson et al. 1998). At the same time, organs and bodies continue with growth, tissue repair, and fighting potentially hazardous infectious invaders. Markers of the inflammatory response to infection and other illnesses

suggest that those lower down the socio-economic hierarchy are working harder to combat contagion. They also have worse health outcomes as we know.

The nervous system turns out to be very plastic—that is, it is capable of remodelling depending on various social and environmental stimuli. It is the major conductor of the body's response to the physical, social, economic, and political environment. Mother nurture facilitates Mother Nature, meaning that early life circumstances and both biological programming (the term used before birth) and embedding (which relates to issues after birth) are heritable. Epigenetic mechanisms—that is heritable changes that are not due to alterations in the DNA—can transmit biology intergenerationally without being genetic. Poorer people have poorer functioning organs. This is easily demonstrated for the lungs by measuring how much air you can blow out in one second (FEV1). The lower you are in the socio-economic hierarchy, the less air you can blow out and this is independent of the usual factors we would hypothesize to be responsible (Hegewald and Crapo 2007). The sociobiology described here does not imply that those lower down the hierarchy are inferior beings in the sense of Thomas Malthus. Psychosocial and other mechanisms that result from living in unequal societies have profound biological effects on our health.

Natural Experiments in Population Health Epidemiology

Just as John Snow could observe the decline in deaths from cholera after he removed the pump handle, which boosted his belief in the hypothesis that there was something in the water that caused the disease, so we can be reassured by experiments that change the factors producing population health.

Box 1.2: Some Methods Used in Epidemiology

- observational ecological studies (e.g., figures 1.3, 1.5)
- cohort studies (Figure 1.3)
- cross-sectional study (Figure 1.2)
- multi-level modelling (requiring powerful computers)

Agriculture

Before the advent of agriculture our health was remarkably good (Cohen 1991). With the domestication of plants and animals, human health declined. In hunter-gatherer societies vigilant sharing was the critical social value. They had few if any possessions and the key resource that was shared with everyone, whether they were related or not, was meat from an occasional big game kill. Given food, shelter, and safety sufficient to sustain health, if everyone is poor, then no one is poorer than anyone else. But with the development of agriculture, a food surplus could be produced. Some individuals proclaimed themselves lord or master and coerced others to produce food for them, build castles, and protect them. As a result, caring

and sharing declined, poverty appeared, diets changed, and food variety declined (Larsen 1995, 2006). Famines began.

Living in close proximity to domestic animals resulted in many infectious organisms changing hosts to produce human disease. The nature of human relationships changed as exploitation began. Throughout recorded history until the last century, the health of human populations has been less than that of primitive societies. The recent improvements in health depend on forms of societal redistribution that favour poorer people along with technological changes that have an impact on living standards. Most of the increases in life expectancy came from reductions in early life mortality.

Japan at the End of the Second World War

Japan became the healthiest country in the world in part because of economic policies resulting from the U.S. occupation of that defeated country after the end of the Second World War (Bezruchka et al. 2008). The "medicine" administered by perhaps the world's greatest population health doctor, General Douglas MacArthur, had three ingredients. The first was demilitarization. Japan was forbidden to have an army and had to resolve disputes peacefully as specified in the constitution that MacArthur wrote. The second ingredient was democratization. Everyone got the vote, and labour unions obtained the right to organize and bargain collectively. A public health clause in the constitution required the government to do all it could to improve health. MacArthur legislated a maximum wage of 65,000 yen per year. The final ingredient was decentralization. The concentration of wealth and power that existed in pre-war Japan was broken up. The 11 large family corporations or *zaibatsu* that controlled most aspects of economic life were dismantled. The most successful land-reform program in history was carried out. Before the war, the land in this rice-farming economy was owned by 37,000 landlords and farmed by millions of tenants. MacArthur purchased the land at a fixed price per hectare and sold it to the tenants at that price, while giving them a 30-year low interest loan to pay for it.

With the dismantling of Japan's hierarchy, the resulting improvement in health was unequalled in any country in the world in medical history in a comparable period of time. Japan's health is better than other nations with comparable income gaps. An important cultural factor that allowed the "medicine" to work was the underlying culture of *wa* or social harmony. Collectively oriented cultures with less inequality and a Confucian dynamism will have better health than more individualistic ones with great power distance that is accepted by the people (Hofstede and Hofstede 2005).

The Former Soviet Union

Japan demonstrates what can happen when hierarchies are dismantled. Countries of the former Soviet Union demonstrate what can happen when huge hierarchies

are created overnight (Wilkinson 2005). Russia was a very hierarchical society during the czarist period, and lagged about 25 life-expectancy years behind the U.S. in 1900. The centrally controlled or command economy in Russia dismantled the wealth gap so that by 1960, the two countries had comparable health indicators. Health gains in Russia faltered in the 1970s and 1980s as its people felt deprived of the apparent wealth in the West depicted by outside media. IMR began increasing in parts of the Soviet Union in the 1970s. This observation prompted Emmanual Todd (1976) to predict the collapse of the Soviet Union as early as 1976. With the dismantling of the former Soviet Union, fabulous wealth was created so that Russia now has the second largest number of billionaires in the world, while 15 years ago it had none.

As the gap between rich and poor grew astronomically, health in Russia declined, something that has been unprecedented in the modern world (Marmot 2004). The only other example where health has declined substantially in the last century also occurred in the last decade in high AIDS-prevalent countries of sub-Saharan Africa. Life expectancy in Russia has dropped about seven years for men and somewhat less for women. The decline has still not abated. The carnage has resulted in between 10 million and 20 million deaths that would not have occurred if health had remained at pre-dissolution levels. The gap between rich and poor in Russia today is greater than czarist levels. People in Russia are about as unaware of their health declines as people in the U.S. are unaware of their poor health standing. The health decline in Russia has been absolute, meaning there are more deaths than before. By contrast, the U.S. has seen a relative health decline, meaning that health has not improved as much as in other rich countries.

Canada–U.S. Health Divergence

Canada is considerably healthier than the United States, but it is less wealthy and spends considerably less on medical care. Comparisons of the two nations' population health allow us to demonstrate the political situations that have created inequalities responsible for this difference. In the 1950s life expectancies in the two nations were almost the same. Health in Canada then improved more rapidly than health in the United States. For working-age men today, for example, mortality rates in Canada are about half of what they are in the United States.

Most American medical students are unaware of this (Agrawal et al., 2005). It is remarkable that citizens in the world's wealthiest and most powerful nation seem to accept dying much younger than they should. Remarkably the U.S.'s inferior performance in international comparative measures such as teen birth rates, youth homicides, incarceration, child poverty, and poor educational performance does not inspire their citizens' desire to do better. The United States was founded on a weak form of government and individuals relied on one another for support. The U.S.'s form of government was, by design, with its separation of powers and lack of a parliamentary system, not very responsive to the popular will (Kingdon 1999).

> **Box 1.3: Health Care and the Public's Health**
>
> Whenever it has been studied, medical care is always one of the leading causes of death (Starfield 2000). In studies of doctors' strikes, the common finding is that mortality does not increase. In fact, it tends to go down (Cunningham et al. 2008). The public believes that postmodernism doesn't apply to medical science. Perhaps half of what is believed to be true in medicine is not. Primary care may be the best part of medical care. Countries that have less of a specialist focus on health care services tend to have better health. Always ask: "Do you want health or health care?"

Canada's government, on the other hand, was more responsive to public opinion and engineered a social compact with more generous welfare provisions. Social expenditures were higher in Canada and performance on social indicators was much better than in the U.S. The United States undertook redistribution programs after the Great Depression to reduce the wealth of the richest 1 percent of Americans by roughly half of what it used to be by 1975.

The rich and powerful in the U.S. have regained their wealth share by limiting any worker wage increases since then and requiring the citizenry to borrow their salaries from home equity and credit cards. The rich also gained massive government support for their financial interests. Lobbying ensured that the United States had the best democracy money could buy. Banking was deregulated, and public welfare was ended. Huge increases in inequality resulted. These policies led to the current global economic collapse.

Canada, on the other hand, continued to provide many social-welfare services as a part of government responsibility. These included low-cost education, subsidized housing, efficient public transportation systems, and universal medical care. Canada remained one of the world's healthiest nations until this century when eroding government policies began to favour the rich. Canada stands in the middle of the collective–individual divide represented by western Europe and the United States. Trends in the health differences between the U.S. and Canada in the coming years depends to a large extent on how responsive governments are to the needs of their populations as they grapple with the economic issues and their long-term global repercussions (Siddiqi and Hertzman 2007).

Conclusions

A positive and action-oriented approach to producing health would be to publicize and act upon what is known regarding the poor health status of countries such as the U.S., which have large gaps between the rich and poor, relative to other rich countries. These gaps result from lack of an egalitarian policy frame. If Canadians have no interest in producing health, they can continue to pursue policies that will increase the gap between our rich and poor, which will move Canada toward the

Box 1.4: Power, Inequality, and the Physical Environment

Cross-sectional studies among U.S. states find that shared political power, less income inequality, strong environmental regulations, and a better quality of the environment are associated with better health outcomes. Political power is measured by voting rates, tax fairness, Medicaid accessibility (meaning health care services for the more impoverished), and educational attainment (Boyce et al. 1999). Green space exposure in England has been linked to income inequality and mortality differences. Those living in greener environments have less inequality in health outcomes. Economic inequalities translate to less healthy physical environments just as they do to disadvantaged social ones (Mitchell and Popham 2008). Recovery in hospitals has been linked to a patient's window providing a bucolic view. This suggests that psychosocial factors team up with physical ones to produce health. Increasing economic growth above the $5,000–$10,000 per capita increases the ecological footprint, indicating further strain on the environment, with no health benefits (Rainham 2007).

U.S. model. This will worsen the growing hierarchy in Canada. Or if Canada wants a healthier population, the government can take policy steps that are diametrically opposite to the current ones. In a democracy there is this choice. It should be an informed one so that the first step is to create awareness of what conditions produce health in populations (Bezruchka 2008).

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Critical Thinking Questions

1. What can societies do to improve conditions in early life so that adult health naturally develops?
2. How do the current trends in Canadian political policies impact health? How can they be more supportive of health?

3. How can the public consider the terms "health" and "health care" separately?
4. Why is producing health so focused on changing individual behaviours?
5. What is the current equivalent of removing the pump handle for Canada? The world?

Further Readings

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A readable summary of how a just society is healthier.

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A definitive presentation of how more equal societies do better for people and the planet.

Relevant Websites

Innocenti Research Group publications

http://www.unicef-irc.org/

This branch of UNICEF presents a host of compilations of research that includes report card comparisons of child indicators among rich nations. Their overview of child well-being, which appeared in 2007, presents many important rankings. Search their publications and Publications Series for Innocenti Report Card.

John Snow

www.ph.ucla.edu/epi/snow.html

A look at the profound influence this man has had on the subject of epidemiology.

Population Health Forum

http://depts.washington.edu/eqhlth/

The Population Health Forum's mission is to raise awareness and initiate dialogue about the ways in which political, economic, and social inequalities interact to affect the overall health status of our society. Their goals are to promote knowledge and advocate for action in service of a healthier society. There is a listserv for updates on population health that you can subscribe to on the site.

The Last Straw Board Game on the Social Determinants of Health

http://www.thelaststraw.ca/

Designed by a McMaster University medical student and a University of Toronto graduate student, it is an entertaining way to consider concepts in this chapter.

UC Atlas of Global Inequality

http://ucatlas.ucsc.edu/

The atlas explores the interaction between global integration (globalization) and inequality. It has generated maps examining some aspects of material inequality, life and death, global connectedness, and economic globalization. It has expanded coverage of health and gender, and added more interactive capacities, enabling users to make comparisons among countries. It has also portrayed aspects of inequality within countries starting with the health consequences of wealth and poverty.

Glossary

Cohort: A group of people followed over time; usually they are born in a specified short period.

Controlling for a factor: This means statistically adjusting in the analysis for a variable (factor) so that this factor has no impact on the outcome one is studying.

Infant mortality rate: The proportion of infants born that die in their first year of life, usually expressed per 1,000.

Life expectancy: The average number of years lived by a population if the age-specific mortality rates in place when the calculation was done continued until everyone had died.

Population health: Another term that came into being over the last decades to distinguish between considering what makes populations healthy as opposed to public health, which tends to mean a select group of interventions, such as immunizations, disease screening, prenatal care, and health education for behaviour change.