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Health of Indigenous Circumpolar Populations

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Abstract

Indigenous circumpolar populations have experienced profound transitions in lifeways over the past half-century as a result of economic development. Although there have been positive aspects of this social transformation, most circumpolar groups today have a triple burden of disease, with a modestly elevated infectious disease level, an elevated and increasing burden of chronic conditions such as obesity and cardiovascular disease, and high rates of mental health–related challenges. The health of contemporary circumpolar populations is not easily characterized because of dramatic regional differences that stem from socioeconomic disparities among nonindigenous groups, individual population histories, lifestyle factors, environmental pollution, and underlying biological variation. Overall health and well-being range from excellent among the Sami of Sweden and Norway to extremely poor among marginalized native populations in northern Russia. Circumpolar groups today are not only threatened by continued regional economic development and pollution, but also uniquely vulnerable to global climate change.

Persistent organic pollutant (POP):

an organic compound from industrial processes [e.g., polychlorinated biphenyls (PCBs)] that resists degradation and can have human health effects

INTRODUCTION

The health of northern populations varies considerably, an unsurprising fact given the enormity of the circumpolar region (17 million km²), its five major areas (Alaska, northern Canada, Greenland, Scandinavia, and northern Russia), and a population of nearly 10 million residents (Chatwood et al. 2012). This collective circumpolar population is characterized by its diversity and includes an array of indigenous groups (several dozen representing seven language families) and a considerable number of recent migrants to the region (Young & Bjerregaard 2008b). Furthermore, circumpolar natives vary, from constituting a small minority of the total regional population (e.g., <1% in Scandinavia) to a near complete majority (e.g., ~90% in Greenland), and the Inuit and several other native northern groups have territories that extend across multiple nations (Young & Bjerregaard 2008b, Young 2012). One prominent circumpolar researcher encapsulated this extreme heterogeneity by comparing the lifeways and health of an Inuit hunter, a Russian mine worker, and a Norwegian schoolteacher (see Chatwood et al. 2011). Thus, summarizing the health of circumpolar populations is an immense challenge, and consequently, no review can be truly comprehensive and without critical omissions.

Here, I review the health of circumpolar populations. I begin with an introduction to the circumpolar region, describing the diverse array of northern environments inhabited by humans, as well as the cultural and biological adaptations they use to cope with severe climatic and ecological challenges. I then focus attention on circumpolar peoples, organizing the discussion by region and concentrating on the indigenous groups for which health data are most available. Next follows a section on patterns of indigenous circumpolar health and key factors such as diet, physical activity, and pollution that shape these health outcomes. I then highlight issues of Arctic health disparities and the risks of global climate change before concluding with a discussion of how anthropology provides a powerful approach through which to unravel the complex interactions among environmental exposure, social factors, and underlying genetic susceptibility in shaping the health of northern populations.

THE CIRCUMPOLAR ENVIRONMENT

Defining “circumpolar” is a surprisingly difficult task because one can delineate the region and people on the basis of latitude, temperature, permafrost boundaries, political divisions, or demographics. Here, “circumpolar” refers to Arctic (above ~66.5°N) and subarctic (55–66.5°N) areas; the terms northern, high-latitude, and Arctic are used synonymously. Given the absence of native groups at the southern pole, the present review focuses on contemporary northern populations (**Figure 1**).

The physical and biological environments in circumpolar regions are diverse and include temperate rainforest, boreal forest (*taiga*), tundra, and polar desert (Young 2012). A recurring misconception by outsiders is that the Arctic is untouched and pristine; instead, this region has experienced rapid economic development over the past half-century and has also endured the effects of environmental contaminants such as persistent organic pollutants (POPs) and heavy metals (Bjerregaard et al. 2004, 2008; Donaldson et al. 2010). Furthermore, circumpolar regions are currently experiencing rapid glacial and sea ice melting and decreased permafrost as a result of global climate change (Anisimov et al. 2007, IPCC 2007).

Circumpolar environments provide a unique set of challenges to human populations, including prolonged and severe cold stress with average monthly temperatures that can, in certain regions, drop to –40°C (–40°F) (Snodgrass et al. 2007). This type of extreme temperature exposes populations to acute cold injuries (e.g., hypothermia and frostbite) and to an increased mortality

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Figure 1

Map of the Arctic showing key countries (*green text*), regions, or political units within countries and selected indigenous circumpolar populations (*black text*). Locations are approximate and do not accurately show population overlap or full geographic distribution. Modified from Arctic Ocean Relief Map by Uwe Dederig through Wikimedia Commons (original available from http://commons.wikimedia.org/wiki/File:Arctic_Ocean_relief_location_map.png).

risk from respiratory infections and cardiovascular events (Mäkinen & Rytönen 2008, Revich & Shaposhnikov 2010, Young & Mäkinen 2010). In addition, northern environments are profoundly seasonal with extreme variation in photoperiod, they have only sparse vegetation, and the overall energy availability in these ecosystems is low (Snodgrass et al. 2007, Snodgrass 2012).

Northern populations use a variety of cultural and behavioral adaptive strategies to survive in circumpolar environments, including tailored clothing and seasonal migratory patterns (Snodgrass et al. 2007). Indigenous northern groups also utilize several biological adaptations to the cold, including body size and proportions that minimize heat loss, upregulated basal metabolic rate (BMR), and vascular responses that conserve heat and preserve functionality (Rode & Shephard 1995; Leonard et al. 2005; Snodgrass et al. 2005, 2007; Leonard & Katzmarzyk 2010). These

Basal metabolic rate (BMR): the minimum energy expenditure required to maintain respiration, circulation, body temperature, and other basic somatic functions



Holocene: the current geologic time period (epoch), which began ~12,000 years ago at the termination of the Pleistocene

biological adaptations appear to consist of a mixture of functional acclimatizional responses and genetic adaptations (Snodgrass et al. 2007, Beall et al. 2012).

CIRCUMPOLAR PEOPLES

Modern humans first permanently settled circumpolar environments only within the past 20,000 years, expanding initially into northern Eurasia and then later to North America and Greenland (Hoffecker 2005, Snodgrass et al. 2007). The Arctic was not fully settled until the Holocene; the development of maritime economies and range expansion seen in many contemporary indigenous northern groups such as the Inuit occurred only within the past few thousand years.

Indigenous Arctic populations are immensely diverse. Groups native to the north range in size from very small (e.g., Ket of central Siberia with ~1,500 people; Kozlov et al. 2007) to more numerous populations such as the Inuit (~165,000 people; Bjerregaard & Young 2008) to very large groups such as the Yakut (~440,000 people; Kozlov et al. 2007). Although all groups specialize to a certain extent in the harvesting of animal resources, traditional subsistence economies vary and include maritime hunting, *taiga* hunting and fishing, and the herding of reindeer, horse, and/or cattle (Cordain et al. 2000, Young 2012). Because a comprehensive discussion of indigenous circumpolar groups is beyond the scope of this review, the following discussion provides details on several groups for which health data are available.

Alaska

Administratively part of the United States, Alaska is an enormous (~1.5 million km²) yet sparsely populated state with a total population of approximately 650,000 (Young & Bjerregaard 2008b). The indigenous population of Alaska (collectively termed Alaska Natives) constitutes nearly 20% of the population and consists of Inuit (sometimes called “Eskimo”), American Indian, and Aleut (Berner 2008). Although early Russians and Americans influenced Alaska’s development beginning in the eighteenth century, it was not until the mid-twentieth century that Alaska experienced substantial economic development and industrialization (Young 2012). Most Alaska Natives today reside in small, remote communities.

Inuit are the direct descendants of the Thule, a group of specialized whale hunters that emerged from the Bering sea coast ~2,000 years ago. The Thule then spread eastward and later transformed into the Inuit ~500 years ago (Hoffecker 2005). Traditional Inuit subsistence broadened to include focus on caribou and smaller marine mammals (Bjerregaard & Young 2008). Most Inuit today still rely on subsistence fishing, hunting, and gathering. At present, Inuit in Alaska number ~47,000 and are composed of two major groups, the Inupiat and the Yup’ik (Berner 2008). The closely related Siberian Yup’ik (*Yuit*) are found on Russia’s Chukchi Peninsula.

Northern Canada

Northern Canada includes the Nunavut, Yukon, and Northwest Territories, which together (3.8 million km²) comprise ~40% of Canada (Young & Bjerregaard 2008b). Population density is extremely low, and the total population of this region is ~50% indigenous. Two other regions—Nunavik in northern Quebec and Labrador—are often considered part of northern Canada. Northern Canada was relatively isolated until the mid-twentieth century, but economic development and urbanization (primarily connected to mining activities) began to accelerate in the 1950s. Northern Canada is home to several indigenous groups, including Inuit, Dene First Nations groups, and Métis (a group defined by mixed First Nations and European heritage)

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(Young 2008a,b). The total Canadian Inuit population is ~51,000 people, of which the largest population concentration is in Nunavut (~22,000) (Young & Bjerregaard 2008b).

Greenland

Greenland is enormous in area (>2 million km²) but has a total population of only ~57,000 people (Bjerregaard & Stensgaard 2008). Although politically part of Denmark, Greenland has considerable political autonomy but relies on substantial subsidies from Denmark. Greenland did experience some development in the early twentieth century, but it was not until the past 50 years that it experienced major social and economic transformations.

Greenland Inuit, known as *kalaallit*, comprise ~90% of Greenland's population (Bjerregaard & Stensgaard 2008). Elements of Greenland Inuit culture are unique and come from extensive connections with European societies. They do, however, have close genetic and linguistic ties with the Inuit population in North America. The traditional diet was based on a maritime economy focused on fish and marine mammals.

Scandinavia

Scandinavia, which includes the Nordic countries of Norway, Sweden, and Finland, has a total combined population of nearly 19 million (Hassler et al. 2008b, Young & Bjerregaard 2008b). The total land area is ~1.1 million km² of which ~380,000 km² is in northern areas.

The indigenous population of the region, the Sami (formerly "Lapp"), historically occupied a region called Sápmi, which stretched across northern Scandinavia and into Russia's Kola Peninsula (Hassler et al. 2008b, Young 2012). The size of the Sami population is not well-known but is estimated at 80,000–110,000 people (Hassler et al. 2008b). Traditionally, Sami subsistence centered on seal hunting but was later transformed around the sixteenth century into an economy focused on nomadic reindeer herding (Hassler et al. 2008a,b; Broadbent 2010); today, most Sami are integrated within larger Scandinavian society. Socioeconomic indicators are fairly similar between the Sami and the non-Sami population in countries such as Sweden, although some evidence indicates that reindeer-herding Sami have lower incomes and less education (Hassler et al. 2008b).

Northern Russia

Northern Russia is an enormous region (>9 million km²) that stretches across Asia from the Kola Peninsula to Chukotka (Young & Bjerregaard 2008b). The total population of northern Russia is ~7.2 million, with an indigenous population [i.e., the 40 groups of "Numerically Small Peoples" of northern Russia (e.g., Evenki, Nenet, Ket, Nganasan, Chukchi, and Yup'ik)] of ~280,000 people. In addition, several other ethnic groups such as the Yakut (~440,000 people) and Buryat (~445,000 people) reside in this region and are considered by most researchers to be indigenous (that approach is followed in this review), yet they are not recognized as indigenous by the Russian state and instead termed ethnic minorities (see Kozlov et al. 2007). The traditional subsistence economy varies among indigenous northern Russians and includes maritime hunting, reindeer hunting, *taiga* hunting and fishing, reindeer herding, and horse and cattle herding.

Indigenous Siberians experienced profound changes in lifeways during the Soviet period and, after the collapse of the Soviet Union in 1991 unleashed catastrophic political and economic changes, these populations again experienced major transformations that forced many to renew their reliance on traditional subsistence activities (Snodgrass et al. 2007, Kozlov & Lisitsyn 2008). The aftereffects of these profound transitions continue to impact native Siberians.

The Evenki are a Tungusic-speaking group of reindeer herders from the northern Siberia *taiga* who number ~35,500 (Forsyth 1992, Leonard et al. 2002). They traditionally were highly nomadic and occupied a large geographic area. Additional information on the Evenki can be found in Leonard and coworkers (1994, 1999, 2002).

The Yakut (Sakha) are concentrated in northeastern Siberia and make up ~45% of the population of the Sakha Republic (Kozlov et al. 2007). Members of the Turkic language family, the Yakut traditionally practiced a complex but variable subsistence strategy focused primarily on transhumant horse and cattle pastoralism (Forsyth 1992, Snodgrass et al. 2005, Crate 2006). The Yakut have experienced particularly rapid shifts in lifeways over the past decade as a result of regional economic development (Snodgrass et al. 2007).

CIRCUMPOLAR HEALTH: AN OVERVIEW

Information on circumpolar health is incomplete and uneven, with major gaps in data availability. Surveillance and reporting are far better in regions such as Alaska and northern Canada and less comprehensive in northern Russia. This issue is compounded by the failure to disaggregate data by ethnicity or locale in much of the epidemiological literature.

In this overview of health in the Arctic, I first describe macrolevel health indicators such as life expectancy and infant mortality and then discuss several key health issues: (a) cardiovascular and metabolic diseases; (b) cancers; (c) infectious diseases; (d) mental health, accidents, and violence; and (e) alcoholism, smoking, and substance abuse.

Life expectancy at birth shows enormous variation among indigenous circumpolar populations, from relatively high among the Sami (~75 years in males, ~80 years in females) to very low among indigenous Siberians (~45–55 years in males, ~55–65 years in females) (Kozlov et al. 2007, Hassler et al. 2008c, Krümmel 2009, Young 2012) (**Table 1**). Data generally show a pronounced disparity in life expectancy in indigenous northern populations compared with nonnative Arctic groups and national populations (Chatwood et al. 2012). For example, life expectancy at birth among the Inuit is lower than among non-Inuit residents but ranges from 4.6 to 12.2 years lower, depending on country (Krümmel 2009). The fall of the Soviet Union in 1991 led to immediate and dramatic declines in health and life expectancy among indigenous Siberians that paralleled but exceeded those documented among the majority population (Leonard et al. 2002, Notzon et al. 2003, Kozlov et al. 2007, Sorensen et al. 2009, Young 2012). Infant mortality rates are also relatively high among most native northerners (>10 per 1,000 live births); in several places such as Nunavut, Greenland, and northern Russia, infant mortality rates are two to three times higher than national levels (Kozlov et al. 2007, Odland & Arbour 2008, Krümmel 2009, Young 2012).

Cardiovascular and Metabolic Diseases

In all indigenous circumpolar populations except the Sami, obesity is at moderate to high levels and has become increasingly prevalent over the past several decades (Snodgrass et al. 2006a, Jørgensen & Young 2008, Jørgensen 2010, Château-Degat et al. 2011, Young 2012). A comprehensive study of Inuit in Canada, Greenland, and Alaska showed obesity [body mass index (BMI) ≥ 30.0] at 16% and 26% in men and women, respectively, but more recent data suggest that these prevalence rates have increased substantially (Young et al. 2007, Zienczuk & Egeland 2012). Obesity has also emerged as an important health issue among indigenous Siberians (Snodgrass et al. 2006a); however, these rates (e.g., 13% in males and 21% in females among the Yakut; Snodgrass et al. 2010a) are currently moderate. Few data on obesity exist for children, but what data are available do indicate that obesity is a growing problem for children as young as preschool

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Table 1 Summary of the health information and key risk factors for selected indigenous peoples from circumpolar regions. Additional information and sources are provided in the text

Region	Indigenous people	Overall health and key health challenges	Main lifestyle, innate, and environmental risks
Alaska (USA)	Inuit, Aleut	<ul style="list-style-type: none"> • Overall good health; modest disparities with nonnative Alaskans and other US residents • Life expectancy at birth lower than other US residents by ~5–7 years • Modest CVD burden; high levels of obesity; moderate hypertension and T2D • High rates of alcoholism, suicide, and accidents • Modestly elevated infectious disease burden 	<ul style="list-style-type: none"> • Dietary change • Low activity levels • High smoking levels • High rate of alcoholism • Psychosocial stress • Pollution • Poor living conditions • Climate change
Northern Canada	Inuit, Dene (First Nations)	<ul style="list-style-type: none"> • Regional variation; better health and fewer disparities in Yukon and NWT, worse in Nunavut • Life expectancy lower than that of other Canadians, especially Nunavut with ~8–10-year difference • Modestly elevated CVD burden; high levels of obesity; moderate hypertension and T2D • Cancer risk especially high in Nunavut • High rates of suicide, accidents, and injuries • Higher infectious disease risk, especially Nunavut 	<ul style="list-style-type: none"> • Dietary change • Low activity levels • High smoking levels • Psychosocial stress • Pollution • Poor living conditions • Climate change
Greenland (Denmark)	Inuit	<ul style="list-style-type: none"> • Overall good health; pronounced disparities with nonnatives in Greenland and Denmark generally • Life expectancy lower in Greenland by ~10 years • Modest CVD burden; high levels of obesity; moderate hypertension and T2D • Cancer risk relatively high • Severe mental health challenges • Modestly elevated infectious disease burden 	<ul style="list-style-type: none"> • Dietary change • Low activity levels • High smoking levels • Psychosocial stress • Pollution • Poor living conditions • Climate change
Scandinavia (Norway, Sweden, Finland)	Sami	<ul style="list-style-type: none"> • Overall excellent health; minimal disparities with nonnative population, although perhaps poorer health among reindeer herders • Life expectancy high and not significantly different from national populations • Low CVD burden; low levels of obesity, hypertension, and T2D • Modestly elevated mental health challenges 	<ul style="list-style-type: none"> • Dietary change
Northern Russia	Evenki, Khanti, Mansi, Yakut (Sakha)	<ul style="list-style-type: none"> • Overall poor health; pronounced disparities compared with nonnative population • Life expectancy lower by ~10 years (but Russia low in general, especially among men) • High infant mortality rate • High CVD burden (especially stroke) but relatively low T2D • Moderate obesity levels and very high hypertension rates • Modestly elevated infectious disease burden • Very high rates of alcoholism, suicide, and violence 	<ul style="list-style-type: none"> • Dietary change • Low activity levels • High smoking levels • Very high rates of alcoholism • Psychosocial stress • Pollution • Poor living conditions • Climate change • Adaptive pattern that may predispose to high blood pressure

Abbreviations: CVD, cardiovascular disease; NWT, Northwest Territories; T2D, type 2 diabetes.



CVD: cardiovascular disease

Metabolic syndrome (MetS):

a constellation of risk factors, including central obesity and insulin resistance, that contribute to the development of CVD

T2D: type 2 diabetes

(Jørgensen & Young 2008, Galloway et al. 2010). The association between obesity and cardiovascular disease (CVD) among the Inuit is distinct, with fewer metabolic consequences of excess adiposity compared with other populations (Young 2007, Young et al. 2007).

The Inuit and several other native northern groups were initially thought to be protected from CVD because several studies in the early twentieth century documented a relatively low cardiovascular burden and a favorable lipid profile (Kozlov et al. 2007, Jørgensen & Young 2008). However, CVD is now one of the leading causes of death among circumpolar populations (Krümmel 2009, Château-Degat et al. 2010, Young 2012). Data show considerable regional variation in CVD; however, Alaska Natives and Sami have a relatively low burden (Young 2012). Pronounced regional variation also exists for cardiovascular risk factors such as hypertension (>140 mm Hg systolic blood pressure and/or >90 mm Hg diastolic blood pressure). Indigenous Siberians have extremely high rates (~20–35%; Kozlov et al. 2007, Snodgrass et al. 2007), whereas other groups such as the Canadian and Greenland Inuit have somewhat lower levels that are classified as intermediate globally (19% and 22%, respectively; Jørgensen et al. 2004, Jørgensen & Young 2008, Château-Degat et al. 2010). Circumpolar groups in general still have a relatively favorable lipid profile and low occurrence of the metabolic syndrome (MetS), although recent data from multiple regions show a rapid pace of health deterioration (Leonard et al. 2005, Boyer et al. 2007, Kozlov et al. 2007, Snodgrass et al. 2010b, Young 2012).

Studies have historically reported relatively low levels of type 2 diabetes (T2D; fasting glucose ≥ 126 mg/dl) among northern groups in all circumpolar regions (Jørgensen & Young 2008). These prevalence rates have increased somewhat in recent decades but are still generally low in many groups, especially native Siberians (e.g., Yakut, Khanty, and Mansi), in whom T2D rates are nearly absent (<5%) and fasting glucose levels among many populations (e.g., Yakut, Khanty, Mansi, and Chukchi) are quite low (~80 mg/dl) (Kozlov et al. 2007; Snodgrass et al. 2010a,b; Young 2012). The Sami also have a relatively low diabetes prevalence (estimated at <5%) and a low fasting glucose population mean of ~79 mg/dl (Kozlov et al. 2007, Sjölander 2011). Fasting glucose values are higher among Greenlanders (~104 mg/dl), as well as among Canadian Inuit (~92 mg/dl) and Alaska Inuit (~94 mg/dl), and rates of T2D are ~7–10% among Inupiat, Aleut, and Greenland Inuit (Jørgensen & Young 2008, Snodgrass et al. 2010b, Young 2012).

The main factors that influence cardiovascular and metabolic risk in northern populations are diet and physical activity. Native northerners, especially maritime societies such as coastal Inuit populations, have traditionally consumed diets very high in protein and fats and low in carbohydrates (Shephard & Rode 1996, Cordain et al. 2000, Kozlov et al. 2007). These traditional diets, many with high levels of *n* – 3 fatty acids, are protective from cardiovascular and metabolic conditions (Kozlov et al. 2007, Young 2012). A major dietary shift is occurring across the North as economic development has accelerated. This transition was perhaps best documented by a study of northern Canada's Igloodik Inuit, which tracked changes in health in the same community over several decades (Shephard & Rode 1996). In addition, a recent study of Greenland and Canadian Inuit documented high levels of market foods (~80%): Younger individuals are consuming fewer *n* – 3 fatty acids and more unhealthy *trans*-fatty acids (Counil et al. 2008). The transition away from traditional foods has led to a greater risk of nutrient deficiencies (e.g., Vitamin D and iron) and increased intake of saturated fats, carbohydrates, and overall calories (Kozlov et al. 2007, Bjerregaard & Jørgensen 2008, Egeland et al. 2011, Andersen et al. 2012, Jamieson et al. 2012). Food insecurity is also emerging as an important issue in many Arctic populations, although continued use of traditional foods continues to be protective (Huet et al. 2012, Young 2012). However, an emerging problem—termed the Arctic dilemma—is that beneficial traditional foods are now increasingly contaminated with industrial pollutants (Kuhnlein & Chan 2000, Bjerregaard & Jørgensen 2008, Krümmel 2009).

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Decreased energy expenditure resulting from declines in habitual physical activity is likely a key contributor to the increased burden of cardiovascular and metabolic diseases in the Arctic, although this issue has not been extensively studied (Shephard & Rode 1996, Bjerregaard & Jørgensen 2008, Dahl-Petersen et al. 2011, Young 2012). Research among the Yakut, for example, has documented modest physical activity levels, with particularly low levels among those least involved with the subsistence herding economy and those consuming more market foods (Snodgrass et al. 2006b). Furthermore, low activity levels in this population have been linked to several health measures, including chronic inflammation and poor lipid profiles (Wilson et al. 2013).

One final issue related to determinants of cardiovascular and metabolic diseases in indigenous circumpolar populations is the contribution of genetic factors to risk patterning. This issue remains unresolved (Hegele & Pollex 2008, Young 2012); studies among the Inuit, for example, show gene frequencies that simultaneously reduce and elevate CVD risk. Founder effects in some populations may also shape risk, such as with the high levels of *BRCA1* mutations among Greenland natives, which contribute to breast cancer risk (Fredslund & Bonefeld-Jørgensen 2012).

Cancers

Cancer is one of the leading causes of death in circumpolar populations, with particularly high incidence and mortality among Inuit in Nunavut and Greenland (Friborg & Hassler 2008, Krümmel 2009, Young 2012). The cancer profile of most northern populations is distinct; the Inuit, for example, have a high incidence of nasopharyngeal and salivary cancers (so-called traditional cancers), as well as high levels of lung and pancreatic cancers (Friborg & Hassler 2008, Alberts et al. 2012, Kirkegaard 2012). Researchers have documented an ongoing shift in cancer profile among northern groups with an increase in cancers more common in industrialized populations (e.g., breast cancer, uterine cancer, and colorectal cancer), as well as a general increase in cancer incidence (Friborg & Hassler 2008, Circumpol. Inuit Cancer Rev. Work. Group 2008, Ehrt et al. 2010). Rates of cancer incidence and mortality are generally low for the Sami (Hassler et al. 2008c). Few high-quality cancer data are available for northern Russians (Kozlov et al. 2007, Vaktkjold et al. 2008).

One area of considerable concern for native northern populations is the risk of environmental contaminants contributing to elevated levels of cancer and to other health issues (e.g., reproductive health and cognitive development) (Bjerregaard et al. 2008, Young 2012). The Arctic is uniquely vulnerable to pollutants because heavy metals (e.g., mercury) and POPs (e.g., PCBs) from lower-latitude industrial activities are transported and deposited in circumpolar regions (McConnell & Edwards 2008). Health risks are particularly acute for native northern populations that regularly consume large marine carnivores (e.g., polar bear and seal) because long marine food chains concentrate pollutants (Van Oostdam et al. 2005, Deutch et al. 2007, Donaldson et al. 2010).

Infectious Disease

Beginning several hundred years ago with intensified contact with Europeans, communicable diseases such as smallpox and measles had a major impact on the health and demography of indigenous circumpolar groups (Waldram et al. 2006, Koch et al. 2008). This infectious disease burden remained high until societal changes within the past half-century drove most infectious diseases into steep decline. Despite this decline, the current burden of infectious disease remains elevated in most circumpolar regions. The pattern of diseases is also unique, with high incidence of gastrointestinal and respiratory tract infections (especially in Nunavut, Greenland, and northern Russia), as well as elevated rates of hepatitis, parasitic infections (e.g., trichinellosis), and invasive bacterial diseases (e.g., *Streptococcus pneumoniae*) (Koch et al. 2008, Jenkins et al. 2011, Young 2012).

Of particular note is the high prevalence of *Helicobacter pylori* infection across much of the Arctic, which helps explain population variation in the occurrence of peptic ulcers, gastritis, iron deficiency anemia, and several cancers (Baggett et al. 2006, Koch et al. 2008, Wiggins et al. 2008, de Martel & Franceschi 2009, Tveit et al. 2011). Furthermore, socioeconomic disparities and the effects of climate change may prevent future declines in infectious disease. One considerable challenge has been the burden of tuberculosis; although incidence has generally declined in recent decades, tuberculosis is still at an elevated level in Alaska, Greenland, Nunavut, and northern Russia (Krümmel 2009). Finally, the Arctic has relatively high rates of sexually transmitted infections, especially gonorrhea and chlamydia; the burden is particularly heavy in Greenland, northern Canada, and Alaska (Healey & Meadows 2007, Young 2012).

A key determinant of the generally high infectious disease burden in native Arctic populations is poor-quality housing, which can expose residents to high levels of unclean water and indoor air pollution (Koch et al. 2008). This is compounded by high rates of smoking and exposure to second-hand smoke. Furthermore, crowding can increase burden of respiratory infections, especially in children, and this condition is severe in Nunavut, Greenland, and parts of northern Russia (Young 2012). Poor living conditions result from physical challenges in the northern environment, the isolation of many native communities, and pronounced socioeconomic disparities (Bjerregaard et al. 2008, Young & Mäkinen 2010).

Mental Health, Accidents, and Violence

Injuries, suicide, and violence are major health challenges for Arctic populations, especially native groups (Young & Hassler 2008). Most indigenous circumpolar populations have a relatively high level of mental health challenges, including anxiety, depression, and suicide; these conditions impose a tremendous health burden in Alaska, northern Canada, Greenland, and northern Russia (McGrath-Hanna et al. 2003, Silvikén & Kvernmo 2008, Timonen 2009, Kaiser et al. 2010, Kral et al. 2011, Young 2012). The suicide rate among Canadian Inuit, for example, is 6–11 times greater than for other Canadians (Krümmel 2009). Suicide, in particular among adolescents and young adults, has increased recently in a number of circumpolar populations, including Alaska Natives and Greenland Inuit (Lehti et al. 2009, Timonen 2009). Mortality from accidents (e.g., drowning and traffic accidents) and violence (e.g., homicide), as well as unintentional injury, are very high in northern Russia, with mortality linked closely to alcohol abuse (Kozlov et al. 2007). Furthermore, levels of injury and violence are also elevated in Alaska, northern Canada, and Greenland and are at least 2–4 times higher than the national rates (Strayer et al. 2010, Young 2012). In contrast, levels of injuries and violence among the Sami are not particularly high.

A major contributor to mental illness and associated conditions among northern populations is chronic psychosocial stress linked to rapid economic development and social transformations over the past half-century (Silvikén & Kvernmo 2008). Studies in a number of circumpolar regions have identified key factors such as long-term unemployment, acculturation and loss of traditional values, lack of self-determination, contamination of traditional foods, and discrimination by non-native populations (Kozlov et al. 2007, Wolsko et al. 2007, Silvikén & Kvernmo 2008, Pufall et al. 2011, Young 2012). Chronic psychosocial stress associated with social change and economic marginalization contributes to elevated blood pressure and greater cardiovascular risk in multiple regions. For example, high levels of chronic psychosocial stress associated with economic development, urbanization, and lifestyle change have been documented among Siberian groups such as the Khanty, Mansi, and Yakut (Kozlov et al. 2003, Tyrylgin 2007, Sorensen et al. 2009). Finally, psychological issues in circumpolar populations must be interpreted within a framework that considers seasonality in temperature and photoperiod because these environmental factors can

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influence thyroid function and impact behavior and mental health (Leonard et al. 2005, Palinkas & Suedfeld 2008). For example, studies have documented relatively high prevalence of seasonal affective disorder (SAD) and other seasonal negative mood states among some Arctic groups, including Inuit from Canada and Greenland; the most elevated levels have been found at the highest latitudes (Haggarty et al. 2002, Kegel et al. 2009).

Alcoholism, Smoking, and Substance Abuse

Alcoholism, smoking, and substance abuse are major health issues for most indigenous northern populations, and they also contribute to an increased risk of CVD and cancer and to accidents and violence (Spein 2008, Young 2012). Alcoholism is most severe in northern Russia, with levels of alcohol use higher than the general Russian population and uncharacteristically high among women (Kozlov et al. 2007). Alcoholism in Russia has become a greater problem with the social and political transformations of the past several decades (Tyrylgina 2007). Smoking is at an astonishingly high level across much of the Arctic, including in an estimated 50–80% of northern Russian natives, 60% of Greenlanders and Nunavut residents, and 84% of Nunavik Inuit (Kozlov et al. 2007, Spein 2008, Château-Degat et al. 2010, Young 2012). The Nunavik study documented that all adult participants under 40 years old were current smokers. Smoking, as well as the use of smokeless tobacco, is also high in children and adolescents in many native communities (Kozlov et al. 2007, Spein 2008). Cigarette smoking is a major contributor to lung cancer in circumpolar populations, including among the Inuit for whom lung cancer incidence and smoking prevalence are thought to be the highest in the world (Friborg & Hassler 2008, Spein 2008). Finally, several studies (e.g., Segal & Saylor 2007) note substance abuse problems with cocaine, marijuana, and inhalants among Alaska Natives.

HEALTH DISPARITIES AND THE LEGACY OF ECONOMIC DEVELOPMENT

Pronounced health disparities have been documented for much of the Arctic, yet this issue has not attracted the same level of attention as has inequality or poor health in other parts of the world (Chatwood et al. 2012). Although much of the Arctic is politically located within some of the world's most developed countries, most circumpolar regions show pronounced and, for some, worsening health disparities compared with the national populations, as well as a strong northern versus southern health gradient (Krümmel 2009, Chatwood et al. 2012, Young 2012). For example, there is a 10-year gap in life expectancy between Canadian Inuit and the general Canadian population (Sheppard & Hetherington 2012).

The range of health disparities in the Arctic is enormous, varying from virtually nonexistent to extreme (Bjerregaard et al. 2008, Chatwood et al. 2012). At one end of the spectrum are the Sami with overall favorable health indicators and no or minimal health disparities compared with the majority Scandinavian population. At the other end of the spectrum are indigenous northern Russians with extremely poor health indicators and marked disparities compared with Russia as a whole.

Despite important improvements in health over the past half-century, most circumpolar populations have seen lower-than-expected gains in life expectancy and infant survival, and the infectious disease burden remains stubbornly high. With increases in chronic disease over the past several decades, there are reasons for concern about a double burden of disease. Furthermore, the enormous toll of mental health–related issues (e.g., alcoholism, suicide, and violence) creates a triple burden of disease for many circumpolar populations.

This pattern of health disparities has developed for several reasons. First, although most northern regions are rich in natural resources (e.g., oil and mineral wealth), their economies

are generally resource extractive, and thus regional wealth does not necessarily translate into health benefits for all. Second, with the exception of the Sami, marked socioeconomic disparities between indigenous and nonindigenous residents contribute to chronic psychosocial stress, differences in living conditions, and other factors that influence risk for chronic conditions, infectious disease, and mental illness (Bjerregaard et al. 2008, Young 2012). However, the case of the Sami shows that these disparities are not inevitable but instead a product of social, economic, and historical factors in each country (Norum & Nieder 2012). The overall excellent health of the Sami has been attributed to relatively slow regional acculturation processes, which have preserved key protective elements of traditional Sami culture, and to the generally favorable socioeconomic conditions (e.g., educational attainment) that are similar to those in non-Sami Scandinavian populations (Hassler et al. 2008a). Third, economic development in most of the Arctic has been particularly rapid and intense, which has placed a heavy emotional strain on populations who are experiencing profound shifts in lifeways and traditions (Bjerregaard et al. 2004). Finally, high levels of environmental pollution contribute to disease burden, and these effects are typically most severe among native communities in remote locales.

CLIMATE CHANGE AND ITS EFFECTS ON CIRCUMPOLAR HEALTH

Indigenous circumpolar groups today are threatened by continued regional economic development and pollution and are also uniquely vulnerable to the effects of global climate change. A number of studies have documented the occurrence of climate change in circumpolar regions, most notably pronounced warming, with predictions for mean annual temperature increases of 3–7°C by the end of the twenty-first century (Parkinson & Evengård 2009, Willis & MacDonald 2011, Revich et al. 2012). Climatic change in the Arctic is more rapid than in other regions and has already led to glacial and sea ice melting and decreased permafrost (Anisimov et al. 2007, IPCC 2007).

The effects of climate change on health are not simple and thus difficult to predict. However, key issues include (a) shifts in weather patterns and environmental conditions (Parkinson & Evengård 2009, Brubaker et al. 2011); (b) higher sea level, which threatens coastal communities (Anisimov et al. 2007); (c) altered access to traditional lands and foods, with effects on diet and emotional well-being (Parkinson & Evengård 2009, Brubaker et al. 2011, Cunsolo Willox et al. 2012, Ford 2012); (d) disruption of water supplies, with concomitant increase in infectious disease burden (Evengard et al. 2011, Ford 2012); and (e) range expansion of parasitic zoonoses into more northern areas (Jenkins et al. 2011, Revich et al. 2012). In fact, climate change has already affected circumpolar lifeways and health, including precipitating increased food insecurity among Canadian and Greenland Inuit (Beaumier & Ford 2010, Goldhar et al. 2010) and damaging community water infrastructure among rural Alaskans increasing hospitalization rates for respiratory and skin infections (Hennessy et al. 2008, Evengard et al. 2011). In short, circumpolar populations are serving as the bellwethers of global climate change. Despite this threat, research has shown many examples of resilience in the face of environmental challenges, as well as effective community-based strategies to mitigate the consequences of climate change (Brubaker et al. 2011, McClymont Peace & Myers 2012).

INTEGRATIVE ANTHROPOLOGICAL APPROACHES TO CIRCUMPOLAR HEALTH

An anthropological approach to circumpolar health provides a powerful lens through which to consider how evolutionary forces shape susceptibility to disease. Furthermore, this holistic, integrative approach allows researchers to elucidate how cultural and individual factors interact

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with underlying genetic susceptibility within the context of a particular environment to structure health risk. This section provides an example of how an evolutionary and biocultural approach can be used to understand the myriad factors that shape circumpolar health.

Indigenous Siberians such as the Yakut and Evenki display a cardiovascular risk profile that contrasts markedly with many lower-latitude groups and includes extremely high levels of hypertension and stroke and moderately high but increasing obesity, yet a relatively favorable lipid profile and a low prevalence of T2D (Snodgrass et al. 2007). This contrasts with other populations that have experienced recent economic development, which have a chronic disease risk profile characterized by moderately elevated blood pressure, high levels of obesity, very high T2D risk, and an unfavorable lipid profile (Weyer et al. 2000, McDade & Nyberg 2010). This regional variation, with few exceptions (Snodgrass et al. 2007, McDade & Nyberg 2010, Liebert et al. 2013), has attracted little attention.

Recent research among the Evenki, Yakut, and Buryat has considered whether metabolic adaptation to the cold and marginal northern environment (i.e., upregulated BMR) structures chronic disease risk (Snodgrass et al. 2007, 2008; Leonard et al. 2009). BMR was found to be positively correlated with blood pressure, even when controlling for a variety of potentially confounding factors (e.g., body composition, age, smoking, and extent of urbanization). This research also documented a negative association between BMR and low-density lipoprotein (LDL) cholesterol. Taken together, these data suggest that, at least for indigenous Siberians, biological adaptation to the circumpolar environment contributes to an increased risk of hypertension but a lower risk of dyslipidemia. Although this research is preliminary, it does suggest that adaptation to the northern environment, combined with the unique Russian political factors that have marginalized native groups, structures the distinctive chronic disease profile seen among indigenous Siberians. More generally, it emphasizes the need to consider regional adaptive patterns when investigating global health variation and underscores the importance of developing innovative models to understand disease patterns that integrate environmental exposure with underlying differences in susceptibility.

ARCTIC HEALTH RESOURCES, RESEARCH NETWORKS, AND INITIATIVES

Arctic Health (<http://www.arctichealth.org/>) is a National Institutes of Health and University of Alaska–sponsored website that serves as a clearinghouse for circumpolar health information and includes a comprehensive publication database and links to the Alaska Native Tribal Health Consortium’s Digital Stories health-related video collection (<http://www.youtube.com/user/ANTHCDigitalStories>).

The *International Journal of Circumpolar Health* (<http://www.circumpolarhealthjournal.net/index.php/ijch/index>) is an open-access journal and is the main publication for articles on the health of indigenous northern peoples.

The International Union for Circumpolar Health (IUCH; <http://www.iuch.net>), an international nongovernmental organization, is a key network that links researchers and policy makers interested in the health and well-being of circumpolar groups; it also brings together regional circumpolar health organizations from the United States, Canada, Greenland, Scandinavia, and Russia (Bruce 2011). The International Congress on Circumpolar Health (ICCH; <http://www.iuch.net/meetings.php>) is the main international conference on circumpolar health and is held every three years (Bjerregaard et al. 2004).

The International Polar Year (IPY; <http://www.ipy.org/>), which occurs approximately every 50 years, is a key circumpolar research initiative and project sponsor. The most recent IPY, the fourth, took place in 2007–2008 and focused attention on the health and well-being of circumpolar populations (ICSU 2004, Parkinson 2011).



SUMMARY POINTS

1. Circumpolar populations are diverse in their traditional subsistence means and culture, genetic backgrounds, and the environments they inhabit. The unique stressors of the circumpolar environment present challenges to which these populations have adapted through cultural, behavioral, and biological means.
2. Summarizing the health of circumpolar populations is challenging because of pronounced regional differences. Overall health and well-being range from excellent among the Sami of Scandinavia to extremely poor among the socially and economically marginalized native populations of northern Russia.
3. These regional health differences are shaped by unique population histories, variation in diet and activity patterns, socioeconomic disparities with nonindigenous groups, environmental pollution, and biological factors.
4. Economic development has brought with it some positive elements, including increases in life expectancy and a lower burden of infectious disease. However, recent social and economic changes have also precipitated a rise in chronic diseases and mental health challenges.
5. Climate change is already affecting the lifeways and health of circumpolar peoples, and its effects will accelerate in the coming century.
6. An anthropological approach that integrates evolutionary and biocultural perspectives provides a powerful tool for examining circumpolar health as it considers environmental exposure, sociocultural factors, and underlying differences in susceptibility.

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