

Indigenous health part 1: determinants and disease patterns

Michael Gracey, Malcolm King

The world's almost 400 million Indigenous people have low standards of health. This poor health is associated with poverty, malnutrition, overcrowding, poor hygiene, environmental contamination, and prevalent infections. Inadequate clinical care and health promotion, and poor disease prevention services aggravate this situation. Some Indigenous groups, as they move from traditional to transitional and modern lifestyles, are rapidly acquiring lifestyle diseases, such as obesity, cardiovascular disease, and type 2 diabetes, and physical, social, and mental disorders linked to misuse of alcohol and of other drugs. Correction of these inequities needs increased awareness, political commitment, and recognition rather than governmental denial and neglect of these serious and complex problems. Indigenous people should be encouraged, trained, and enabled to become increasingly involved in overcoming these challenges.

Introduction

There are more than 370 million Indigenous people worldwide and they live in countries on every inhabited continent.^{1,2} The definition of Indigenous can be difficult, even contentious;^{2,3} panel 1 shows criteria that can be used to this end. Some Indigenous groups are easily identified, such as native Americans, Australia's Aboriginal people, Māori in New Zealand, and the original inhabitants of Pacific Ocean nations who were present long before Europeans.³ Indigenous peoples are variously called Indigenous, Aboriginal, tribal, or minority groups or peoples.³ Poor definition of Indigenous identification contributes to the groups' marginalisation and inadequate data for their numbers, health, and socioeconomic circumstances.³ Most countries do not officially recognise their Indigenous groups, and have inaccurate or no published statistical data for these peoples. Therefore, systematic information about health, morbidity, and mortality is sparse.^{2,3} Most reports relate to specific conditions and small groups. In this Review we discuss issues of worldwide importance and draw on Australian Indigenous experience as an example. Despite great diversity of Indigenous peoples, many similarities in their health and illnesses and their determinants exist.

Indigenous people come from thousands of cultures and are over-represented among the poor and disadvantaged. Overall, their health compares unfavourably with their non-Indigenous counterparts.³ Their susceptibility to disease is exacerbated by poor living conditions and water supplies, often with restricted access to fresh and nutritious food, and inadequate health services. Panel 2 summarises their main health problems.

Effects of colonisation

Common to many Indigenous groups are the powerful effects of colonisation on their people and their lands by outsiders who later dominated societies and alienated them from their own ways of life. This colonisation adversely affected physical, social, emotional, and mental health and wellbeing in traditional societies. Extrapolation between different groups is unwise because local circumstances differ greatly.

We need to understand how colonisation affected the lives of Indigenous peoples to understand their health today. The effect of colonisation was and is profound. Many colonisers were European, including Belgian, British, Dutch, French, German, Italian, Portuguese, Russian, and Spanish; but there were also Asian colonists, including Chinese, Indonesian, Japanese, and Malaysians.² The biggest Indigenous populations are in the most populous countries, such as China, India, Indonesia, Asian Russia, and former Soviet Union countries. Some nations deny the existence of their Indigenous populations because of ignorance, embarrassment, or political expediency.

Foreign intruders introduced microorganisms to which traditional groups had not been exposed and were susceptible. The devastating entry of smallpox, measles, and tuberculosis into the long-isolated Indigenous inhabitants of Australia is a good example.⁴ Likewise, infections introduced by colonists seriously affected Indigenous populations in the Americas and elsewhere.

Traditional Indigenous people were careful custodians of the environments that provided them and future generations with sustenance, including water, plants, animals that they hunted and fished, and from which they gathered eggs and tidal shoreline foods, such as shellfish and marine plants. Habitats of local foods and plants were protected to ensure that they were not spoiled by human or animal predators or pests and to maintain

Lancet 2009; 374: 65–75

See Editorial page 2

See Perspectives page 19

See Review page 76

Unity of First People of Australia, Perth, WA, Australia (Prof M Gracey MD); and University of Alberta, Edmonton, AB, Canada (Prof M King PhD)

Correspondence to:

Prof M Gracey, Unity of First People of Australia, Perth, WA, 6005, Australia
m.gracey@optusnet.com.au

Search strategy and selection criteria

We searched a combination of sources, including PubMed, concentrating on original publications and reviews from the preceding 10 years. The search was not confined to the English language. Keywords used included: "Indigenous", "Aboriginal", or "Aborigines", linked with "health", "nutrition", "malnutrition", "growth", "infants", "children", "pregnancy", "maternal health", "adolescents", "infections", "parasites", "hypertension", "cardiovascular disease", "diabetes", "renal disease", "dialysis", "alcohol", "drugs", "trauma", "accidents", "drowning", "poisoning", "homicide", "suicide", and "mortality". Information was obtained from other sources such as websites from international organisations, including UN and WHO. Some information came from earlier reviews and books of particular relevance; these works are in the public domain and are referenced here. We also had access to unpublished official reports about the health of Indigenous people in Australia.

Panel 1: Criteria to help to define Indigenous peoples¹

- Self-identification as Indigenous peoples by individuals and acceptance as such by their community
- Historical continuity and land occupation before invasion and colonisation
- Strong links to territories (land and water) and related natural resources
- Distinct social, economic, or political systems
- Distinct language, culture, religion, ceremonies, and beliefs
- Tendency to form non-dominant groups of society
- Resolution to maintain and reproduce ancestral environments and systems as distinct peoples and communities
- Tendency to manage their own affairs separate from centralised state authorities

Panel 2: Major health problems of Indigenous peoples

- High infant and young child mortality
- High maternal morbidity and mortality
- Heavy infectious disease burdens
- Malnutrition and retarded growth
- Shortened life expectancy at birth
- Diseases and deaths associated with cigarette smoking
- Social problems, illnesses, and deaths linked to misuse of alcohol and other drugs
- Accidents, poisonings, interpersonal violence, homicide, and suicide
- Obesity, diabetes, hypertension, cardiovascular disease, and chronic renal disease (lifestyle diseases)
- Diseases caused by environmental contamination (eg, by heavy metals, industrial gases, and effluent wastes) and infectious diseases caused by faecal contamination

Panel 3: Nutritional deficiencies of Indigenous peoples

Besides hunger and general inadequacy of food and dietary energy (calories), specific deficiencies of various nutrients are widespread. Examples are iron deficiency, which can be caused by dietary inadequacy or secondary to blood loss, intestinal parasites, or malaria; hypothyroidism, shortness of iodine affects hundreds of millions of people; poor vitamin intake (eg, vitamins A and D, folic acid); and heavy metals, such as zinc. These deficiencies and any underlying causes, including poverty and inadequate food, should be corrected to reach satisfactory outcomes for those affected.

their long-term sustainability. Water supplies were protected from loss and spoilage, and for agriculturalist groups protection of water supplies was very important to support their crops.

Colonisation had a powerful effect on Indigenous populations. It blocked access to or destroyed traditional farming, food-gathering, or hunting and fishing places and practices.^{5,6} This change made the previous inhabitants dependent on colonisers for foods that were often unfamiliar to them and of inferior nutrient quality (panel 3). Colonists introduced harmful substances such as tobacco and alcohol, which had serious long-term effects on health and caused severe social, psychological, and emotional damage.⁶⁻⁸

The fabric of traditional societies was shredded by colonisation. Traditional life was suppressed by alien regulations imposed on people who had lived, sometimes for many thousands of years, with well established traditional laws, languages, dress, religions, sacred ceremonies, rituals, healers, and remedies. This legalised disruption was worsened by socioeconomic and political marginalisation, and by racial prejudice which was often entrenched and institutionalised. This process was hastened by the often brutal dispossession of traditional lands, and subsequent poverty, undereducation, unemployment, exploitation by unscrupulous employers and landlords, and increasing dependence on social welfare or begging in cities and towns. Many Indigenous groups have to live on unproductive land or in towns, cities and their fringes, slums, or squatter camps that are environmentally degraded health hazards, contaminated by heavy metals and industrial waste (figures 1 and 2).⁹

These oppressive factors caused severe inequalities in Indigenous health status, unsatisfactory disease and vital statistics, impaired emotional and social wellbeing, and poor prospects for future generations.¹⁰ These issues should be taken seriously to redress socioeconomic and health inequities for Indigenous populations worldwide. This redressal is an immense challenge, engaging different levels of governments, various international agencies, non-governmental organisations, clinicians, and health policy makers and administrators. Indigenous people should be meaningfully engaged rather than prejudicially excluded from these endeavours.

Health of children and mothers

Poor living conditions, inadequate nutrition, and exposure to high rates of infection cause a heavy burden of disease in infants and children.¹¹⁻¹³ These diseases are mainly skin infections, acute and chronic ear disease, dental caries, trachoma, diarrhoeal diseases, parasite infestations, upper and lower respiratory tract infections, urinary tract infections, and viral and bacterial infections affecting the nervous system. Indigenous children have high rates of low birthweight and being small-for-gestational age. These factors can affect development of cardiovascular disease, renal disease, and diabetes in adulthood.¹⁴

Unfavourable perinatal and neonatal health outcomes, including deaths, are pressing issues, especially in developing countries.¹⁵ Several interventions could cost-effectively save many of these lives.¹⁶ These interventions, including improved clinical care to poorly served groups, should engage families and communities and improve home-care practices. Better and well coordinated care and supervision for mothers and babies should be implemented simultaneously.¹⁷

Some diseases are prevalent in specific areas, such as tropical regions. These diseases include malaria, measles, dengue, haemorrhagic fevers, amoebiasis, ancylostomiasis, ascariasis, strongyloidiasis, schistosomiasis, and viral infections such as hepatitis and encephalitis. HIV

infections affect many Indigenous infants, children, and adolescents. Childhood diseases are linked to substandard hygiene, nutrition, and immune status, worsened by heavy exposure to environmental microbial contamination such as contaminated water, food, utensils, or person-to-person or animal-vector-spread diseases such as giardiasis or salmonellosis. Infections are also associated with falling breastfeeding practices and contamination of non-human milks or other fluids.

Socioeconomic status is a major determinant of disparities in Indigenous health, irrespective of ethnicity.¹⁸ Immunisation is effective against vaccine-preventable childhood viral infections in which strain variation is low and herd immunity is high, as in measles and hepatitis B.¹⁹ However, universal vaccination is often not feasible in Indigenous populations, especially in remote areas. Vaccine-preventable diseases, including measles, mumps, diphtheria, rubella, pertussis, and tetanus have been controlled in most non-Indigenous populations but are still rife and potentially fatal in many Indigenous groups. This area should be a priority for action by governments and non-governmental organisations.

Many groups do not have access to traditional foods^{5,6} and depend on commercial foods sold in Indigenous community stores or in small towns, villages, or at roadhouses; their infants and children are often malnourished. This malnourishment is frequently caused by poverty and insufficient food, and is worsened by inadequate facilities in the home to securely store and keep food cool and uncontaminated. Substandard nutrition of infants and young children can be associated with maternal ill-health and malnutrition, or both, which can negatively affect pregnancy and predispose to premature birth, low birthweight, and intrauterine growth retardation.²⁰ Childhood growth faltering and malnutrition are major challenges and are associated with increased mortality. About 15% of Aboriginal children aged less than 5 years in Australia's Northern Territory are underweight, 11% are stunted, and 9% are wasted.²¹ Soundly based and community-delivered nutrition education, linked to interventions that enlist carers, community health workers, and community members, can help to prevent growth faltering.²¹ Increased infant mortality is prevalent in many Indigenous populations and is related to social and economic circumstances and restricted access to adequate health care. Childhood malnutrition, impaired growth, and stunting are often associated with repeated or chronic infections. Gastrointestinal infections and parasite infestations are especially important because of their negative effects on intestinal digestion and malabsorption of nutrients, minerals, and vitamins.²² Millions of increasingly urbanised Indigenous youngsters now face the consequences of overnutrition rather than undernutrition, including chronic lifestyle diseases.²³

Pregnant women, nursing mothers, infants, and children form a large part of Indigenous populations.^{2,24}



Figure 1: Typical housing for Australian Aboriginal people in 2008
Inadequate housing and overcrowding prevail in urban, periurban, rural, and remote Indigenous populations; many other Indigenous people are homeless or live in makeshift camps and shanties.



Figure 2: Hazardous waste in an Aboriginal housing area in tropical northwest Australia in 2006
Environmental contamination predisposes to high rates of recurrent and chronic infections in many communities.

Maternal health before and during pregnancy and while nursing their infants is essential for the health, nutrition, and growth of infants and young children. Many Indigenous mothers are ill-prepared for pregnancy. They can be very young or have been pregnant many times and, consequently, at high risk of complications to themselves or their infants. They also tend to have high rates of other risk factors, including (1) undernutrition during pregnancy, which can be worsened by the necessity of many mothers to do strenuous physical work throughout pregnancy, such as labouring on farms, harvesting and carrying crops or traditional foods, and carrying water daily for many kilometres for domestic chores; (2) anaemia caused by nutrient deficiencies (eg, iron) and underlying disease, or both; (3) deficiencies of other nutrients (eg, iodine, zinc, and vitamins); (4) inadequate preparation, education, and prenatal and postnatal clinical care; (5) high rates of largely preventable urinary tract infections;²⁵ (6) gestational diabetes, which can pre-date permanent diabetes; and (7) scant human, clinical, and laboratory resources

for safe pregnancy, delivery, and postnatal care. Many Indigenous women, especially those in poor countries, have little or no access to basic clinical staff and facilities that should be part of the routine care of women before, during, and after pregnancy. Gestational glucose tolerance,²⁶ obesity, pregravid weight, and weight gain during pregnancy can adversely affect maternal and fetal outcomes,²⁷ including HbA_{1c} and blood pressure measurements in later life.²⁸

In many Indigenous societies, traditional midwives and healers give important advice and care to women before and during pregnancy and after parturition. Modern health professionals could usefully collaborate with them so that mothers and infants benefit from their experience.

Indigenous adolescents have many important health-related disadvantages that cause ill-health and disability (panel 4). These disadvantages are worsened by poor educational standards, inadequate knowledge of the determinants of health, and frequent absence of access to and use of good quality clinical care and preventive health services.

Burden of infectious disease

Indigenous people have much higher rates of infection than do their non-Indigenous counterparts, and these infections are likely to be more severe or more frequently fatal in Indigenous groups. The nature, frequency, and severity of infection depends on age, nutritional status, impaired immunity, presence of diabetes, personal living conditions and hygiene, exposure to infections and disease-carrying vectors, immunisation status, geography, and climate.

Skin infections are very common, especially in children. Some examples are: bacterial infections of abrasions, lacerations, vesicles, burns, pustules, and furuncles; superinfection of extensive lesions, such as impetigo; mycoses, including tinea of the head, body, feet, and skin folds (this can be very extensive); candidosis or moniliasis; parasitoses, including scabies, skin, and soft tissue infestation by larvae of flies, pediculosis, insect stings, and bites of fleas and ticks; cutaneous *Larva migrans*; and leprosy and yaws. These infections can cause permanent scarring and can allow entry of streptococcal

infections and invasive diseases such as nephritis or endocarditis.^{29–31}

Respiratory and gastrointestinal infections often coexist; they cause widespread illnesses and deaths, especially in infants and young children. Upper and lower respiratory tract infections are prevalent³² and deaths from pneumonia are “a permanent global emergency”.³³ Episodes often coincide with other infections such as gastroenteritis, meningitis, encephalitis, and locally endemic or epidemic diseases—eg, malaria. Respiratory infections can be drug-resistant such that mortality can be very high, especially in patients with malnutrition and impaired immunity. Measles can cause rapidly fatal pneumonia. Tuberculosis is still widely prevalent in many countries and should be suspected in patients with chronic symptoms.^{34,35}

Immunisation can help to control some respiratory infections such as pneumococcal disease, *Haemophilus influenzae* type b, tuberculosis, pertussis, diphtheria, measles, and other viral infections.¹⁹ There has been improvement in controlling measles. Vaccination programmes undertaken by the Pan American Health Organization have reduced Indigenous transmission of measles; political commitment was important in achieving this reduction and more effective control is feasible in future.³⁶ Overcrowding and indoor or outdoor air pollution (eg, from cooking and heating fires, cigarette smoke, and atmospheric pollution) predispose to airway disease and respiratory infections.^{32,37,38}

Otitis is prevalent;³⁹ most episodes of otitis externa can be successfully managed conservatively but otitis media is often much harder to manage and surgery might be necessary. Hearing loss can be permanent if the inner ear is chronically damaged and if audiological management is unavailable. This loss can impede future education, training, and employment.

Diarrhoeal diseases are often accompanied by other infections, malnutrition, and specific nutrient deficiencies, especially in children. Causative agents include viruses, bacteria, parasites, protozoa, fungi, and yeasts. Symptoms range from mild to potentially fatal, as with cholera, shigellosis, and other enteroinvasive infections. Viral diarrhoeas can cause severe watery diarrhoea and widespread morbidity and mortality. Many diarrhoeal episodes do not respond to antibiotics—for example, those caused by non-bacterial agents. Rotavirus vaccine research has proceeded for many years, but vaccines are not yet generally available.⁴⁰ Such protection might not be effective in Indigenous populations for several years because of the multiplicity of strains involved, the technical problems and costs of developing effective stable polyvalent vaccines, and the logistical difficulties in their distribution.

Malaria is widespread in tropical countries and causes serious morbidity and millions of deaths. Many strains of plasmodium are multidrug-resistant and work is continuing towards producing vaccines to control the

Panel 4: Health-related problems of Indigenous adolescents

- Little knowledge of determinants of health and disease risk
- Increasing use of harmful substances such as tobacco, alcohol, and other drugs
- High-risk sexual activities
- High-risk, unplanned, and poorly supervised pregnancies
- Violence and trauma in crowded communities and urban environments
- Increasing rate of obesity in increasingly urban populations
- Mental and emotional disorders

infection.⁴¹ Preventive measures, such as spraying mosquitoes, might be unavailable or ineffective. Indigenous populations are often unaware of the usefulness of simple protective equipment such as mosquito nets, and generally cannot afford them. To reduce the vast disease burden and deaths from malaria, many international non-governmental organisations are taking part in community-based programmes, including education, control of transmission of infection, and use of personal protective procedures.

Invasive meningococcal infections can cause potentially fatal illnesses, including pneumonia and septicaemia; vaccines exist⁴² but are often inaccessible to Indigenous populations. Urinary tract infections²⁹ are very common and often have serious long-term sequelae, including renal failure.^{43–45} Importantly, these infections are generally asymptomatic and in Indigenous men and women can cause long-term complications, such as chronic renal insufficiency, unless detected early and managed energetically.^{25,46–48} Sexually transmissible infections are prevalent^{49–51} and cause immense personal, family, and community damage. The introduction of a vaccine against human papillomavirus infection^{52–54} might help to reduce the risk of cervical carcinoma, but only for those who have access to the vaccine. Immunisation against vaccine-preventable diseases in Indigenous populations should be very high priority. But there are inherent problems related to costs, production of sufficient vaccine stocks, adequate storage, transportation, and distribution facilities, and availability of trained staff to administer vaccines and to gather together people to be vaccinated. All these considerations assume access to epidemiological information to alert authorities of the need for vaccination.

HIV/AIDS has been called “the first postmodern pandemic”⁵⁵ and HIV infection is a continuing health crisis in racial and ethnic minorities, including Indigenous people.⁵⁶ This situation is interwoven with prevalent socioeconomic difficulties, including poverty, homelessness, substance misuse, and unequal access to health care. The AIDS epidemic disproportionately affects such populations, especially women.⁵⁶ Maternal HIV infection has particular importance to infants and young children because of increased risk of perinatal mortality, transplacental transmission of the virus, and the consequences of probable premature maternal death. Rates of HIV/AIDS are high in many Indigenous groups—for example, in American Indians, Alaskan Native populations,⁵⁷ Indigenous Canadians,⁵⁸ in African races,^{6,59} and people in the Asia-Pacific region.^{60,61} The HIV incidence in Indigenous Mayan Guatemalans, who represent 42% of the country’s population, may be three times as high as in the rest of the population.⁶²

Such findings led UNAIDS to take action, by studying trends, vigorously promoting prevention, and engaging Indigenous representatives in decision making. Use of Indigenous languages is important in these processes.

Transmigration to urban areas increases the risk of sexually transmitted infections, including HIV/AIDS, in Indigenous populations. The upsurge of these infections in the Indigenous peoples of Brazil, particularly those involved in agrarian conflicts or migrating to towns and cities, led to the establishment of Special Indigenous Health Districts. This system allowed improvement in disease surveillance, treatment, and control, and encouraged greater participation of Indigenous community health workers in the network’s activities and assessment.⁶³

The AIDS epidemic is rapidly worsening in the Asia-Pacific region. Most of the Indigenous population does not have access to information, skills, methods, and infrastructure that are necessary for detection, treatment, and prevention, and mainstream health campaigns are inappropriate and ineffective.⁶⁰ The high rates of sexually transmitted infections in Aboriginal people in Western Australia are associated with high rates of HIV notifications.⁶⁴ From 1994 to 2002, the age-standardised rate ratios of HIV notifications, compared with non-Indigenous people, were 2:1 for men and 18:1 for women. Public health authorities are attempting to control these problems but “the clock is ticking”.⁶⁴

Infections of the nervous system, such as meningitis and encephalitis, can have disabling long-term complications and are potentially fatal. Effective treatment might not be available or accessible. Some of the causative agents are bacteria (including tuberculosis), rickettsiae, viruses, and fungi. These infections can cause brain abscesses. Ophthalmic infections often cause visual impairment or blindness.

Soft tissue infections, such as pyomyositis, are often deep-seated and serious, especially in children. Osteomyelitis can be blood-borne and associated with penetrating injuries or fractures. Dental and periodontal diseases are common and can be associated with rheumatic and other forms of cardiovascular disease.^{65,66}

Urbanisation and upsurge of lifestyle diseases

Urbanisation has had a profound effect in the past century. The process of urbanisation is usually regarded as the growth of cities and rural-to-urban migration. Millions of Indigenous people now live in urban or periurban areas. The effects of urbanisation are virtually worldwide and are not confined to large groups. These effects are caused by increasing commercialism, acculturation, and rapidly changing lifestyles. They include modern high-calorie, high-fat, high-salt, and low-fibre diets, changing infant feeding practices, decreased physical activity, overcrowding, and environmental contamination.²³ The effects of urbanisation on health, including chronic lifestyle diseases, have been intensifying in industrialised countries for many years and are a major international public health problem. These hazards have emerged more recently in Indigenous groups that seem prone to them, such as the Indigenous peoples of North America

Panel 5: Major difficulties, trends, and factors that affect Indigenous health**Persistent problems**

- Poverty, hunger, environmental contamination, frequent infections, and parasites
- Infant and child malnutrition and growth failure
- High infant and young child mortality
- Maternal ill-health and high mortality
- Chronic ill-health and disabilities
- Shortened life expectancy
- Poor understanding of the complexities of Indigenous health by health professionals
- Widespread prejudice about perceived inadequacies of Indigenous people
- False expectations that medical strategies alone can overcome Indigenous health problems
- Government preoccupation with sickness services rather than wellness strategies
- Bureaucratic mishandling of culturally sensitive matters beyond their rigid protocols
- Insufficient chances for Indigenous people to be trained and take part in their health care
- Inadequate systematic data to allow surveillance and improvement of Indigenous health care
- Government indifference, ignorance, neglect, and denial about the poor state of Indigenous health

Areas with improvement

- Suppression of some vaccine-preventable diseases
- Improved pregnancy outcomes, including birthweights
- Lower rates of some infections and related deaths, especially in infants and young children
- Reduced maternal, infant, and young child mortality
- Increased life expectancy in some populations
- Improved education in some Indigenous groups and their employment in health-related fields
- Introduction of Indigenous components to education and training of health professionals
- Training of Indigenous people for careers in health professions
- Increased participation of Indigenous people and groups in policy-making and political affairs
- Widening awareness of the seriousness of health issues in Indigenous peoples
- Formal recognition by some national governments of Indigenous peoples' rights (eg, Australia, Canada, Japan)

Areas of deterioration

- Erosion of the authority of Indigenous Elders
- Illnesses associated with overcrowding and environmental contamination in squatter settlements, urban slums, and disaster situations
- The rapid upsurge of lifestyle diseases
- Respiratory and peripheral vascular disease associated with cigarette smoking
- Diseases and social problems associated with misuse of alcohol and other drugs
- Emotional, mental, and psychiatric illnesses
- Interpersonal and family violence, including, child abuse, homicide, and suicide
- Motor vehicle and other accidents and poisonings
- Sexually transmissible diseases, including HIV/AIDS

and Australia. The negative health effects of urbanisation now occur in *barrios* (small towns) and even in very remote Aboriginal communities in the Australian outback.²³ Misuse of alcohol and other drugs, injuries, poisonings, violence, and accidental deaths and injuries are also important hazards.^{23,67}

The worsening epidemic of lifestyle diseases includes obesity, hypertension, cardiovascular disease, type 2 diabetes mellitus, chronic renal disease, and renal failure.^{68,69} This epidemic is part of an international “crisis in public health”.⁷⁰ These disorders are now prevalent in Indigenous populations—for example, in Australia^{71–73} and the Americas.^{74–78} These disorders have emerged recently in these groups, perhaps because of genetic predisposition and changed diet and lifestyle.^{72,73,79–81} This issue is so serious in remote Aboriginal peoples living in northwest Australia that 40% of all adults and almost 60% of those aged 35 years or older have diabetes.⁷¹ Some Indigenous children become overweight and hyperinsulinaemic as young as age 5 years.⁸² Aboriginal children up to 17 years of age in Western Australia have a diagnosis rate of diabetes that is 18 times that of their non-Indigenous counterparts.⁸³ This disturbing upsurge has occurred in many Indigenous populations, especially in recent decades. Previously, the main childhood nutritional disorders in Indigenous Australians were malnutrition, stunting, and infections; now, increasingly, they are obesity and related risks of lifestyle diseases.⁷² This nutrition transition has occurred in many countries, including in Chilean adults and children.⁸⁴

Chronic diseases have become worldwide health problems that cause many millions of deaths every year.⁸⁵ This epidemic is worsening in low-income and middle-income groups and is driven by rapid social and environmental changes that aggravate the prevalence of preventable risk factors.⁸⁶ This situation helps to explain the importance of the risk factors in Indigenous populations. The main risk factors for chronic disease are unhealthy diet, decreased physical activity, and tobacco use. These factors apply in lower socioeconomic groups in industrialised, developing, and transitional societies.⁸⁵ Non-communicable diseases tend to increase as rates of infectious diseases lessen. The global burden of disease differs greatly around the world. Infectious and nutritional diseases are major problems in Africa, but are very much less so in high-income regions such as Europe. Non-communicable diseases are more important in higher-income regions, such as Europe, the Americas, and now the western Pacific and southeast Asia regions of WHO as these regions have become more affluent and urban.⁸⁷ However, such data can be misleading because they are aggregated and do not reveal variations within regions or countries. Chronic diseases and their risk factors need to be countered by promotion of healthy lifestyles, change in food habits, encouragement of physical activity and sport, discouragement of cigarette smoking and alcohol and drug misuse,⁸⁵ and by fostering of physical and emotional wellness (panel 5). Unless these changes take place chronic diseases will spread more widely as more and more Indigenous people adopt sedentary modern lifestyles. Related morbidity and mortality can be improved by control of blood glucose, blood pressure, and lipid concentrations.⁸⁸ Remote

Australian Aboriginal groups, given the opportunity, can collaborate through community-based programmes and with conventional clinical services to keep the devastating effects of these disorders to a minimum.⁷¹ Indigenous people should be encouraged, trained, and enabled to become increasingly engaged in and take responsibility for their own health and wellbeing.^{2,89}

Changing patterns of Indigenous health

Major difficulties, trends, and factors that affect Indigenous health are summarised in panel 5. Clearly, Indigenous people should have better health than they do at present, which will depend on recognition of the problems and resolute action to overcome them. Approaches should relate to local circumstances, interaction between Indigenous and non-Indigenous parts of society, and provision of improved health-related services.

Is Indigenous health changing? This important but sweeping question has no simple answer, mainly because of scarcity of reliable data. Such information is urgently needed to document present health status in Indigenous people, develop appropriate strategies and programmes, assess effectiveness of those activities and modify them if necessary, compare health standards between different groups of Indigenous and non-Indigenous people, and study changes in Indigenous health over time.

How can health or wellness be measured? Widely used indicators include infant mortality, mortality of children aged 0–5 years, incidence or prevalence of diseases and their risk factors, and life expectancy at birth. These are clinically-orientated statistical markers that give no indication of broader issues of physical wellness or social wellbeing. Indicators that use mortality rates measure the worst outcomes. More comprehensive indicators of health and wellness, presence or absence of disease or risk factors, and long-term outcomes are needed.

Disability-adjusted life year (DALY) assessment is a widely accepted single summary measure of population health. On the basis of this assessment to measure the main risk factors, diseases, and causes of excess mortality in Indigenous Australians,⁹⁰ the age-adjusted rate ratios of DALYs were higher in Indigenous Australians than in the total Australian population (see table). Among 20 diseases and injuries causing the greatest burdens in men were homicide and violence (relative risk 6·8), inflammatory heart disease (6·3), and lower respiratory tract infections (6·1). For women the greatest differentials were for rheumatic heart disease (26·4), homicide and violence (11·0), and alcohol dependence and harmful use (7·9).

11 risk factors collectively explained 37% of the Australian Indigenous disease burden. These factors were tobacco use, alcohol, illicit drug use, high body mass, inadequate physical activity, low intake of fruit and vegetables, high blood pressure, high cholesterol concentration, unsafe sex, child sexual abuse, and physical abuse of intimate partners. Some of these factors

were major contributors to cardiovascular disease, diabetes, chronic respiratory disease, and injuries and violence, which shows their importance when designing and implementing strategies and interventions to lessen the burden of disease, injury, and premature deaths. Of 193 countries, all Australian men aged 15–60 years had the seventh lowest and all Australian women the 12th lowest probability of dying in 2003, yet Indigenous Australians were in a worse position than the East Timorese, whose probability of dying was worse than 130th in that list of 193 countries. These findings have many important implications. The major risk factors should be targeted more carefully, and better health-care facilities and services are needed because mortality in ill Indigenous Australians is worse than in other Australians. Furthermore, the disability and mortality gaps are greatest for young Indigenous people. Risk reduction in young people should have much higher priority than it does now.

The Millennium Development Goals expect that all people should benefit from development.⁹¹ However, worldwide, Indigenous populations have higher mortality than their non-Indigenous counterparts.⁹² The Indigenous versus non-Indigenous mortality gap is worse in Australia than in other Organisation for Economic Co-operation and Development nations with disadvantaged Indigenous populations, including Canada, New Zealand, and the USA.⁹² This gap in Australia reached a stark peak of 17 years in 1996–2001,⁹³ and was partly responsible for the formal government apology to Indigenous Australians.⁹⁴ The federal government is now committed to closing this gap and other forms of long-term disadvantage that Indigenous Australians have.⁹⁵ These disadvantages consist of housing availability and standards, community infrastructure and services such as water supplies, environmental hygiene, educational attainments, training and employment opportunities, and accessibility to health care. These gaps will probably not be closed by the target date of 2030 despite our best efforts and irrespective of various strategies, social and medical, that have been proposed.⁹⁶ Regrettably, inadequate attention seems to have been given to potential gains that could be achieved through more meaningful involvement of Indigenous Australians and their communities in this task.

Close scrutiny of the use of mortality or life expectancy as a measure of the health of Indigenous peoples raises

	Men	Women
Cardiovascular disease	4·5	5·1
Diabetes	4·4	6·0
Intentional injuries	3·9	5·3
Unintentional injuries	2·4	2·9
Chronic respiratory disease	2·5	2·6

Table: Age-adjusted rate ratios of Indigenous to total Australian DALYs⁹⁰

some important issues. In Canada, for example, there were substantial gains in life expectancy at birth in the Indigenous population from the 1940s onwards so that by 2000 the unfavourable gap for Indigenous Canadian men versus other Canadian men was only 7 years and for women was 5 years.⁹⁷ There were also steep declines in Canadian Indigenous infant mortality rates over a similar period, although the reduction was more striking for infants of First Nations people than for the Inuit, who still have infant mortality rates three times those of the national Canadian rates.⁹⁷ There have been substantial reductions in Indigenous infant mortality in Australia, too, over the past few decades, although the rate is still double or three-fold that of non-Indigenous Australian infants. Information from selected states has to be used because consistent, reliable, nationwide data are not available.⁹⁸ Between 1991 and 2005, the Indigenous infant mortality rate in Western Australia (WA) and South Australia (SA) fell from roughly 23 deaths per 1000 livebirths to about ten deaths per 1000 livebirths; the decline in WA was 39% and in SA was 26%.⁹⁸ Over the same period the relative rate ratios (Indigenous versus non-Indigenous) of infant mortality rates in those jurisdictions changed from more than 4 to about 2.5.⁹⁷ Over the same period Indigenous all-age mortality rates decreased somewhat but, despite that, in WA, SA, and the Northern Territory the mortality rate ratios (Indigenous versus non-Indigenous) increased because non-Indigenous mortality also declined substantially.⁹⁸ To regard Indigenous people, even in one country, as a single, homogeneous entity is hazardous. A major feature of

Indigenous populations is their great diversity. Observers often think of Australian Aboriginal people as a single group. But there were hundreds of Aboriginal groups or nations before colonisation, and dozens of languages and cultures. Cultural diversity persists, especially in remote areas.

Conclusions

When considering Indigenous health worldwide, one can feel overwhelmed and discouraged by the great disparities in health and disease statistics. Using Indigenous Australians as an example,⁹⁰ we see that Indigenous peoples have higher rates of physical, mental, and emotional illness, injuries, disability, and earlier and higher mortality than do their non-Indigenous counterparts. The mortality gap between Indigenous and other Australians is considerably greater than the disability gap—ie, when they are ill, they are more likely to die than are non-Indigenous Australians. This discrepancy is probably caused by late presentation, frequent severe or complicated illnesses, inadequate access to good clinical care, and inadequate follow-up, compliance with drugs, and prevention of complications. Diabetes, cardiovascular disease, and tobacco use account for half the Indigenous health gap; as well as tobacco use, these diseases share other lifestyle risk factors. Rather than seeing this situation as a cause for despair, it should be seen as a potential target for greater health gains in the sicker group. Improvement could be achieved by addressing particular diseases and risk factors, targeting the most affected age groups, and providing effective interventions. Infections and neonatal disorders are examples in which targeted interventions should produce substantial health gains. These messages should be convincingly conveyed to politicians, policy makers, and community leaders. They have to be persuaded that Indigenous health demands priority and that prevention is better than cure.

There are some simple, affordable, and effective ways to improve Indigenous health. Basic hygiene could be improved through better personal, domestic, and community hygiene, disposal of dirty or stagnant water, sewage, and litter, and prompt treatment of skin sores. Clean drinking water should be provided to target communities and families, and local people should know the importance of it and relevant authorities should assist by making sure that supplies are clean. Heavy work, particularly by women and children, of carrying domestic water over long distances should be reduced. Local communities, their representatives, and health committees should be encouraged to contribute to and take responsibility for their health (figure 3). These groups might need financial, physical, and other support from governments and other organisations to be able to do so. Health and hygiene education should be provided to individuals, families, and communities, with a focus on community participation.



Figure 3: Aboriginal Elders in the Kimberley region in the far northwest of Australia. They are taking part in Indigenous-driven, community-based health programmes. The local spirit figure of the Wandjina is on the mural.

The basic causes of illness are similar in Indigenous and non-Indigenous peoples. But the burden of disease, disability, and death is consistently greater in Indigenous than in non-Indigenous people. The principles for improvement we mention require acknowledgment by governments of Indigenous peoples' special rights and needs; adequate, regularly collected data about Indigenous health and related factors; adequate resources to close the gaps in health, disease, disability, and mortality between Indigenous and other peoples; and addressing socioeconomic inequities between Indigenous and non-Indigenous populations to overcome these discrepancies (see panel 6).

These issues should all be addressed to overcome these problems. This process will need recognition and improved understanding of the issues, commitment by governments to contribute much more than previously, and acceptance that Indigenous people have to be more meaningfully engaged in these efforts. Most governments have given little attention to Indigenous health because of ignorance, indifference, political unpopularity with the grim realities of the situation, and failure to officially recognise or enumerate Indigenous people in official statistics. Agencies that have provided clinical and related health-care services for Indigenous people have often had little success because of an absence of awareness or acceptance of Indigenous cultural behaviours (including taboos) and needs, such as for families to be present during clinic visits and when patients are hospitalised, for female patients to have female clinical staff in attendance (and male staff for male patients). Furthermore, specific ethnic or tribal groups need culturally appropriate clinical carers, and insensitivities to Indigenous attitudes and behaviours such as not keeping to rigid timetables for clinic visits have contributed to this failure. Indigenous people often need long and painstaking explanations about the causes of their illnesses, how their drugs work, and why they should keep to the clinical instructions they have been given. Many conventional clinical-carers are unaware of these needs or are too impatient or busy to appreciate their importance.⁹⁹ Indigenous people often have difficulty understanding the language of the dominant society. Better communication is key to improvement of health. Large health bureaucracies often fail in many of these areas.⁹⁹

Health standards of Indigenous peoples are unacceptably poor but there is no need to despair; correction of the present situation needs a radical reorientation of previous strategies that have been ineffective or virtually non-existent. Apart from the approaches we propose in this section, also important is to enable, train, and encourage Indigenous people to take responsibility for programmes and services that affect their health and for them to work closely with existing health-care systems. Emphasis on the urgent need for

Panel 6: Key strategies to improve Indigenous health

Health of mothers and children

- Prenatal clinical care, health and nutrition education for pregnancy
- Avoidance of risks in pregnancy such as smoking, alcohol, and other drugs
- Detection of disease and disease risk promptly in pregnancy and treat as needed
- Avoidance and treatment of anaemia and other nutritional deficiencies
- Provision of adequate facilities and services for safe birthing
- Encouragement of breastfeeding and safe, nutritious weaning practices
- Regular monitoring of child growth and use of appropriate nutritional and clinical care
- Early referral of infants and children for clinical treatment
- Encouragement of healthy lifestyles, avoidance of high-risk health behaviours such as unsafe sex, smoking, and alcohol and drug misuse

Nutritional deficiencies

- Provision of enough nutritious and affordable food
- Targeting of vulnerable groups such as pregnant women, infants, and elderly people
- Provision of nutritional supplements as needed (eg, iron, iodine, zinc, and folic acid)
- Treatment of underlying causes such as malaria, intestinal parasites, and blood loss

Infectious diseases

- Provision of adequate housing, clean food and water supplies, and food storage places
- Encouragement of personal, family, and community hygiene at all times
- Disposal of rubbish, sewage, and solid waste, and draining of stagnant ponds and waters
- Prevention of contamination of water supplies and areas where people meet or eat
- Suppression of vectors of infections such as flies, mosquitoes, other insects, and larger animals
- Immunisation programmes against vaccine-preventable diseases
- Early and adequate treatment of infections

Urbanisation and lifestyle diseases

- Encouragement of nutritious eating habits throughout life
- Encouragement of regular exercise and weight control
- Discouragement of cigarette smoking and alcohol and drug misuse
- Regular and opportunistic screening, or both, for risk factors and follow up
- Encouragement and supervision of compliance with drug treatment and follow up
- Prevention of long-term complications—eg, by diet, exercise, weight control, and clinical care
- Encouragement of Indigenous involvement in community-based wellness programmes

local, regional, national, and international statistics about Indigenous health is important to allow assessment of future trends and usefulness of interventions.

Contributors

MG was the primary author and did most of the search of published work. MK contributed to the review of published work and writing.

Conflicts of interest

MG is a medical adviser to the Unity of First People of Australia, an Aboriginal-run not-for-profit organisation. He has no financial conflicts of interest. MK declares that he has no conflicts of interest.

References

- 1 United Nations Permanent Forum on Indigenous Issues. Who are Indigenous peoples? http://www.un.org/esa/socdev/unpfii/documents/5session_factsheet1.pdf (accessed June 18, 2008).
- 2 Nettleton C, Napolitano DA, Stephens C. An overview of current knowledge of the social determinants of Indigenous health: working paper, compilers. Geneva: World Health Organization, 2007.
- 3 Stephens C, Nettleton C, Porter J, Willis R, Clark S. Indigenous peoples' health—why are they behind everyone, everywhere? *Lancet* 2005; **366**: 10–13.

- 4 Campbell J. Invisible invaders. Smallpox and other diseases in Aboriginal Australia, 1780–1880. Melbourne: Melbourne University Press, 2002.
- 5 Elkin AP. The Australian Aborigines. London and Sydney: Angus & Robertson Publishers, 1973.
- 6 Ohenjo N, Willis R, Jackson D, Nettleton C, Good K, Mugarura B. Health of Indigenous people in Africa. *Lancet* 2006; **367**: 1937–46.
- 7 Blakely T, Fawcett J, Hunt D, Wilson N. What is the contribution of smoking and socioeconomic position to ethnic inequalities in mortality in New Zealand? *Lancet* 2006; **368**: 44–52.
- 8 Hunter E. Aboriginal health and history. Power and prejudice in remote Australia. Cambridge: Cambridge University Press, 1993.
- 9 Bastos WR, Gomes JP, Oliveira RC, et al. Mercury in the environment and riverside population in the Madeira River Basin, Amazon, Brazil. *Sci Total Environ* 2006; **368**: 344–51.
- 10 Horton R. Indigenous peoples: time to act now for equity and health. *Lancet* 2006; **367**: 1705–07.
- 11 Gracey M. Australian Aboriginal child health. *Ann Trop Paediatr* 1999; **18** (suppl): S53–59.
- 12 Currie B, Brewster D. Childhood infections in the tropical north of Australia. *J Paediatr Child Health* 2001; **37**: 326–30.
- 13 Carville KS, Lehmann D, Hall G, et al. Infection is the major component of the disease burden in Aboriginal and non-Aboriginal Australian children: a population-based study. *Pediatr Infect Dis J* 2007; **26**: 210–16.
- 14 Gluckman P, Hanson MA, Pinal C. The developmental origins of adult disease. *Matern Child Nutr* 2005; **1**: 130–41.
- 15 Bhutta ZA, Darmstadt GL, Hasan BS, Haws RA. Community-based interventions for improving perinatal and neonatal health outcomes in developing countries: a review of the evidence. *Pediatrics* 2005; **115** (suppl 2): 519–617.
- 16 Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, de Bernis L, for the *Lancet Neonatal Survival Steering Team*. Evidence-based, cost-effective interventions: how many newborn babies can we save? *Lancet* 2005; **365**: 977–88.
- 17 Martinez J, Paul VK, Bhutta ZA, et al, for the *Lancet Neonatal Survival Steering Team*. Neonatal survival: a call for action. *Lancet* 2005; **365**: 1189–97.
- 18 Subramanian SV, Davey Smith G, Subramanyam M. Indigenous health and socioeconomic status in India. *PLoS Med* 2006; **3**: e421.
- 19 Menzies R, McIntyre P. Vaccine preventable diseases and vaccination policy for indigenous populations. *Epidemiol Rev* 2006; **28**: 71–80.
- 20 Freemantle CJ, Read AW, de Klerk NH, McAullay D, Anderson IP, Stanley FJ. Patterns, trends, and increasing disparities in mortality for Aboriginal and non-Aboriginal infants born in Western Australia, 1980–2001: population database study. *Lancet* 2006; **367**: 1758–66.
- 21 McDonald EL, Baillie RS, Rumbold AR, Morris PS, Paterson BA. Preventing growth faltering among Australian Indigenous children: implications for policy and practice. *Med J Aust* 2008; **188**: S84–86.
- 22 Gracey MS. Nutrition, bacteria and the gut. *Br Med Bull* 1981; **37**: 71–75.
- 23 Gracey M. Child health in an urbanizing world. *Acta Paediatr* 2002; **91**: 1–8.
- 24 Montenegro RA, Stephens C. Indigenous health in Latin America and the Caribbean. *Lancet* 2006; **367**: 1859–69.
- 25 Bookallil M, Chalmers E, Andrew B. Challenges in preventing pyelonephritis in pregnant women in Indigenous communities. *Rural Remote Health* 2005; **5**: 395.
- 26 Franks PW, Looker HC, Kobes S, et al. Gestational glucose tolerance and risk of type 2 diabetes in young Pima Indian offspring. *Diabetes* 2006; **55**: 460–65.
- 27 Brennd EA, Dannenbaum D, Willows ND. Pregnancy outcomes of First Nations women in relation to pregravid weight and pregnancy weight gain. *J Obstet Gynaecol Can* 2005; **27**: 936–44.
- 28 Bunt JC, Tataranni PA, Salbe AD. Intrauterine exposure to diabetes is a determinant of hemoglobin A1c and systolic blood pressure in Pima Indian children. *J Clin Endocrinol Metab* 2006; **90**: 3225–29.
- 29 Steer AC, Danchin MH, Carapetis JR. Group A streptococcal infections in children. *J Paediatr Child Health* 2007; **43**: 2003–13.
- 30 Carapetis JR, Steer AC, Mulholland EK, Weber M. The global burden of group A streptococcal diseases. *Lancet Infect Dis* 2005; **5**: 685–94.
- 31 Steer AC, Jenney AJW, Oppedisano F, et al. High burden of invasive beta-hemolytic streptococcal infections in Fiji. *Epidemiol Infect* 2008; **136**: 621–27.
- 32 Kovesi T, Gilbert NL, Stocco C, et al. Indoor air quality and the risk of lower respiratory tract infections in young Canadian Inuit children. *CMAJ* 2007; **177**: 155–60.
- 33 Mulholland EK. Childhood pneumonia mortality—a permanent global emergency. *Lancet* 2007; **370**: 285–89.
- 34 Basta PC, Coimbra CE Jr, Escobar AL, Santos RV, Alves LC, Fonseca LS. Survey for tuberculosis in an indigenous population of Amazonia: the Surui of Rondônia, Brazil. *Trans R Soc Trop Med Hyg* 2006; **100**: 579–85.
- 35 Cook VJ, Hernández-Garduño E, Kunimoto D, et al, for the Canadian Molecular Epidemiology of Tuberculosis Study Group. The lack of association between bacille Calmette-Guérin vaccination and clustering of Aboriginals with tuberculosis in Western Canada. *Can Respir J* 2005; **12**: 134–38.
- 36 De Quadros CA, Izurieta H, Carrasco P, Brana M, Tambini G. Progress toward measles eradication in the regions of the Americas. *J Infect Dis* 2003; **187** (suppl 1): S102–10.
- 37 Liu S, Zhou Y, Wang X, et al. Biomass fuels are the probable risk factor for chronic obstructive pulmonary disease in rural South China. *Thorax* 2007; **62**: 889–97.
- 38 Diaz E, Bruce N, Pope D, et al. Lung function and symptoms among Indigenous Mayan women exposed to high levels of indoor air pollution. *Int J Tuberc Lung Dis* 2007; **11**: 1372–79.
- 39 Bowd A. Otitis media: health and social consequences for aboriginal youth in Canada's north. *Int J Circumpolar Health* 2005; **64**: 5–15.
- 40 Dennehy PH. Rotavirus vaccines—an update. *Vaccine* 2007; **25**: 3137–41.
- 41 Sharma S, Pathak S. Malaria vaccine: a current perspective. *J Vector Borne Dis* 2008; **45**: 1–20.
- 42 Fishbein DB, Broder KR, Markowitz L, Messonnier N. New, and some not-so-new, vaccines for adolescents and diseases they prevent. *Pediatrics* 2008; **121** (suppl 1): S5–14.
- 43 Hoy WE, Hughson MD, Singh GR, Douglas-Denton R, Bertram JF. Reduced nephron number and glomerulomegaly in Australian Aborigines: a group at high risk for renal disease and hypertension. *Kidney Int* 2006; **70**: 104–10.
- 44 Dyck RF. Tracking ancient pathways to a modern epidemic: diabetic end-stage renal disease in Saskatchewan aboriginal people. *Kidney Int Suppl* 2005; **97**: S53–57.
- 45 Weil EJ, Nelson RG. Kidney disease among the indigenous peoples of Oceania. *Ethn Dis* 2006; **16** (suppl 2): 24–30.
- 46 Zhanel GG, Nicolle LE, Harding GK. Prevalence of asymptomatic bacteriuria and associated host factors in women with diabetes mellitus. The Manitoba diabetic infection study group. *Clin Infect Dis* 1995; **21**: 316–22.
- 47 Gracey M, Spargo RM, Smith P, et al. Risk factors for ill-health in a remote desert-dwelling Aboriginal community in Western Australia. *Aust N Z J Med* 1996; **26**: 171–79.
- 48 Hochman ME, Watt JP, Reid R, O'Brien KL. The prevalence and incidence of end-stage renal disease in Native American adults on the Navajo reservation. *Kidney Int* 2007; **71**: 931–37.
- 49 Wright MR, Giele CM, Dance PR, Thompson SC. Fulfilling prophecy? Sexually transmitted infections and HIV in Indigenous people in Western Australia. *Med J Aust* 2005; **183**: 124–28.
- 50 Gupta G. How men's power over women fuels the HIV epidemic. *BMJ* 2005; **324**: 184–85.
- 51 Zavaleta C, Fernández C, Konda K, Valderrama Y, Vermund SH, Gotuzzo E. High prevalence of HIV and syphilis in a remote native community of the Peruvian Amazon. *Am J Trop Med Hyg* 2007; **76**: 703–05.
- 52 Franco EL, Harper DM. Vaccination against human papilloma-virus infection: a new paradigm in cervical cancer control. *Vaccine* 2005; **23**: 2388–94.
- 53 Harper DM, Franco EL, Wheeler CM, et al. Sustained efficacy up to 4.5 years of a bivalent L1 virus-like particle vaccine against human papillomavirus types 16 and 18: follow-up from a randomised control trial. *Lancet* 2006; **367**: 1247–55.

- 54 Leggatt GR, Frazer IH. HPV vaccines: the beginning of the end for cervical cancer. *Curr Opin Immunol* 2007; **19**: 232–38.
- 55 Kallings LO. The first postmodern pandemic: 25 years of HIV/AIDS. *J Intern Med* 2008; **263**: 218–43.
- 56 Cargill VA, Stone VE. HIV/AIDS: a minority health issue. *Med Clin North Am* 2005; **89**: 895–912.
- 57 McNaughton AD, Neal JJ, Li J, Fleming PL. Epidemiologic profile of HIV among American Indians/Alaska Natives in the USA through 2000. *Ethn Health* 2005; **10**: 57–71.
- 58 Larkin J, Flicker S, Koleszar-Green R, Mintz S, Dagnino M, Mitchell C. HIV risk, systemic inequities, and Aboriginal youth: widening the circle for HIV prevention programming. *Can J Public Health* 2007; **98**: 179–82.
- 59 Smith DJ. Modern marriage, men's extramarital sex, and HIV risk in southeastern Nigeria. *Am J Public Health* 2007; **97**: 997–1005.
- 60 Lockhart M, Chaplin S, Seddon T. Sixth international congress on AIDS in Asia and the Pacific, Melbourne, 2001. <http://www.latrobe.edu.au/aidsap/icaap/reports/downloads.html> (accessed Aug 20, 2008).
- 61 Wardlow H. Men's extramarital sexuality in rural Papua New Guinea. *Am J Public Health* 2007; **97**: 1006–14.
- 62 Hernandez B, de Gruben D. Inclusion of indigenous population in the AIDS response to achieve the universal access: the case of Guatemala. XII International AIDS conference; Mexico City; Aug 3–8, 2008. Abstract MOPE1080. <http://www.aids2008.org/Pag/Abstracts.aspx?AID=8672> (accessed Feb 18, 2009).
- 63 Lopez V, Brito I. Indigenous populations: cultural diversity and STD/HIV/AIDS control actions in Brazil. XII International AIDS conference; Mexico City; Aug 3–8, 2008. Abstract MOPE1078. <http://www.aids2008.org/Pag/Abstracts.aspx?AID=9174> (accessed Feb 18, 2009).
- 64 Wright MR, Giele CM, Dance PR, Thompson SC. Fulfilling prophecy? Sexually transmitted infections and HIV in Indigenous people in Western Australia. *Med J Aust* 2005; **183**: 124–28.
- 65 Li X, Kolltveit KM, Kronstat L, Olsen I. Systemic diseases caused by oral infection. *Clin Microbiol Rev* 2000; **13**: 547–58.
- 66 Demmer RT, Devarieux M. Periodontal infections and cardiovascular disease: the heart of the matter. *J Am Dent Assoc* 2006; **137**: 14S–20.
- 67 Jamieson LM, Harrison JE, Berry JG. Hospitalisation for head injury due to assault among Indigenous and non-Indigenous Australians, July, 1999–June, 2005. *Med J Aust* 2008; **188**: 576–79.
- 68 Rhoades DA. Racial misclassification and disparities in cardiovascular disease among American Indians and Alaska Natives. *Circulation* 2005; **111**: 1250–56.
- 69 Scavini M, Shah VO, Stidley CA, et al. Kidney disease among the Zuni Indians: the Zuni kidney project. *Kidney Int Suppl* 2005; **97**: S126–31.
- 70 Lobstein T, Baur L, Uauy R. Obesity in children and young people: a crisis in public health. *Obes Rev* 2004; **5** (suppl 1): 4–85.
- 71 Gracey M, Bridge E, Martin D, et al. An Aboriginal-driven program to prevent, control and manage nutrition-related “lifestyle” diseases including diabetes. *Asia Pac J Clin Nutr* 2006; **15**: 178–88.
- 72 Gracey MS. Nutrition-related disorders in Indigenous Australians: how things have changed. *Med J Aust* 2007; **186**: 15–17.
- 73 Burke V, Zhao Y, Lee AH, et al. Predictors of type 2 diabetes and diabetes-related hospitalisation in an Australian Aboriginal cohort. *Diabetes Res Clin Pract* 2007; **78**: 360–68.
- 74 Young TK, Reading J, Elias B, O'Neil JD. Type 2 diabetes mellitus in Canada's First Nations: status of an epidemic in progress. *CMAJ* 2000; **163**: 561–66.
- 75 Young TK. Review of research on aboriginal populations in Canada: relevance to their health needs. *BMJ* 2003; **327**: 419–22.
- 76 MacMillan HL, MacMillan AB, Offord DR, Dingle JL. Aboriginal health. *CMAJ* 1996; **155**: 1569–78.
- 77 Rodriguez-Morán M, Guerrer-Romero F, Brito-Zurito O, et al. Cardiovascular risk factors and acculturation in Yaquis and Tepehuanos Indians from Mexico. *Arch Med Res* 2008; **39**: 352–57.
- 78 Pavkov ME, Hanson RL, Knowler WC, Bennett PH, Krakoff J, Nelson RG. Changing patterns of type 2 diabetes incidence among Pima Indians. *Diabetes Care* 2007; **30**: 1758–63.
- 79 Neel JV. The “Thrifty Genotype” in 1998. *Nutr Rev* 1999; **57**: S2–9.
- 80 O'Dea K, Patel M, Kubisch D, Hopper J, Traianedes K. Obesity, diabetes, and hyperlipidemia in a central Australian Aboriginal community with a long history of acculturation. *Diabetes Care* 1993; **16**: 1004–10.
- 81 Stang J, Zephier EM, Story M, et al. Dietary intakes of nutrients thought to modify cardiovascular risk from three groups of American Indians: the strong heart dietary study, phase II. *J Am Diet Assoc* 2005; **105**: 1895–903.
- 82 Salbe AD, Weyer C, Lindsay RS, Ravussin E, Tataranni PA. Assessing risk factors for obesity between childhood and adolescence: I. Birth weight, childhood adiposity, parental obesity, insulin and leptin. *Pediatrics* 2002; **110**: 299–306.
- 83 McMahon SK, Haynes A, Ratnam N, et al. Increase in type 2 diabetes in children and adolescents in Western Australia. *Med J Aust* 2004; **180**: 459–61.
- 84 Albala C, Vio F, Kain J, Uauy R. Nutrition transition in Chile: determinants and consequences. *Public Health Nutr* 2002; **5**: 123–28.
- 85 Strong K, Mathers C, Epping-Jordan J, Beaglehole R. Preventing chronic disease: a priority for global health. *Int J Epidemiol* 2006; **35**: 492–94.
- 86 WHO. Preventing chronic diseases: a vital investment. Geneva: World Health Organization, 2005. http://www.who.int/chp/chronic_disease_report/en/ (accessed June 7, 2009).
- 87 WHO. The global burden of disease: 2004 update. Part 4. Burden of disease: DALYs. Geneva: World Health Organization, 2008. http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_part4.pdf (accessed Feb 7, 2009).
- 88 Wilson C, Gilliland S, Cullen T, et al. Diabetes outcomes in the Indian health system during the era of the special diabetes program for Indians and the government performance and results act. *Am J Public Health* 2005; **95**: 1518–22.
- 89 Stephens C, Porter J, Nettleton C, Willis R. Disappearing, displaced, and undervalued: a call to action for indigenous health worldwide. *Lancet* 2006; **367**: 2019–28.
- 90 Vos T, Barker B, Stanley L, Lopez AD. The burden of disease and injury in Aboriginal and Torres Strait Islander peoples: summary report. Brisbane: School of Population Health, University of Queensland, 2007. <http://www.uq.edu.au/bodce/2003-indigenous-burden-of-disease-report> (accessed June 7, 2009).
- 91 United Nations. United Nations Millennium Development. Resolution 55/2. New York: United Nations, 2000.
- 92 Hill K, Barker B, Vos T. Excess Indigenous mortality: are Indigenous Australians more severely disadvantaged than other Indigenous populations? *Int J Epidemiol* 2007; **36**: 580–89.
- 93 Australian Bureau of Statistics. Calculating experimental life tables for use in population estimates and projections of Aboriginal and Torres Strait Islander Australians, 1991 to 2001. Demography working paper 2004/03. Cat No 3106.0.55.003. Canberra: Australian Bureau of Statistics, 2004.
- 94 Commonwealth of Australia. Parliamentary Debates. House of Representatives. Apology to Australia's Indigenous peoples. Feb 13, 2008. http://parlinfo.aph.gov.au/parlInfo/genpdf/chamber/hansardr/2008-02-13/0003/hansard_frag.pdf;fileType%3Dapplication%2Fpdf (accessed June 7, 2009).
- 95 Department of families, housing, community services and Indigenous affairs. Closing the gap on Indigenous disadvantage: the challenge for Australia. Canberra: Australian Government, 2009. www.facs.gov.au/sa/indigenous/pubs/general/Documents/closing_the_gap/default.htm (accessed June 5, 2009).
- 96 Hoy WE. “Closing the gap” by 2030: aspiration versus reality in Indigenous health. *Med J Aust* 2009; **190**: 542–44.
- 97 Waldram JB, Herring A, Young TK, eds. Aboriginal health in Canada. 2nd edn. Toronto: University of Toronto Press, 2006 and 2008.
- 98 Pink B, Allbon P. The health and welfare of Australia's Aboriginal and Torres Strait Islander peoples 2008. Canberra: Australian Bureau of Statistics and Australian Institute of Health and Welfare, 2008.
- 99 Trudgen RI. Why warriors lie down and die. Darwin: Aboriginal Resource and Development Services, 2000.