GLOBAL CLIMATE CHANGE & CHILD HEALTH

Children's Health and the Environment
WHO Training Package for the Health Sector
World Health Organization
www.who.int/ceh

<<NOTE TO USER: Please add details of the date, time, place and sponsorship of the meeting for which you are using this presentation in the space indicated.>>

<<NOTE TO USER: This is a large set of slides from which the presenter should select the most relevant ones to use in a specific presentation. These slides cover many facets of the problem. Present only those slides that apply most directly to the local situation in the region. It is also very useful if you present regional/local examples of both climate change related health threats and solutions, both adaptation and mitigation.>>
Global Climate Change and Child Health

OBJECTIVES

- To understand the unique nature of human impact on the global environment in the 21st Century with an emphasis on global climate change
- To understand the health consequences to children from global climate change
- To explore multi-stakeholder, multi-sector strategies for protecting children’s health, now and in the future, from global climate change
Global Climate Change and Child Health

OUTLINE

- Setting the stage
  - Major human trends
  - Human impact on global environment
  - Climate change as imminent threat

- Effects on children from
  - Global climate change

- Prevention and protection of health

<<NOTE TO USER: This presentation has three parts. The first part is general and sets the stage by discussing major trends in human activities and their broad impact on the global environment and human health. The second part concentrates climate change as one of the most immanent global public health threats. The last part discusses actions from international to individual level which are needed to protect children’s health in a world of ongoing global environmental changes.>>

Pictures:
- UN Special Session on Children (010321e)
- WHO
We live in unique times in human history. This image represents the dramatic changes that have occurred over the past 50 years. Within the span of a single human lifetime we have gone from being earth bound, to being able to look back at ourselves from space. Satellites now reveal images of shrinking of the tropical rain forests, intensification of agriculture, loss of wetlands, and expansion of urban centres. New technology can measure changes in global photosynthesis, the water cycle and other major geophysical cycles linked to human activities.

Picture:
•NASA (National Aeronautic and Space Administration, USA) (sealevel.jpl.nasa.gov/overview/images/earth.jpg).
Several major human trends act as forces driving global environmental change. Primary among these trends is the expanding human population.

Humanity is in the steepest portion of an exponential population growth curve. It took hundreds of thousands of years for humans to reach a population of one billion around 1800, but only 130 years to generate the second billion in 1927. Over the next 70 years, the population tripled to 6 billion in 1999. In 2009, global population is over 6.8 billion and by 2050 there will be between 8 and 13 billion humans on the planet. Most of the population growth will be in cities in developing nations. Linked to population rise are 3 major global changes in the way humans live on the planet. These are urbanization, industrialization and globalization. These 3 changes will be discussed on the next 3 slides.

Reference:

Graph:
• Dr. K. Shea.
The first change is urbanization. This composite satellite image shows city lights from space and depicts the degree of urbanization in the world currently. The graph shows that at the beginning of the 20th century over 86% of humans lived in rural areas, now it is about 50%. In 1990, about 14% of humans lived in urban areas, now it is about 50%. Cities and megacities continue to evolve.

Of the 2.18 billion children under age 18 years (618 million under age 5 years) in the world, 1.9 billion under 18 years (and 552 million under age 5 years) live in developing countries where urbanization is proceeding most rapidly.

References:

Picture:
• NASA
The second change is industrialization. Industrialization is interconnected with urbanization and population growth. With it comes increased energy production and use, increased resource extraction, crowding and pollution. It also produces more goods and services, allows specialization and increased productivity and ultimately produces the epidemiologic transition from high infant mortality and early death from infectious diseases, to longer life and the morbidity of chronic disease of “prosperity” such as cardiovascular disease, cancer and obesity.

Picture:
• US EPA (US Environmental Protection Agency).
And the third major trend that marks these times as unique is the phenomenon of globalization. Globalization has brought many advantages including rapid movement of people (transportation), global movement of goods and services (trade), and wide dissemination of information and communication (technology). Globalization has also imposed some challenges; humans are numerous and capable of rapid movement and modification of the physical environment. The consequence of population pressure, urbanization, industrialization and globalization is that there are no longer as many frontiers (large wilderness areas rich in resources). Humanity is distributed across the globe and extracting resources from land and sea rapidly.

Picture:
In scientific terms, earth is a “closed system” which means that with the single exception of energy from the sun, the only source of raw materials to provide food, shelter, goods and services is the earth itself. Now that there are so many humans using these raw materials, humans are making an unprecedented impact and the consequences are global. These impacts can be measured from the global to the regional to the individual to the molecular level. The next few slides outline and give examples of anthropogenic (man-made) environmental change on multiple levels. Understanding the global nature of human impacts at all levels is necessary to understand the health threats to children and to develop solutions.

Picture:
• NASA
Scientists now talk about Earth being a “human dominated” system and humans as the major evolutionary force on the planet.

- Humans are making changes in the basic support systems of the planet including depletion of the protective stratospheric ozone layer and forcing rapid climate change (represented here by the NASA picture of the San Quintin Glacier retreat, in Chile).
- Humans are affecting the distribution and abundance of life on Earth through
  - land transformation (deforestation, desertification, urbanization),
  - over hunting and over fishing that threatens species by preventing normal replenishment of populations,
  - introduction of invasive and exotic plants and animals brought from different parts of the world that may become pests or thrive because of lack of natural predators or competitors.
- All of these trends, often resulting in massive extinctions (expanded upon in later slide).

- And humans are actively accelerating genetic evolution by the use of chemicals such as antibiotics and pesticides as well as embarking on direct manipulation of plant and animal DNA. (See subsequent slides)

There is also a human-induced global change in the elemental cycles of nitrogen, sulfur and potassium. Various other environmental changes are now occurring worldwide, in a rather more mosaic fashion. These include depletion of freshwater, degradation of agroecosystems, depletion of fisheries, and the dissemination of chemical pollution (POPs, pesticides, heavy metals, etc.).

The following slides give examples of a few of these dramatic changes.

Reference:


In addition to altering global ecology, technology and human population growth also affect evolutionary trajectories, dramatically accelerating evolutionary change in other species, especially in commercially important, pest, and disease organisms. Such changes are apparent in antibiotic and human immunodeficiency virus (HIV) resistance to drugs, plant and insect resistance to pesticides, rapid changes in invasive species, life-history change in commercial fisheries, and pest adaptation to biological engineering products. This accelerated evolution costs at least $33 billion to $50 billion a year in the United States. Slowing and controlling arms races in disease and pest management have been successful in diverse ecological and economic systems, illustrating how applied evolutionary principles can help reduce the impact of humankind on evolution.

Picture:

-NASA
At the planetary level, human impact is of enormous magnitude. In 1997, a group of scientists concluded that human activities had transformed or degraded 50% of the land mass of the Earth; humans controlled the flow and levels of 2/3 of the rivers of the Earth; humans had already harvested to the limit or exhausted 2/3 of all marine fisheries; and humans contributed half of the nitrogen fixation that occurs each year through industrial production of nitrogen fertilizers and other industrial production, consumption and waste.

Reference:

Graph:
•Dr. K. Shea
Primarily due to habitat destruction, but also by overhunting, overfishing, industrial pollution and toxic chemicals, humans are causing the most massive extinction of species since the dinosaurs went extinct 65 million years ago. Whereas the baseline species extinction rate had been about 1 species per million species per year, now it is a thousand fold higher. Some estimate that from ¼ to ½ of all plant species are endangered. Plants are our primary producers, the basis of the food web, and the only means by which sunlight is transformed into the organic building blocks of life. These changes are irreversible.

References:

Pictures:
• NOAA’s Estuarine Research Reserve Collection (www.photolib.noaa.gov/700s/nerr0390.jpg).
Humans are also affecting life on Earth at the microscopic and genetic level. This familiar graph of the steady rise of penicillin resistant *Streptococcus pneumoniae* throughout the last few decades is one of many examples of how large scale human use of antibiotics has forced the genetic evolution in another species, bacteria.

**Reference:**


As part of the ongoing multinational SENTRY antimicrobial resistance surveillance program, a total of 1,047 respiratory tract isolates of *Streptococcus pneumoniae*, 845 from 27 United States medical centers and 202 from seven Canadian institutions, were collected between February and June 1997 and characterized in a central laboratory. In the United States, the overall percentages of penicillin-intermediate strains and strains with high-level resistance to penicillin were 27.8% and 16.0%, respectively. In Canada, these values were 21.8% and 8.4%, respectively. Among the 31 centers in the United States and Canada that contributed at least 19 isolates, the combined rate of intermediate plus resistant strains varied between 24.0% and 67.8%. The in vitro activity of 19 other antimicrobials was assessed against all study isolates. Overall rates of resistance among selected agents in the United States and Canada, respectively, were as follows: amoxicillin, 18.1% and 10.5%; cefaclor, 38.3% and 26.2%; cefuroxime, 19.5% and 12.9%; cefpodoxime, 18.6% and 11.4%; cefepime, 8.2% and 4.5%; cefotaxime, 4.0% and 3.0%; macrolides (i.e., erythromycin, azithromycin, and clarithromycin), 11.7%-14.3% and 5.0%-7.4%; clindamycin, 3.5% and 3.5%; chloramphenicol, 3.9% and 4.0%; tetracycline, 10.2% and 10.9%; and trimethoprim-sulfamethoxazole, 19.8% and 15.8%.

**Graph:**

• Dr. K. Shea
Global Climate Change and Child Health

ANTHROPOCENE EPOCH
Humans are the greatest evolutionary force

- Scale of change
  - Microscopic → Planetary
    - Air
    - Water
    - Food
    - Fire

- Rate of change
  - Decades not millennia

- Inequity
  - Within & among nations/regions
  - Across generations

Some scientists are proposing that we name this changing environment the Anthropocene Epoch on the geologic time scale because of the reality of human domination and evolutionary pressure. The scale of change ranges from microscopic to planetary and affects the basic supports of life – air, water, food and fire. The rate of change is now measured in decades versus the millennia of previous epochs. Finally, there is wide distributional inequity of these effects of anthropogenic forces within and among nations and regions and across generations. In other words, the countries most responsible for global environmental degradation have benefited in the short term, but the harms will be felt most acutely in the poorest countries that had less of a role in causing that same degradation. Similarly, generations in the future will be left to cope with the results of excess resource extraction, pollution and degradation of ecosystems caused by those living now.

Reference:

Picture:
- NASA
Global Climate Change and Child Health

CHALLENGES TO HUMAN HEALTH AND DEVELOPMENT

DRIVING FORCES
- Population growth
- Upsurge of urbanization
- New industrialization
- Rapid globalization
- Pervasive poverty and inequity
- Non-sustainable consumption
- Excessive population growth
- Trans-boundary chemical transport
- Increased use of biotechnology

GLOBAL ENVIRONMENTAL CHANGE
- Climate change
- Ozone depletion
- Desertification/deforestation
- Forest fires
- Loss of biodiversity

ENVIRONMENTAL DEGRADATION

Children are disproportionately vulnerable, suffering most of the effects, now...and in the future

These large scale changes caused by human activity create unique problems, especially for children, as is depicted on this summary slide. A number of new driving forces and global environmental changes pose challenges to human health and to the environment. These challenges contribute to environmental degradation – and environmental degradation disproportionately affects children.

<<READ SLIDE>>

<<NOTE TO SPEAKER: The driving forces and global environmental changes mentioned are self-explanatory. However, speakers may need to expand on one or two of the points, if considered relevant. An example of this is urbanization as illustrated below.>>

Reference:


The upsurge of urbanization, often poorly planned and uncontrolled, has caused major impacts on human societies for at least two centuries. Urban environments and urbanized lifestyles have strong influences on health and well-being, including on infant and childhood populations in developed and underdeveloped countries, as well as among societies in developmental and environmental transition around the world. Urbanization will inevitably have significant impacts on the health of future generations. Notably, the health consequences of urbanized lifestyles are not confined to residents of cities and large towns but rather are becoming manifest in rapidly changing, previously traditional societies in rural and remote areas because globalization is altering infant feeding practices and the dietary habits and lifestyle patterns of their children. In underdeveloped countries, overcrowding and environmental pollution are huge problems that are exacerbated by undernutrition and infection, particularly respiratory and diarrhoeal diseases. In developed societies, other problems like injuries; poisonings; violence; drug abuse; exposure to chemical, biological, industrial, and atmospheric pollutants, including pesticides; sexually transmissible diseases; and 'lifestyle' diseases, including obesity and cardiovascular disease risk; are of great current and potential importance.
The distinctive aspect of global environmental change is its scale. For the first time, humankind is exerting sufficient pressure on the earth’s biophysical systems to cause changes in some environmental processes and conditions at the global level. Several such environmental changes have now been confirmed, in particular stratospheric ozone depletion and climate change. These large-scale environmental changes do not necessarily pose qualitatively new risks to health. Rather, they amplify and extend the health risks posed by many existing environmental hazards. Global warming (climate change) is well studied and provides a good example of a global change with health consequences that affect everyone, but children more than most.
Global Climate Change and Child Health

GREENHOUSE GASES AND GLOBAL WARMING

Earth is covered by a blanket of gases which allows energy from the sun to reach the earth’s surface, where some of it is converted to heat energy. Most of the heat is re-radiated towards space and some is re-radiated towards the ground by greenhouse gases in the atmosphere. This is a natural effect which keeps the Earth’s temperature at a level necessary to support life.

Human activities—particularly burning of fossil fuels, coal, oil and natural gas, agriculture and land clearing—are generating more greenhouse gases. Greater concentrations of greenhouse gases will trap more heat and raise the Earth’s surface temperature.

If Earth had no atmosphere, it would be a frozen planet without life. Gases in the atmosphere (including water vapour, carbon dioxide, methane and nitrous oxides) temporarily trap some of the energy from the sun and convert it to heat, which maintains an average surface temperature on earth that is capable of sustaining life. This is known as the greenhouse effect and is necessary for sustained life on earth.

Human activities, particularly the burning of fossil fuels, have increased the concentration of greenhouse gases in the atmosphere dramatically over the last century, forcing increased warming in the lower atmosphere. This enhanced greenhouse effect is changing climate in a variety of ways and has consequences for human health.

<<READ Captions:
BOX ONE— Earth is covered by a blanket of gases which allows energy from the sun to reach the Earth’s surface, where some of it is converted to heat energy. Most of the heat is re-radiated towards space, but some is re-radiated towards the ground by greenhouse gases in the atmosphere. This is a natural effect which keeps the Earth’s temperature at a level necessary to support life.

BOX TWO— Human activities—particularly burning of fossil fuels (coal, oil and natural gas), agriculture and land clearing—are generating more greenhouse gases. Greater concentrations of greenhouse gases will trap more heat and raise the Earth’s surface temperature.>>

Pictures:
This graph shows the indisputable increases in carbon dioxide in the Earth's atmosphere as measured at the top of Mount Mauna Loa on the Island of Hawaii. Human activities are responsible for this dramatic rise.

This increase in greenhouse gases is causing an increase in the surface temperature and affects weather and climate. Weather is the continuously changing condition of the atmosphere; climate is any long-term change in the patterns of average weather of a specific region or the Earth as a whole. Climate change reflects abnormal variations to the Earth's climate and subsequent effects on other parts of the Earth, such as in the ice caps over durations ranging from decades to millions of years. Over the last few decades, human activity is changing the atmospheric composition and causing rapid global climate changes.

*Graph: NASA*
Global Climate Change and Child Health

"Warming of the climate system is unequivocal"

as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising average sea level.

This quote from the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) could not be more clear.

<<READ:
11 of the 12 years between 1995 and 2006 rank among the 11 warmest years in the instrumental record (since 1850), and human activity is causing it. This complex graph summarizes all the human influences on climate, the positive or heating forcings and the negative or cooling forcings are noted in the top section. They overwhelm the natural variation in solar radiation (second to bottom line) and the aggregate effect is that humans are warming the planet (bottom line of graphic).

This is the conclusion of the most respected group of international climate scientists in the world who have, in very strong language, come to consensus.>>

Picture:
• IPCC (Intergovernmental Panel on Climate Change), WG I, 2007 (www.ipcc.ch/index.htm).
Solomon S et al., eds. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2007. (Chapter 2, p. 136, Fig. 2.1).
Global Climate Change and Child Health

DIRECT HEALTH IMPACTS OF GLOBAL WARMING

↑ Air pollution related illness
↑ Injury, death and illness from extreme weather events
↑ Water-borne diseases
↑ Food-borne diseases
↑ Vector-borne illness
↑ Heat Related illnesses and deaths
↓ Cold related deaths

Not only are polar bears and coral reefs imperilled by climate change, but human health is threatened as well. And as previously noted, children are expected to be disproportionately affected by the health consequences of climate change. Direct health impacts of climate change include:

References:

Human activity has contributed to climate change. The relationship between climate and child health has not been well investigated. This review discusses the role of climate change on child health and suggests 3 ways in which this relationship may manifest. First, environmental changes associated with anthropogenic greenhouse gases can lead to respiratory diseases, sunburn, melanoma, and immunosuppression. Second, climate change may directly cause heat stroke, drowning, gastrointestinal diseases, and psychosocial maldevelopment. Third, ecologic alterations triggered by climate change can increase rates of malnutrition, allergies and exposure to mycotoxins, vector-borne diseases (malaria, dengue, encephalitis, Lyme disease), and emerging infectious diseases. Further climate change is likely, given global industrial and political realities. Proactive and preventive physician action, research focused on the differential effects of climate change on subpopulations including children, and policy advocacy on the individual and federal levels could contain climate change and inform appropriate prevention and response.


There is a broad scientific consensus that the global climate is warming, the process is accelerating, and that human activities are very likely (>90% probability) the main cause. This warming will have effects on ecosystems and human health, many of them adverse. Children will experience both the direct and indirect effects of climate change. Actions taken by individuals, communities, businesses, and governments will affect the magnitude and rate of global climate change and resultant health impacts. This technical report reviews the nature of the global problem and anticipated health effects on children and supports the recommendations in the accompanying policy statement on climate change and children's health.
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AIR POLLUTION-RELATED ILLNESS

Ground level ozone:

↑ Sensitivity of children at lower levels
↑ Frequency/severity of asthma attacks (strong evidence)
   ↑ ER visits
   ↑ Hospitalizations
↑ Incidence (some evidence)
↑ Independently with temperature

Poor air quality is especially dangerous to children because they spend more time outside than adults, are more physically active, breathe more per unit body weight, and have immature and developing lungs susceptible to damage. With climate change, we expect air pollution-related illness to increase by at least 3 mechanisms.

First, in a hotter world, ground-level ozone will increase. A large body of evidence shows that children are more sensitive to ground level ozone than adults, even children without asthma. In asthmatics, ozone triggers more frequent and more severe asthma attacks, as measured by emergency room visits and hospitalizations for asthma. There is some evidence that ozone can contribute to developing new asthma in highly exposed children. Ozone production increases with temperature, so in a hotter world, there will be more ozone pollution.

Reference:

Ambient (outdoor) air pollution is now recognized as an important problem, both nationally and worldwide. Our scientific understanding of the spectrum of health effects of air pollution has increased, and numerous studies are finding important health effects from air pollution at levels once considered safe. Children and infants are among the most susceptible to many of the air pollutants. In addition to associations between air pollution and respiratory symptoms, asthma exacerbations, and asthma hospitalizations, recent studies have found links between air pollution and preterm birth, infant mortality, deficits in lung growth, and possibly, development of asthma. This policy statement summarizes the recent literature linking ambient air pollution to adverse health outcomes in children and includes a perspective on the current regulatory process. The statement provides advice to pediatricians on how to integrate issues regarding air quality and health into patient education and children’s environmental health advocacy and concludes with recommendations to the government on promotion of effective air-pollution policies to ensure protection of children’s health.

Picture:
• US EPA (US Environmental Protection Agency).
The second category of air pollution related illness derives from population driven increased energy production. If we meet increased demand by burning more fossil fuels, major air pollutants will go up. We’ll see increased particulates, oxides of nitrogen and sulfur, volatile organic hydrocarbons and, of course, more ozone. There is robust evidence that childhood exposure to these specific air pollutants is related to decreased lung growth and permanent decrements in pulmonary function as well as increases in respiratory infection, asthma, infant and all age mortality, miscarriages, preterm and low birth weight births. Mercury, which comes from burning coal, also ends up in the food chain and threatens the development of the brain and nervous system.

Picture:
*Courtesy of Philip J. Redman, USGS (US Geological Survey)*
Climate change may alter human exposure to chemicals. The physical changes in temperature, wind, and rainfall caused by climate change will affect the distribution and break-down of chemicals in complex ways. The effect on human exposure will vary widely according to the properties of specific chemicals and chemical combinations, soil and water conditions, wind patterns, topography, land use, level of development, and human population characteristics.

Climate change-related chemical exposures may pose disproportionate threats to populations in high risk groups. Malnutrition, particularly in the very young, may compound and worsen effects from any toxic chemical exposure.

Reference:

• WHO (www.who.int/ifcs/documents/general/clim_change.pdf)

Picture:

• WHO (www.who.int/ifcs/documents/general/clim_change.pdf)
Human allergic response to airborne plant pollens contributes to hay fever, allergic rhinitis and allergic asthma. Sensitization to allergens in early childhood can cause an allergic (including asthmatic) disposition. Ambient pollen levels may rise in response to higher atmospheric carbon dioxide concentrations and higher temperatures. Pollen counts have been rising, and this may be partly a result of increased carbon dioxide, warmer winters, the earlier arrival of spring, or excess of nitrogen. Thus, climate change may already be contributing to the increased incidence of hay fever and asthma that has occurred in many parts of the world in recent decades.

The figure shows the results of a recent experiment by Lewis H. Ziska, a plant physiologist at the United States Department of Agriculture, who did the pollen counts on ragweed grown in indoor chambers at various levels of atmospheric CO$_2$, from about the turn-of-the-century levels of 280 parts per million (ppm) to just below today’s levels of 370 ppm to future predicted levels of 600 ppm. Pollen production went from 5.5 grams to 10 grams to 20 grams as CO$_2$ moved through these three levels.

References:
• D’Amato G, Liccardi G, D’Amato M. Environmental risk factors (outdoor air pollution and climatic changes) and increased trend of respiratory allergy. Journal of Investigational Allergology and Clinical Immunology, 2000, 10:123-128.
• Wuthrich B. In Switzerland, pollinosis has really increased in the last decade. Allergy and Clinical Immunology News, 1991, 3:41-44.

Graph:
• Dr. K. Shea
Global Climate Change and Child Health

INCREASED AEROALLERGENS, INCREASED ILLNESS

- Study on the length of the Ambrosia pollen season for the Montreal region between 1994 and 2002
- Relation between high pollen counts and medical consultation
  - OR 2.69, 95% CI 1.32-5.52 - day of high pollen counts
  - OR 2.48, 95% CI 1.26-4.88 - 5 days after high pollen counts
- Statistically significant increase in the length of the ragweed pollen season with rising temperatures

In addition to increased pollen production in higher ambient CO₂, we are already measuring longer pollen seasons with warming and earlier springs. This study from Canada, showed a statistically significant increase in the length of the ragweed pollen season with rising temperatures. On the day of high pollen count, people were 2.69 times as likely to seek medical care as on days of low pollen counts. On 5 days after high pollen count, people were 2.48 times as likely to seek medical care as on days of low pollen counts. A warmer world with more CO₂ is likely to create more misery for allergic individuals.

OR = Odds Ratio; CI = Confidence Interval

Reference:

The aim of this study is to evaluate the influence of meteorological factors on Ambrosia pollen concentrations and its impact on medical consultations for allergic rhinitis of residents from various socio-economic levels in Montréal (Québec, Canada) between 1994 and 2002. The study was conducted to recognize the sensitivity of pollen productivity to daily climate variability in order to estimate the consequences on human health vulnerability in the context of global climate change. Information related to medical consultations for allergic rhinitis due to pollen comes from the Quebec Health Insurance Board (Régie de l’assurance-maladie du Québec). Ambrosia pollen concentration was measured by the Aerobiology Research Laboratories (Nepean, Ontario). Daily temperature (maximum, minimum, and mean) and precipitation data were obtained from the Meteorological Service of Canada. Socio-economic data come from the 1996 and 2001 census data of Statistics Canada. Between 1994 and 2002, during the Ambrosia pollen season, 7667 consultations for allergic rhinitis due to pollen were recorded. We found a significant association between the number of medical consultations and pollen levels. Significant associations were detected for over-consultation the day of exposure, 1, 2, 3 and 5 days after exposure to high levels of pollen. The consultation rate is higher from low-income residents (3.10 consultations per 10,000 inhabitants) than for high-income (1.65 consultations per 10,000 inhabitants). Considering the demonstrated impact of pollen levels on health, it has become critical to ensure adequate monitoring of Ambrosia and its meteorological sensitivity in the context of the anticipated climate change and its potential consequences on human health.
While not an aeroallergen, this study from Duke University is worth mentioning. It suggests that high CO\textsubscript{2} conditions may have a qualitative impact on some allergens. They grew poison ivy in elevated CO\textsubscript{2} conditions within a full ecosystem and found that it grew faster, bigger and better and produced a higher proportion of the more allergenic congeners of the noxious oils. If this happens with aeroallergens as well, individuals with respiratory allergens could be made more ill as atmospheric CO\textsubscript{2} rises.

Reference:

Contact with poison ivy (Toxicodendron radicans) is one of the most widely reported ailments at poison centers in the United States, and this plant has been introduced throughout the world, where it occurs with other allergenic members of the cashew family (Anacardiaceae). Approximately 80\% of humans develop dermatitis upon exposure to the carbon-based active compound, urushiol. It is not known how poison ivy might respond to increasing concentrations of atmospheric carbon dioxide (CO\textsubscript{2}), but previous work done in controlled growth chambers shows that other vines exhibit large growth enhancement from elevated CO\textsubscript{2}. Rising CO\textsubscript{2} is potentially responsible for the increased vine abundance that is inhibiting forest regeneration and increasing tree mortality around the world. In this 6-year study at the Duke University Free-Air CO\textsubscript{2} Enrichment experiment, we show that elevated atmospheric CO\textsubscript{2} in an intact forest ecosystem increases photosynthesis, water use efficiency, growth, and population biomass of poison ivy. The CO\textsubscript{2} growth stimulation exceeds that of most other woody species. Furthermore, high-CO\textsubscript{2} plants produce a more allergenic form of urushiol. Our results indicate that Toxicodendron taxa will become more abundant and more “toxic” in the future, potentially affecting global forest dynamics and human health.
A second category of climate sensitive health effects has to do with increases in extreme weather events such as storms and floods, drought and fires, and extreme precipitation.

Pictures:
• NASA and NPS (US National Park Service)
Global Climate Change and Child Health

STORMS AND FLOODS

- Drowning and injury
- Psychological sequelae
- Post traumatic stress disorder
  - After Hurricane Andrew
    - 20-30% adults
    - 77% children
      moderate to severe (21 months later)

The hydrological cycle accelerates with global warming. As heat energy accumulates in the deep ocean, more water evaporates, causing increased intensity and frequency of precipitation. Evaporation from soil may also be increased, causing drought. Models indicate that there will be more heavy deluges, with flooding, and more frequent and longer droughts.

Extreme weather events such as heavy precipitation, severe storms, floods, droughts, and cyclones may have increased in frequency, duration, and intensity in some regions over the past century. An increase in the frequency of large floods over the twentieth century has recently been demonstrated, and several-fold increases in the frequency of what are currently considered extreme wet seasons are predicted for various regions, using a range of climate models. Recent climate catastrophes, such as Hurricane Mitch in Honduras, have had major adverse health impact. Over the past decade, floods in Bangladesh, China, various parts of Europe, Mozambique and Venezuela have taken a considerable toll on human life and well-being.

Severe weather events have many effects on child health. Studies of earthquakes indicate that women and young children are more vulnerable to the acute impacts of natural disasters and famines. Floods cause child injuries and death by drowning, and also compromise clean water supplies, fostering epidemics of diarrhoea. In Peru, hospital admissions for paediatric diarrhoea were 50% above the seasonal norm after precipitation and flooding related to the El Niño-Southern Oscillation (ENSO). Following Hurricane Mitch, 30 000 cases of cholera occurred in Central America.

Weather disasters devastate homes, spawning refugee communities that are likely to have poor public health. Basic life support systems, including water, forests and other natural resources, may also be undermined by climate change. Food production and availability are impaired by droughts and floods. Children are especially vulnerable to the emotional trauma caused by sudden changes in living routines and social networks, and the social disruption, economic damage and population displacement caused by weather disasters can impair their psychological and social development.

Studies of Post Traumatic Stress Disorder after Hurricane Andrew in the south-eastern USA found that children are 2-3 times more likely than adults to suffer symptoms of post traumatic stress disorder and that these symptoms endure longer in children than in adults.

<<NOTE TO USER: If you have local data and images, please replace USA example or add additional slide.>>

References:

Pictures:
- NOAA
Global Climate Change and Child Health

EXPOSURE TO MYCOTOXINS

- Drought: weakens seed kernels of plants, allowing greater fungal contamination
- Flooding: causes moist conditions that promote fungal growth
- Aflatoxins are specifically expected to become more prevalent
- Young children among most vulnerable


Warmer temperatures and extreme weather events encourage the growth of mycotoxin-producing fungi, including Aspergillus, Claviceps, Stachybotrys, and Fusarium spp. Mycotoxins are implicated in the pathogenesis of cancers, ergotism, and birth defects. Aspergillus can produce aflatoxin, a potent mycotoxin that has caused much death and disease in Africa and Asia.

Reference:

Human activity has contributed to climate change. The relationship between climate and child health has not been well investigated. This review discusses the role of climate change on child health and suggests 3 ways in which this relationship may manifest. First, environmental changes associated with anthropogenic greenhouse gases can lead to respiratory diseases, sunburn, melanoma, and immunosuppression. Second, climate change may directly cause heat stroke, drowning, gastrointestinal diseases, and psychosocial maldevelopment. Third, ecologic alterations triggered by climate change can increase rates of malnutrition, allergies and exposure to mycotoxins, vector-borne diseases (malaria, dengue, encephalitides, Lyme disease), and emerging infectious diseases. Further climate change is likely, given global industrial and political realities. Proactive and preventive physician action, research focused on the differential effects of climate change on subpopulations including children, and policy advocacy on the individual and federal levels could contain climate change and inform appropriate prevention and response.
Global Climate Change and Child Health

EXTREME PRECIPITATION

- High correlation waterborne illness outbreaks
  - 68% in USA over 45 years after rainfall >80th percentile
  - Surface and Ground water

- Waterborne disease
  - Diarrhoea from unsafe water
    - 4 billion cases/year causing 1.8 million deaths
    - Most deaths in children under 5 years
    - Represent 15% of deaths of under 5s in developing countries
  - Pregnant women, infants, young children among the most vulnerable

- Diarrhoeal disease correlates with temperature
  - Hot weather favours
    - Bacteria
    - Entamoeba
    - Protozoa

Even in fully industrialized countries with well developed public health infrastructure and early warming systems, there is a high correlation with heavy rain events and waterborne illness. A recent retrospective analysis found that over the past 45 years, 68% of all waterborne outbreaks in the USA historically followed rain that was above the 80 percentile of normal. In the developing world, unsafe water is a major problem at all times. To give an indication of the scale of health problems caused by lack of safe water, there are approximately 4 billion cases of diarrhoea each year, causing 1.8 million deaths. These deaths occur mostly among children under the age of 5 year and represent 15% of all deaths in this age group in developing countries. It is certain that these problems would be affected adversely by extreme precipitation events stimulated by global warming and climate change.

<<NOTE TO READER: there is a WHO module on water pollution which builds on this information>>

Finally, diarrhoeal disease is highly sensitive to climatic conditions and shows strong seasonal variations in many locations. The usual positive correlation of diarrhoeal disease with temperature reflects the fact that most cases in tropical developing countries are caused by bacteria, entamoebae and protozoa, all of which are favoured by high temperatures.

<<NOTE TO USER: If you have local data, please replace USA example or add additional slide.>>

Reference:
Global Climate Change and Child Health

**FOOD-BORNE INFECTION**

- Higher ambient temperatures
  - Different eating behaviour
  - Faster growth of food-borne pathogens
- More children hospitalizations for diarrhoea/dehydration
  - e.g. 8% increase per °C above normal average during El Niño

Along with water-borne infections, food-borne infections are also likely to increase with climate change. This is partly because of changes in eating behaviour including more outdoor food preparation and dining, and partly because many food-borne pathogens grow faster in warmer weather. There will be more children with diarrhoea and likely more hospitalizations for dehydration. In one 6-year study from Peru, researchers found an 8% increase in hospitalizations for diarrhoea and dehydration for every degree centigrade above the normal average temperature. This analysis controlled for seasonal variations and long-term trends, thus imparting high confidence to the observed relationship of diarrhoeal disease with temperature.

This chart shows a clear correlation between peak temperatures and peaks in cases of *Campylobacter*, *E coli*, and *Salmonella* infections in Alberta, Canada. Hot weather yields more illness.

**References:**

**Graph:**
Global Climate Change and Child Health

GLOBAL WARMING AND DIARRHOEAL ILLNESSES

A similar time series analysis in Fiji assessed the relationship of monthly reported incidence of diarrhoea to variations in temperature and rainfall, allowing for the effects of seasonal variation and long-term trends. The reported incidence increased by approximately 3% for each degree increase in temperature, by 2% per unit increase in rainfall above 5 x 10-5 kg/m² per minute (average rainfall conditions), and by 8% per unit decrease in rainfall below this level.

These studies indicate that future changes in mean climatic conditions and in the occurrence of extreme weather events are likely to significantly affect the incidence of diarrheal disease in children. As well as meteorological influences on microbial exposures, child diarrheal disease may also increase because drinking water becomes contaminated by toxins from warming-induced algal blooms.

Reference:

Freshwater resources are a high-priority issue in the Pacific region. Water shortage is a serious problem in many small island states, and many depend heavily on rainwater as the source of their water. Lack of safe water supplies is an important factor in diarrheal illness. There have been no previous studies looking specifically at the relationship between climate variability and diarrhea in the Pacific region. We carried out two related studies to explore the potential relationship between climate variability and the incidence of diarrhea in the Pacific Islands. In the first study, we examined the average annual rates of diarrhea in adults, as well as temperature and water availability from 1986 to 1994 for 18 Pacific Island countries. There was a positive association between annual average temperature and the rate of diarrhea reports, and a negative association between water availability and diarrhea rates. In the second study, we examined diarrhea notifications in Fiji in relation to estimates of temperature and rainfall, using Poison regression analysis of monthly data for 1978-1998. There were positive associations between diarrhea reports and temperature and between diarrhea reports and extremes of rainfall. These results are consistent with previous research and suggest that global climate change is likely to exacerbate diarrheal illness in many Pacific Island countries.

Graph:
Global Climate Change and Child Health

VECTOR-BORNE ILLNESS

- Enhanced infection prevalence
- Prolonged transmission season
- Extended range

Global warming is also likely to change the pattern of vector-borne illness because insects and rodents respond quickly to changes in temperature and moisture by migrating and increasing numbers.

The reproduction and survival of blood-feeding vector organisms, such as mosquitoes and ticks, are greatly affected by climate and other ecological factors. Higher temperatures, changes in precipitation, and altered climate variability may therefore change the distribution of vector-borne diseases, both spatially and seasonally. Immunologically naive populations may thus face unfamiliar pathogens. In some locations, climate change may actually lead to decreased vector-borne disease transmission because of reduced rainfall or excessively high temperatures.

In general, without strong public health defences, the anticipated increases in range and seasonality of pathogens and their vector organisms will cause a greater incidence of various infectious diseases. Children are particularly susceptible to malaria, dengue fever and various forms of encephalitis. For example, the prevalence of vector-borne illness is likely to increase with global warming because increases in temperature: 1) accelerate vector life cycle 2) shorten incubation time of the parasite in the vector and 3) prolong transmission seasons. Furthermore, higher temperatures will change the range of vectors both in latitude and altitude.

References:

Picture:
- CDC (Centers for Disease Control and Prevention) (www.cdc.gov/malaria/biology/mosquito/index.htm)
Global Climate Change and Child Health

MALARIA

Malaria is the world's most serious vector-borne disease. About 40% of the world's population currently live in malaria-endemic areas. Various mathematical modelling studies have estimated that increased temperatures will expand the geographical range of conditions conducive to malaria transmission, both to higher altitudes and higher latitudes. Further, elevated temperatures, in combination with conducive patterns of rainfall and surface water, will extend the transmission season in some locations. Some data suggest that global warming may have already exacerbated malaria incidence, especially in areas where transmission is limited by low temperatures or high altitude.

Children experience disproportionately high levels of both morbidity and mortality from malaria. Young children have little specific immunity to malarial species and may therefore suffer yearly attacks of debilitating and potentially fatal disease. Children are also more susceptible to cerebral malaria and to the hypoglycaemia that is secondary to malaria, both of which can lead to neurological damage and, often, death.

While excessive heat kills mosquitoes, warmer average temperatures within their survival range increase their reproduction, biting activity, and the rate at which pathogens mature within them, including the malaria parasite, *Plasmodium*. Furthermore, warm nights and warm winters in particular favour insect maturation and survival. This is the specific warming pattern that climate change induces, and mosquitoes will therefore probably mature faster and live longer with climate change.

References:

Picture:
- WHO (mosquito.who.int/cmca_upload/0/000/015/372/RBMInfosheet_1.htm)
Global Climate Change and Child Health

LYME DISEASE IN USA

Greater climate variability will increase the incidence and geographical distribution of other vector-borne diseases, including mosquito-borne encephalitis, tick-borne encephalitis, and Lyme disease. Children are especially vulnerable to mosquito and tick bites, because they tend to play outside and are closer to the ground where ticks and mosquitoes can be found. The reported incidence of Lyme disease in the USA is highest among children aged 5–10 years, almost twice that among older children and adults.

Warm winters encourage the overwintering of ticks. Global climate change will therefore foster the geographical spread of tick-borne diseases. A recent study in Sweden showed that a decade of milder winters and earlier springs in the 1980s was related to a significant increase in the range and incidence of tick-borne encephalitis.

In the USA, there has been increases in a number of vector-borne illnesses. Lyme disease is one of these. The case rate per thousand has increased almost 20 fold in 20 years. While rarely fatal, Lyme disease has the potential for long term morbidity. The population at risk is people who work or play outside, including children.

Graph:

•CDC. MMWR. August 8, 2003, 52(31):741-750
Warm winters encourage the overwintering of ticks. Global climate change will therefore foster the geographical spread of tick-borne diseases. This study from Sweden shows that a decade of milder winters and earlier springs in the 1980s was related to a significant increase in the range and incidence of tick-borne encephalitis. These maps show the increased tick reservoir. More recently, Canada has reported *Ixodes* encroaching on their southern provinces linked to climate change.

Reference:

Picture:
- CDC (www.cdc.gov/healthypets/diseases/lyme.htm).
The good news about global warming is that there will be a decline in cold related deaths. The bad news is that there will be more deaths due to heat. It is predicted that small changes in mean climate conditions will trigger relatively large changes in the frequency and severity of heat waves. Heat waves are therefore expected to increase in number and intensity in the future.

By extrapolation from many prior studies, any future increase in the frequency and severity of heat waves will increase the risks of death and serious illness. The very old, the very young and the sick are particularly vulnerable to thermal stress. Children are less able than adults to modify their local (usually domestic) climate, especially if a heat wave is sudden and severe. In children, heat stroke is the most serious outcome of central or peripheral impairment of body temperature regulation, and may result in death.

For example, the slide shows average annual deaths due to hot weather in US as deaths/million population. While this is clearly more of a problem for the elderly, you can see that the death rate curve is really a check mark curve with a higher rates at the both extremes of age. Vulnerable populations include also those with debilitating conditions, urban dwellers and the poor. Children can be in multiple high risk categories.

<<NOTE TO USER: Please substitute local data on health related illness if available.>>

References:

During 1979-1999, over 8,015 deaths in the United States was associated with excessive heat exposure†, 3,829 (48%) were “due to weather conditions,” 377 (5%) were “of man-made origins” (i.e., heat generated in vehicles, kitchens, boiler rooms, furnace rooms, and factories), and 3,809 (48%) were “of unspecified origin” (3); 182 deaths per year (range: 54-651) were associated with excessive heat due to weather conditions. Of the 3,764 (98%) deaths specified as due to weather conditions with a reported age (3), 142 (4%) occurred among children aged <4 years, and 1,068 (28%) occurred among persons aged ≥75 years.

It is crucial to consider future health effects which may result from global environmental change. Indeed children will inherit the world and societies created now. As world population grows, that growth is projected to be almost entirely in developing nations. 90% of disaster victims live in developing nations. The effects of global change are likely to be disproportionately felt in these poor countries with least capacity to respond. Food and water security will become issues of concern, biodiversity is clearly threatened, forced human migration from sea level rise will likely occur and there are concerns about reduced economic capacity. The WHO and the Harvard University Global Burden of Disease project suggests that by 2020 one of the two leading causes of morbidity in the world will be depression. And we understand better than ever the spectre of increasing violence and terrorism in a stressed world.

**Picture:**

• WHO

<table>
<thead>
<tr>
<th>Indirect (Future) Threats to Children’s Health</th>
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<tbody>
<tr>
<td>Unequal burden of disease</td>
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<tr>
<td>Loss of food and water security</td>
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<tr>
<td>Loss of biological capital</td>
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<tr>
<td>Forced migration</td>
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<tr>
<td>- Sea level rise</td>
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<tr>
<td>- Redistribution of crops</td>
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<tr>
<td>- Desertification, drought</td>
</tr>
<tr>
<td>Reduced economic capacity</td>
</tr>
<tr>
<td>Depression, mental illness</td>
</tr>
<tr>
<td>Violence and terrorism</td>
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</tbody>
</table>
Indirect health effects from global warming are related to ecological alternations and disruptions of food supply. Childhood malnutrition was estimated to account for 15.9% of the total burden of premature death and disabling disease in 1990. A multiplicity of biological, social, political, and economic factors affect the incidence of malnutrition, but one of the fundamental determinants is the availability of staple foods, predominantly cereal grains.

Climate change has multiple effects on food availability. Because there is more carbon dioxide in the atmosphere, plants take up more CO$_2$ and less nitrogen. Plant protein content is thus reduced, with less nitrogen available as building blocks. Although elevated atmospheric carbon dioxide may increase plant biomass, the nutritional content of the biomass may be impaired. Further, the increased carbon-to-nitrogen ratio, by reducing the synthesis of alkaloids and other nitrogen-based plant defences, may increase the eating of plants by insects, rodents and other pests. Increased evaporation may reduce soil moisture, while flooding may cause some arable land to become saline. Climate change can also reduce parasite resistance in livestock.

This figure from the 5$^{th}$ chapter of the Working Group II of the 4$^{th}$ Assessment of the IPCC (2007) shows the estimated yields of 3 important cereal crops (maize, wheat and rice) at mid to high latitudes (column on left) and low latitudes (column on right) under increasing temperatures. After an initial levelling or slight boost, yields fall under most scenarios as temperature rises.

**Graphs:**
- [IPCC (Intergovernmental Panel on Climate Change), WG II, 2008 (www.ipcc.ch/index.htm)].
- Parry ML et al., eds. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK, 2008. (Chapter 5, p. 286, Fig. 5.2).
Of the many possible health consequences of climate change, the Intergovernmental Panel on Climate Change has tried to project within the large uncertainties at the global level, what health effects are most likely. Here you see that almost all health impacts are negative, and all of them are likely to hit children harder than other groups.

**Picture:**
- IPCC (Intergovernmental Panel on Climate Change), WG II, 2008 (www.ipcc.ch/index.htm).
- Parry ML et al., eds. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 2008. (Chapter 8, p. 418, Fig. 8.3).
What can be done to address health threats from climate change and prevent future threats? What will the future bring? What tools do we have to help us plan and act responsibly?

Climate models are now tested and useful at the global to continental level. This figure shows the historical record in the black line. The blue shaded areas show model predictions without human influence or forcings. Notice that these blue areas fail to predict the recent temperature rises, indicating they are missing some crucial cause of temperature, namely the influence of humans. The pink areas show full model predictions with both “natural” and human forcings taken into account. The models reproduce within standard confidence what we have measured historically. This is important, because the ability of the models to predict the temperatures in the past gives us greater confidence that they will also be able to predict temperatures in the future (within the broad band of predictions show as the pink swaths in the Figures).

Picture:
- IPCC (Intergovernmental Panel on Climate Change), WG I, 2007 (www.ipcc.ch/index.htm).
- Solomon S et al., eds. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2007 (Fig. SMP5).
This slide shows a predicted range of trajectories for the global average surface temperature. The orange line represents the energy stored in the system based on greenhouse gases already in the air as of 2000. In other words, if we had magically stopped all emissions as of 2000, warming would continue throughout the century due to carbon dioxide stored in oceans and heat stored in the oceans and land. The far right bar is more or less status quo with a central prediction of 4 °C rise by 2100, and a 90% confidence range of 2.4 degrees to 6.4 degrees. The intermediate predictions are based on different scenarios of population growth, social cohesion, technological change and fuel choices.

There is alarming overlap between these indicators of dangerous climate change and all of the predictions for temperature change this century. Status quo would put us well above the realm of 4-6 meter sea level rise and into the "massive extinctions" projected by the Intergovernmental Panel on Climate Change 4th report.

Picture:
•IPCC (Intergovernmental Panel on Climate Change), WG I, 2007 (www.ipcc.ch/index.htm).
Solomon S et al., eds. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2007. (Chapter 9, p. 703, Fig. 9.2).
Global Climate Change and Child Health

WHAT IS "DANGEROUS CLIMATE CHANGE"?

Changes “irreversible” in human time

- Sea level rise (ice behaviour poorly understood)
  - Partial melting of Greenland and West Antarctic are expected from temperatures rises 1-4°C above 1990 resulting in 4-6 meter rise in ocean levels
    - Total melting is possible within centuries leading to 15 meter rise

- Species extinctions
  - 20-30% of plant and animal species at risk of extinction with >1.5-2.5°C average rise
  - Massive extinctions likely with 4-5°C rise


So, what does this mean in terms of impacts? In 1992, 192 countries signed the UN Framework Convention on Climate Change which commits countries to “prevent dangerous anthropogenic interference with the climate system”. One way to define this, is as harmful changes that are irreversible on the human time scale. These can be encapsulated in 2 crucial endpoints – sea level rise and species extinctions. The Intergovernmental Panel on Climate Change predictions are conservative in that they acknowledge the poor level of understanding of ice behaviour and exclude possible effects of the melting of the big ice sheets of Greenland and Antarctica in their predictions; they do caution that there is moderate confidence that some melting of these sheets would happen with temperatures between 1 and 4 degree C and result in a 4-6 meter (12-15 foot) sea level rise. This could increase to 15 meters (45 feet) within a few centuries if both completely melt. It adds up to being a dangerous unknown in the ability to predict the future.

Species extinctions are anticipated, indeed occurring, and as much as 30% of plants and animals are considered at risk of extinction with as little as 1.5-2.5 °C rise in temperature. Massive extinctions are likely, according to IPCC, with 4-5 °C.
“For all those concerned about the environmental health of children, the time to translate knowledge into action is now.”

Progress can and must be made in addressing current and future threats to children’s health from global climate change. This quotation is from the Bangkok Statement and emphasizes the urgent need to begin now working to safeguard children’s environmental public health.

Reference:

Pictures:
•WHO
The chair of the Intergovernmental Panel on Climate Change assures us that individual and collective actions can succeed.

We must focus on 2 goals urgently and simultaneously. We must adapt to the warming that is already guaranteed. This means giving infusions of resource support to our public health infrastructure and disaster preparedness programs and always remembering a specific focus on vulnerable populations, the needs of children and future generations. This is a familiar territory and analogous to secondary prevention in health.

We must also engage in effective global mitigation strategies to “prevent dangerous anthropogenic interference with the climate system”; also familiar territory – primary prevention.

*Picture:*

• WHO
Global Climate Change and Child Health

GLOBAL RESPONSE: COMMON BUT DIFFERENTIATED RESPONSIBILITY

50 years of Carbon Emissions

Mortality from 4 climate-sensitive conditions

“...the largest health inequity of our time.”

These goals must be pursued globally -- but as the UN Framework Convention on Climate Change stresses-- there is common but differentiated responsibility. This map compares 50 years of carbon emissions and mortality from 4 climate sensitive conditions (malaria, diarrhoea, malnutrition and inland flooding). As the author, Jonathan Patz, phrases it this is the largest health inequity of our time.

So a global response with common but differentiated responsibilities according to capacities.

Reference:

Climate change, as an environmental hazard operating at the global scale, poses a unique and “involuntary exposure” to many societies, and therefore represents possibly the largest health inequity of our time. According to statistics from the World Health Organization (WHO), regions or populations already experiencing the most increase in diseases attributable to temperature rise in the past 30 years ironically contain those populations least responsible for causing greenhouse gas warming of the planet. Average global carbon emissions approximate one metric ton per year (tC/yr) per person. In 2004, United States per capita emissions neared 6 tC/yr (with Canada and Australia not far behind), and Japan and Western European countries range from 2 to 5 tC/yr per capita. Yet developing countries’ per capita emissions approximate 0.6 tC/yr, and more than 50 countries are below 0.2 tC/yr (or 30-fold less than an average American). This imbalance between populations suffering from an increase in climate-sensitive diseases versus those nations producing greenhouse gases that cause global warming can be quantified using a “natural debt” index, which is the cumulative depleted CO2 emissions per capita. This is a better representation of the responsibility for current warming than a single year’s emissions. By this measure, for example, the relative responsibilities of the U.S. in relation to those of India or China is nearly double that using an index of current emissions, although it does not greatly change the relationship between India and China. Rich countries like the U.S. have caused much more of today's warming than poor ones, which have not been emitting at significant levels for many years yet, no matter what current emissions indicate. Along with taking necessary measures to reduce the extent of global warming and the associated impacts, society also needs to pursue equitable solutions that first protect the most vulnerable population groups; be they defined by demographics, income, or location. For example, according to the WHO, 89% of the disease burden attributable to climate change afflicts children under age 5 (obviously an innocent and “nonconsenting” segment of the population), presenting another major axis of inequity. Not only is the health burden from climate change itself greatest among the world’s poor, but some of the major mitigation approaches to reduce the degree of warming may produce negative side effects disproportionately among the poor, for example, competition for land from biofuels creating pressure on food prices. Of course, in today’s globalized world, eventually all nations will share some risk, but underserved populations will suffer first and most strongly from climate change. Moreover, growing recognition that society faces a nonlinear and potentially irreversible threat has deep ethical implications about humanity’s stewardship of the planet that affect both rich and poor.

Picture:
Given that the process of climate change is already underway – as are other global environmental changes – and that the world is committed to the continuation of such change over at least several decades, societies must now also seek adaptations that will lessen its adverse health impacts. Many of the climate-amplified risks to children’s health would be lessened by strengthening public health infrastructure and environmental management – including sanitation, fresh water provision, immunization programmes, mosquito control, improved housing quality, and better and more secure nutrition.
Global Climate Change and Child Health

LOCAL STRATEGIES

- Educate individuals and communities about sustainability
  - Primary and secondary schoolchildren
  - Community leaders

- Sustainable local practices
  - Coastal Communities
  - Inland Communities
  - Urban versus Rural Communities

<<NOTE TO USER: Please complete this slide with actions appropriate for your audience/region>>

There is also a need for increased education of primary and secondary schoolchildren about the need for communities to think and act in ecologically sustainable ways, and about the ways of lessening personal and family exposure to environmental hazards consequent upon global environmental changes. Finally, there are some risk-reducing responses that are specific to the hazards of environmental change – such as strengthening coastal defences against rising seas, managing local and regional fisheries sustainably in order to maintain nutritional (especially protein) supplies, and altering clothing and recreational behaviour to reduce exposure of children to ultraviolet radiation.
Global Climate Change and Child Health

ROLE OF HEALTH SECTOR
ADAPTATION - PREPARE FOR THE UNAVOIDABLE

- Direct patient care
  - Optimize immunizations and access to care
  - Teach use of UV, heat, air quality indices, early warning systems and responses
  - Identify vulnerable individuals in the practice

- Work with local public health officials
  - Develop a local “climate-related health risk profile”
  - Include vulnerable groups’ issues in disaster planning
  - Develop low toxicity vector control programs
  - Improve disease reporting and surveillance

- In the Community
  - Protect drinking water supply and quality
  - Support local agriculture
  - Develop broad partnerships and programs across sectors

The role of the health sector is crucial.
We need to respond in direct patient care by actions like <<READ FIRST BULLET>>.
We need to work at the local public health level to <<READ SECOND BULLET>>.
We need to work directly in the community to do things like <<READ THIRD BULLET>>.
Global Climate Change and Child Health

**HEALTH LEADERSHIP**

The 10 Essential Services of Public Health, With Climate Change Examples

<table>
<thead>
<tr>
<th>Service</th>
<th>Climate Change Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Monitor health status to identify and solve community health problems.</td>
<td>Tracking of diseases and trends related to climate change.</td>
</tr>
<tr>
<td>2. Diagnose and investigate health problems and health hazards in the community.</td>
<td>Investigation of infectious water, food, and vector-borne disease outbreaks.</td>
</tr>
<tr>
<td>3. Inform, educate, and empower people about health issues.</td>
<td>Informing the public and policymakers about health impacts of climate change.</td>
</tr>
<tr>
<td>4. Mobilize community partnerships and action to identify and solve health problems.</td>
<td>Public health partnerships with industry, other professional groups, faith communities, and others, to craft and implement solutions.</td>
</tr>
<tr>
<td>5. Develop policies and plans that support individual and community health efforts.</td>
<td>Municipal heat wave preparedness plans.</td>
</tr>
<tr>
<td>6. Enforce laws and regulations that protect health and ensure safety.</td>
<td>Little role for public health.</td>
</tr>
<tr>
<td>7. Link people to needed personal health services and ensure the provision of health care when otherwise unavailable.</td>
<td>Health care service provision following disasters.</td>
</tr>
<tr>
<td>8. Ensure competent public and personal health care workforce.</td>
<td>Training of health care providers on health aspects of climate change.</td>
</tr>
<tr>
<td>9. Ensure effectiveness, accessibility, and quality of personal and population-based health services.</td>
<td>Program assessment of preparedness efforts such as influenza plans.</td>
</tr>
<tr>
<td>10. Research for new insights and innovative solutions to health problems.</td>
<td>Research on health effects of climate change, including innovative techniques such as modeling, and research on optimal adaptation strategies.</td>
</tr>
</tbody>
</table>

The good news is that this is really NOTHING NEW – already within standard operating procedures - the 10 essential services of public health - and disaster preparedness and preparations for pandemic flu. We just need to identify and highlight regional and local conditions likely to worsen with climate change, the most vulnerable populations, and develop protocols and approaches to minimize health impacts.

**Reference:**


*There is scientific consensus that the global climate is changing, with rising surface temperatures, melting ice and snow, rising sea levels, and increasing climate variability. These changes are expected to have substantial impacts on human health. There are known, effective public health responses for many of these impacts, but the scope, timeline, and complexity of climate change are unprecedented. We propose a public health approach to climate change, based on the essential public health services, that extends to both clinical and population health services and emphasizes the coordination of government agencies (federal, state, and local), academia, the private sector, and nongovernmental organizations.*

**Picture:**


Used with copyright permission.
Global Climate Change and Child Health

ADAPTATION – E.G. HEAT WAVES

- Extreme heat response programs – local level
  - Telephone “heatlines”
  - Neighbourhood buddy systems
  - Public cooling stations
  - Cooperation with seniors organizations
  - Coordinate with local utilities
  - Outreach to at risk groups including homeless

- Medical response
  - Ensure adequate emergency room and in-patient capacity

NOAA Heat/Health Watch Warning Systems

Examples of programs spreading in the USA are the Extreme Heat Response Programs at the local level. They involve using the heat health watch warning systems to initiate 

Local medical infrastructure must be beefed up enough to ensure adequate ER and inpatient capacity for those who slip through the cracks of the above.

- Activating telephone heat hotlines
- Alerting neighbourhood volunteers, family members, and friends
- Providing public air-conditioned buildings and transportation to these facilities
- Working with local "aging agencies" to educate at-risk individuals
- Coordinating with local utility companies to ensure that service to residential electricity customers is not shut off during a heat wave.

Reference:
- EPA (www.epa.gov/hiri/about/heatresponseprograms.html).

Graph:
A second USA example is anticipating health harms related to flooding both acutely and in the aftermath. We are getting better at averting death and disease from floods by educating early responders, local officials and public health workers regarding flood related hazards such as:

- Tetanus booster
- Food & water safety
- Sanitation & hygiene
- Power outages
- Carbon monoxide risk
- Animal & insects
- Cleanup
- Mould and mycotoxins
- Electrical hazards
- Re-entering flooded buildings

Picture:
• CDC (emergency.cdc.gov/disasters/floods/)
Global Climate Change and Child Health

GENERAL APPROACH TO ADAPTATION

1. Determine the scope of the assessment
2. Describe current burden of climate-related diseases
3. Describe current strategies and approaches to these diseases
4. Review health impacts in other sectors
5. Assess future potential health impacts
6. Synthesize in report or profile
7. Identify adaptation options and evaluation tools

Ebi KL. Environ Health Perspect, 2006;114(12):1930-4.

Kris Ebi has developed a general approach to climate change adaptation that can be used to develop locally relevant climate risk profiles for adaptation purposes. There are 7 basic steps. It is logical, straightforward, not overwhelming – but it does require attention and multi-sector cooperation.

Reference:
Global Climate Change and Child Health

LOCAL HEALTH DEPARTMENTS IN USA

Representative national sample: 217 local HD directors with 61% response rate

- CC is (70%) or will be (78%) a significant local health problem
  - Only 19% listed CC as a top 10 priority
- 77% perceived lack of local expertise to cope
  - Similar or higher numbers for perceived state and federal expertise
- Some programs established on CC-related health problems
  - Most common: active transport, food & water safety, and vector control
  - Least attention to mental health problems
- Mitigation programs at fewer than 20%
  - Least attention to reducing GHG emissions and energy use

Unfortunately, at least in the US, local health departments (HD) are not yet ready for climate change related problems. This paper by Maibach is of a nationally-representative sample of health department directors. Interestingly, most of them believed climate change was already or would definitely cause health problems for them, but under 1/5 listed it has a top 10 priority. Most believed they lacked local expertise to cope and more believed there was a lack of state level and federal level expertise to help them cope. Some health departments had programs already established, which address climate related health conditions, but very few had any mitigation programs going. There is fertile ground for work at the local health department level on this issue.

Reference:
The chair of the Intergovernmental Panel on Climate Change assures us that individual and collective actions can succeed. We must focus on 2 goals urgently and simultaneously. We must adapt to the warming that is already guaranteed. This means giving infusions of resource support to our public health infrastructure and disaster preparedness programs and always remembering a specific focus on vulnerable populations, the needs of children and future generations. This is a familiar territory and analogous to secondary prevention in health.

We must also engage in effective global mitigation strategies to “prevent dangerous anthropogenic interference with the climate system”; also familiar territory – primary prevention.

*Pictures:*
- WHO
Global Climate Change and Child Health

**MITIGATION: AVOID THE UNMANAGEABLE**

- Everyone’s responsibility
  - CO₂ is the main problem

- Action must be individual to international

- Options vary greatly
  - By regional climate
  - By level of development
  - By institutional organization

- **Good for health!**
  - Health professionals natural leaders

Mitigation is for everyone, at all levels, according to our abilities. Carbon dioxide is the major and growing greenhouse gas and is the logical place to begin mitigation strategies. (See IPCC AR4 reports at www.ipcc.ch/ipccreports/assessments-reports.htm for further details, graphics and explanations)

<<READ SLIDE>>

The really good thing is that many mitigation strategies are good for health, making health professionals natural leaders.
Global Climate Change and Child Health

HEALTH CO-BENEFITS OF MITIGATION

<table>
<thead>
<tr>
<th></th>
<th>Fossil fuel use</th>
<th>Preserve forest sinks</th>
<th>Urban Heat Island</th>
<th>Sustainable urban design</th>
<th>Improve transport</th>
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</thead>
<tbody>
<tr>
<td>Cardiovascular disease</td>
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<tr>
<td>Respiratory Diseases</td>
<td>+++</td>
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<td>Obesity-related</td>
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<td>Mental health</td>
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<td>Infectious diseases</td>
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</tbody>
</table>

+++ very good evidence, ++ good evidence, + some evidence


And it is even evidence based. Here are standard mitigation strategies and major categories of disease. Look at all the plus signs where improved health and mitigation converge and are supported by the scientific literature.

Urban Heat Island is a US metropolitan area which is significantly warmer than its surrounding rural areas.

Reference:

Table:
• Dr. K. Shea
Recognizing this -- World Health Day 2008 was organized around the theme of Protecting Health from climate change. Here’s the astonishing and empowering reality. Globally 45% of per capita carbon footprint comes from individual activities, choices under our personal control. In the highly industrialized nations the per capita footprint is much higher (e.g., 60% in the USA) compared to footprints in OECD or developing nations. So mitigation in the most developed countries will mean using less energy (contraction), eliminating waste and over consumption and making a rapid transition to low/no carbon energy. In still developing countries, it means climate proofing the country by developing with clean energy and sustainable practices as initial strategies.
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MITIGATION STRATEGIES

- Personal choices MATTER
  - Calculate your carbon footprint
  - Reduce it iteratively and tell the stories
- Practice choices MATTER
  - “Green” your office and institution
  - Educate and innovate
- Political choices MATTER
  - Make change locally
  - Educate decision makers
  - Participate fully in the local political process

www.healthandenvironment.org/?module=uploads&func=download&fileId=418

Mitigation, particularly in the industrialized world, must include changes in personal actions and choices. The Health Community, accustomed to anticipatory guidance, primary prevention and health values can be leaders at the local level in mitigation. There are many ways to proceed. Some ideas include at the personal level:

1) Calculate your carbon footprint, work to reduce it and tell the stories.

2) At the medical practice level: green your medical offices and institutions (www.gghc.org), educate colleagues, staff and patients about climate change and effective mitigation strategies. Enjoy being innovative and creative in ways to reduce carbon footprints in the community. Individuals acting collectively through individual changes can make great differences, but political action is also necessary.

3) Educate local decision makers on the potential health threats from unchecked climate change in your area and the importance of proactive, preventive measures. Become politically engaged to champion mitigation and adaptation strategies that require government assistance.

The website at the bottom of the slide will guide you to a paper that has lots of ideas and resources for mitigation strategies.
From the health perspective, the urgent need for mitigation of greenhouse gases provides opportunities for health co-benefits from major mitigation strategies. The next 2 slides have examples of possible positives strategies that benefit health and reduce climate change in 2 different examples of fully developed and rapidly developing countries.

In the USA, becoming less car dependent will help fight the obesity epidemic and clean the air of major pollutants. Moving away from electronic entertainment reduces demand for energy and reinvigorates social interactions which reduces social isolation and fights epidemic depression. Supporting local agriculture to reduce the long distance transportation of food, as well as eating fresh and low on the food chain will reduce emissions from production and distribution of food, improve nutrition, reduce the risk of a number of serious health conditions, and support the local economy. Energy efficiency at home and in the office makes sense because it saves money – liberating wasted dollars for other uses including medicines and medical care for those in need. The health community can be leaders in finding these Win-Win scenarios and encouraging action at all levels in order to capitalize on them.
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FIND THE WIN-WIN CHOICES – E.G. INDIA

- Replace biomass with clean renewable energy and develop “smart” local electrical grids
  - Reduces emissions and prevents new emissions, prevents cardiopulmonary diseases and death, gets necessary energy to households

- Improve public transport, create bike lanes
  - Reduces need for personal vehicle, decreases congestion, noise, and air pollution, promotes active transport

- Promote solar hot-water and water conservation
  - Reduces air pollution, promotes health, saves money

- Strengthen traditional diet – continue to eat low on the food chain, local and organic when available
  - Supports local farms/economy, improved nutritional quality, prevents obesity, lower risk of chronic diseases

Mitigation in a country like India might include

<<READ BULLETS>>
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WIN-WIN-WIN: THE TRIPLE BOTTOM LINE

1. Sustainable communities (Planet)
2. Strong economy (Profit)
3. Health (People)

- Alternative energy – wind, wave, solar
  - Carbon neutral
  - New green jobs, keep energy profits local
  - Clean air
- Green buses, more bikes
  - Reduced cars and emissions
  - New “green jobs”
  - Clean air, fewer accidents, more physical activity

And many communities are talking about the triple bottom line Planet, Profit, and People – there are triple wins in mitigation strategies.
<<READ BULLETS>>
Prevention is always preferred in public health. This applies particularly in this setting, where environmental change processes may acquire momentum and may induce irreversible changes in important components of the biosphere’s life-support systems. Climate change is a global public health threat of unprecedented scale and urgency. It will require cooperation and leadership at all levels to discover and implement all the solutions necessary to prevent dangerous climate change. The health sector has an important leadership role to play.

Reference:

Picture:
• WHO (www.who.int/globalchange/en/)
The impacts of global environmental change on child health span a wide spectrum, covering respiratory health, temperature regulation, trauma, nutrition, development, allergy, infectious disease, mental health, skin cancer, and immunological changes. Nevertheless, there remains a serious lack of empirical data on how climate change specifically affects child health. Much of this knowledge gap reflects the fact that global climate change is a recent and inherently slow process. Furthermore, scientific and popular consensuses have only recently converged in recognizing that climate change and the other global environmental changes require both research and policy attention.

We need more research on how changes in temperature, precipitation and extreme weather events, and their resultant ecological changes, affect children's health. Because many aspects of the physiology and metabolism of children differ markedly from those of adults, several of the health impacts in children, of climate change and other global environmental changes are likely to be distinctive.

To protect children fully from these health consequences will require a substantial change in our pattern of economic activities and in our technology choices. By understanding better the range and extent of risks posed to by climate change and other global environmental changes, we will strengthen the contribution of the health sciences to the ongoing public debate over the future, sustainable, management of the biosphere.

We must urgently to address the threats to health from climate change because we hold our future in our hands—and it is our children.
Acknowledgements

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