

Join the Conversation: Talking About the Health Consequences of Global Heating/Climate Destabilization

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ABSTRACT

Global heating/climate destabilization is likely to be the most serious public health problem in this century. This article encourages health care workers to discuss climate change and provides a short summary of climate change/health information. There are talking points with references that may be of practical use. Although climate change is a global crisis that requires global solutions, by conversing with others, an individual may be able to take effective climate action.

BACKGROUND

Climate change may become the greatest health problem of this century.¹ Children today and future generations face an uncertain and unsafe future caused, in part, by global heating/climate destabilization, often called climate change.^{2,3} Discussing its health effects with patients, colleagues, family, and friends may be an effective and practical action for concerned health professionals who have demanding professional duties^{4,5} and may result in greater public pressure to reduce greenhouse gas emissions.

This article provides a summary of climate change, air pollution, and health information intended to facilitate discussions for health professionals in their daily conversations. It is organized as a collection of talking points linking health and climate. A broad array of climate and health information is presented to emphasize the importance of climate change and permit the reader to choose from many topics. Table 1 includes a list of talking points about the direct health effects of climate change. Table 2 consists of informa-

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tion about tipping point warnings called “boundaries.” These boundaries anticipate major changes beyond which Earth’s capacity to sustain life diminishes. The Box lists key messages. Because climate change affects the entire Earth ecosystem, diverse information from different scientific fields has been included. Dissimilar information is included because every topic mentioned is a health topic.

METHODS

The Intergovernmental Panel on Climate Change (IPCC), World Health Organization (WHO), *New England Journal of Medicine*, and *Lancet* commission reports and reviews provided most of the information on the health effects of global heating/climate destabilization and air pollution for this article.^{1-3,6-9} For boundary and tipping point information, a PubMed search was conducted for English language articles published from January 1, 2014 through March 31, 2022 using the terms “boundary” and “rockstrom.” “Rockstrom” was chosen because Professor Johan Rockstrom is a pioneering researcher in the study of earth system boundaries.¹⁰ Review articles were selected from the PubMed list.

For information about the deposition of particulates in human tissues, a PubMed search for English language articles published from January 1, 2014 through March 31, 2022 was performed using “particulates” and “human placenta,” “particulates” and “human heart,” and “particulates” and “human brain.” A single article that demonstrated the presence of air pollution deposits in heart, brain, or placental tissue was chosen from each search result.

For mortality from heat, a PubMed search for English language articles published from January 1, 2015 through March 31, 2022 was performed using the search terms “heat” and “global mortality.” A single modeling study about global heat mortality was selected as an example because the authors were able to provide an

estimate of annual heat mortality over time compared to the rise in the Earth's mean surface temperature.

The collection of talking points derives from my experience giving presentations and trying to answer questions on climate and health. The US Army War College¹¹ report is helpful when speaking to someone who discounts climate science. Heating, anoxia, and acidification of water may be appropriate for a person with an interest in Wisconsin lakes or fishing; and discussing the novel *Never Let Me Go*¹² may encourage people to consider an adolescent's perspective on climate change.

RESULTS

The average atmospheric temperature just above the Earth's surface (global mean surface temperature) increased by 1 °C to 1.1 °C (1.8 °F to 2 °F) between the years 1900 and 2017.⁶ By 2040, this increase may become 1.5 °C (2.7 °F).⁶ An increase in concentration of greenhouse gasses in the atmosphere causes global heating by reducing heat flow to outer space and accumulating heat energy within the atmosphere.⁶ Heat accumulation on Earth causes global heating and also destabilizes the climate by causing a greater number of severe weather events. As a result of global heating, a child born today will experience more wildfires, floods, weather-induced crop failures, droughts, and heat waves than a child living in a stable preindustrial climate like Earth had in the year 1750.¹³ Between 2000 and 2018, an average of 490,000 persons died each year worldwide from excessive heat.¹⁴ During the years of this modeling study, average global temperature increased by 0.26 °C, and heat deaths increased by 0.21%. As global heating progresses, it is likely that mortality from heat exposure will rise steeply.

There is a close relationship between global heating/climate destabilization and air pollution. Fossil fuel combustion is the dominant cause of global heating and the principal cause of air pollution.² Each year, about 4 million people worldwide die prematurely from this outdoor (not household) air pollution.^{15,16} Nanoparticles from fossil fuel combustion accumulate not only in human lung tissue, but also brain, heart, and placental tissues.¹⁶⁻¹⁹ These deposits may explain, in part, why fossil fuel pollution causes lung cancer, increased susceptibility to pulmonary infections, myocardial infarction, stroke, preterm birth, low birth weight, and exacerbations of asthma and chronic obstructive pulmonary disease.²⁰ Reducing climate change helps everyone, regardless of age, by reducing air pollution.

Table 1 lists health effects of global heating/climate destabilization. Because of the complex relationships between health and changes in Earth's ecosystem, it may not be possible to anticipate all of the health problems caused by global heating. For example, the relationship between heat exposure and kidney disease has been recognized only recently. Table 2 describes some boundaries of Earth's ecosystem. A boundary is a warning that the Earth system is approaching a tipping point. The IPCC defines a tipping point as a critical threshold in the Earth system that, when

exceeded, can lead to a significant and possibly irreversible change in the state of the system.⁷ Crossing a boundary reduces the Earth's ability to sustain life. The climate boundary—thought to be 350 parts per million (PPM) of carbon dioxide (CO₂) in the atmosphere—already has been exceeded. Not only is it important to stop increasing the atmospheric concentration of CO₂, but it may be necessary to reduce it from the current value of 420 PPM to 350 PPM to preserve a healthy planet. The documentary film entitled *Breaking Boundaries* with David Attenborough and Johan Rockstrom explains all of the known Earth ecosystem boundaries, including climate change.¹⁰

Human influence is the dominant cause of global heating.⁹ Human actions cause climate change by releasing greenhouse gases into the atmosphere as a result of fossil fuel extraction and combustion and industrial forms of agriculture. The major greenhouse gases responsible for global heating today are CO₂, methane (CH₄), and nitrous oxide (N₂O). To limit global heating to 1.5 °C, greenhouse gas emissions would probably have to be reduced to zero by 2050.^{9,10}

HOW GREENHOUSE GASES HEAT EARTH

The amount of energy at Earth's surface determines its climate;⁹ increase the energy and the climate becomes hotter and storms become more powerful. The energy balance of the Earth as a whole is determined by the difference between incoming and outgoing energies at the top of the atmosphere. The greenhouse effect increases a planet's surface temperature by reducing the rate at which the planet loses energy to outer space. This is similar to adding insulation to your home to increase inside temperature without requiring more energy from the furnace.

The atmosphere contains a continuous stream of heat (infrared energy) moving from the Earth's surface to outer space because outer space is colder. Greenhouse gas molecules absorb and emit some of this infrared energy, sequestering heat in the atmosphere and causing Earth to warm.^{21,22} Some molecules with 3 or more atoms like CO₂ and CH₄ can absorb and emit infrared energy. Molecules that have the ability to absorb infrared energy usually have an uneven distribution of electrical charge called a dipole within the molecule. Absorption of infrared energy changes the position of the dipole within the molecule. Later, when the infrared energy is emitted, the dipole returns to its former position. This dipole shift is called a vibration. Infrared energy causes vibrations of greenhouse gases in the atmosphere. A greenhouse gas molecule absorbs and later emits a unit (photon or quantum) of energy. The fundamental problem is that the direction of the emitted photon is random. The movement of the photon towards outer space is likely to be lost. This greenhouse gas effect becomes harmful to organisms—as it is now—when greenhouse gas concentrations increase and cause rapid global heating. This is because the more greenhouse gases in the atmosphere, the greater the amount of sequestered infrared energy.²¹ Human activities, particularly fos-

Table 1. How Climate Destabilization Affects Human Health

Health Problem	Explanation	Ref
Mental health problems	Observing and hearing about the decline of the natural world; loss of home or occupation from weather disasters; may lead to stress, fear, despair, and other mental health problems.	25
Heat-related illness and death	Hyperthermia is a loss of internal body temperature regulation caused by heat exposure. Heat stroke is hyperthermia plus central nervous system dysfunction, such as fainting, seizure, or coma. Heat stroke may be fatal.	7
Heat-related chronic kidney disease	Uncertain etiology; related to manual labor, dehydration, and extreme heat; particularly affecting outdoor workers in tropical climates.	24
More vector-borne disease	Ticks and mosquitoes migrate towards the poles and to higher altitudes as temperatures warm and summer is longer: eg, malaria, dengue, Lyme disease, West Nile encephalitis, zikavirus, Powassan virus.	8
Threats to sources of fresh water	Drought, mountain glacier loss, toxic blooms, floods, exhaustion of underground aquifers, salt water contamination of coastal aquifers.	25
Reduced agricultural harvests caused by heat, drought, floods, ground-level ozone	Declines in production of maize, wheat, rice, soybeans resulting in food scarcity as global heating continues.	25
Declining air quality	Higher temperatures cause more ground-level ozone. There is more particle pollution from wildfires causing respiratory and cardiovascular disease.	7
Displacement of human populations (forced migration)	Sea level rise, extreme heat, drought, and reduced food harvests force people to leave their traditional homes, increasing geopolitical instability.	11
Possible conflicts over fresh water and other essential resources	Rivers, lakes, and glaciers at national boundaries may be disputed as fresh water resources diminish.	11
Declining seafood harvests due to ocean heating and declining ocean pH	Ocean and lake heatwaves and acidification of water by carbonic acid killing marine life. Since 1899, ocean pH has declined by 0.2 while ocean temperature has increased by 0.9°C.	6
Toxic blooms of microorganisms in lakes and oceans	Warming lake and ocean waters contaminated by nitrogen and phosphorous from fertilizer, manure, or sewage cause rapid growth of microorganisms, reduce fresh water availability, and kill marine life.	7
Floods in some areas	Higher water vapor concentrations in the atmosphere cause heavier rainfall in some places, contamination of drinking water by infected or poisoned flood waters, and infrastructure damage.	7
More powerful tropical storms, more precipitation per storm	Warmer ocean waters provide more energy to storms, causing destructive coastal hurricanes and damage infrastructure.	25
Sea level rise	Caused by thermal expansion of water and melting of glaciers on land (loss of Greenland and Antarctic ice sheets and glaciers everywhere).	7
Drought, expansion of desert terrain	In some areas, rainfall does not increase with temperature, causing hot drought (US West megadrought) and reduced crop harvests due to heat and insufficient water.	7
Increase in poverty	Repeated and extensive weather catastrophes and forced population migrations exhaust resources.	8
More water-borne infectious diseases due to floods, warmer ocean and lake water	As waters warm, bacterial populations increase; eg, <i>Vibrio</i> bacteria in salt water causing cholera, gastroenteritis, necrotizing fasciitis.	8

Table 2. Examples of Planetary Boundaries^{26,27}

Boundary ^a	Description	How Boundary Relates to Health
Climate change	Caused by greenhouse gas emissions into atmosphere, resulting in a hotter Earth with more extreme weather events.	Boundary exceeded – rapid global heating and climate destabilization. Return [CO ₂] in atmosphere to 350 PPM.
Biogeochemical flows	Excessive use of synthetic fertilizer causing release of nitrogen and phosphorous into bodies of water.	Toxic blooms when water is warm enough – dead zones in oceans and lakes – boundary exceeded in some locations, such as mouth of Mississippi River.
Freshwater use	Using more fresh water than natural systems can produce, water pollution by human activities and floods	Insufficient water for drinking and agriculture.
Land-system change	Loss of tropical, temperate, and boreal forests caused by clearing for farming, logging, and wildfires	More rapid global heating; less CO ₂ removed from atmosphere by trees.
Loss of biosphere integrity	Biodiversity loss due to deaths of plants and animals	Reduced plant and animal populations; mass extinctions.
Ocean acidification and heating	CO ₂ in atmosphere dissolves into ocean water forming carbonic acid, reducing pH of water. As oceans warm, O ₂ concentrations decline.	Mass extinctions of marine life, loss of coral reefs, reduced seafood harvests.

Abbreviations: CO₂, carbon dioxide; PPM, parts per million; O₂, oxygen.

^aNot all boundaries are listed. A boundary is a warning of a massive global shift that may be difficult to undo. These global catastrophes are often called “tipping points.” Crossing planetary boundaries reduces the ability of Earth to sustain life.

oil fuel extraction (CH₄), combustion (CO₂), and application of synthetic fertilizers (N₂O), increase greenhouse gas concentrations in the atmosphere and ocean. Each year about 35 billion tons of CO₂ and 120 million tons of CH₄ are released by human actions. Water vapor is also a greenhouse gas, as it can absorb infrared energy, but human activities do not directly add water vapor to the atmosphere. However, local increases in water vapor concentrations in the atmosphere are an indirect result of human greenhouse gas emissions and amplify global heating (see below).

CLIMATE DESTABILIZATION TOPICS THAT MAY BE HELPFUL IN CONVERSATIONS

Solvable

Possibly the single most important point about climate change is that we can solve the problem by reducing atmospheric greenhouse gas concentrations. We can stop burning fossil fuels for energy, and we can actively remove CO₂ from the atmosphere using natural means (trees, soil restoration, ocean, and land preservation) and sophisticated machines that capture CO₂. Efforts to reduce greenhouse gas emissions usually also reduce air pollution from toxic chemicals.

Military

The US Army War College issued a report on climate change.¹¹ Although not intended as a medical report, health considerations occupy an important place in the report. Military strategists worry that global heating worsens existing national security threats by causing geopolitical instability and forced migrations of human populations. There may be displacement of tens of millions of people from the Middle East and Africa due to extreme heat and agricultural collapse. In the future, regions of the planet may become unfit for human habitation, leading to mass migrations on a scale not yet seen. The populations of Pakistan, India, and China depend on Himalayan glaciers for fresh water, creating a potential for dispute. Access to potable water could become a political threat or a weapon of war. Climate change can diminish access to resources, such as food or water, which, in turn, can increase the possibility of conflict.

US Army War College report summary:¹¹

- The US military is “precariously unprepared” for climate change.
- Climate change is likely to worsen in coming years.
- Sea level rise, food and water insecurity, and extreme weather events may displace tens of millions of people worldwide.
- Military personnel must provide more humanitarian assistance as weather disasters increase.
- As temperatures increase, military personnel require more water when deployed.
- There are more cases of heat stroke and tropical diseases.
- There are more summer power grid failures as increased demand confronts aging infrastructure.

- Sea level rise affects US coastal and island military bases.
- There is a need for military environmental stewardship and greater energy efficiency.

Methane and Natural Gas

Methane emissions are a special problem caused in part by extraction and combustion of natural gas. Sometimes called “methane gas,” natural gas consists of a mixture of organic gases with methane as a major component. During gas extraction, transportation, and use, methane enters the atmosphere. CH₄ is more effective at retaining heat than CO₂ and is responsible for about 15% to 20% of global heating today.²⁸ It is just as necessary to reduce CH₄ emissions to mitigate climate change as it is to reduce CO₂ emissions. Natural gas use causes less toxic air pollution than coal or oil combustion but emits too much greenhouse gas to be compatible with a healthy future.

Amplifiers of Global Heating

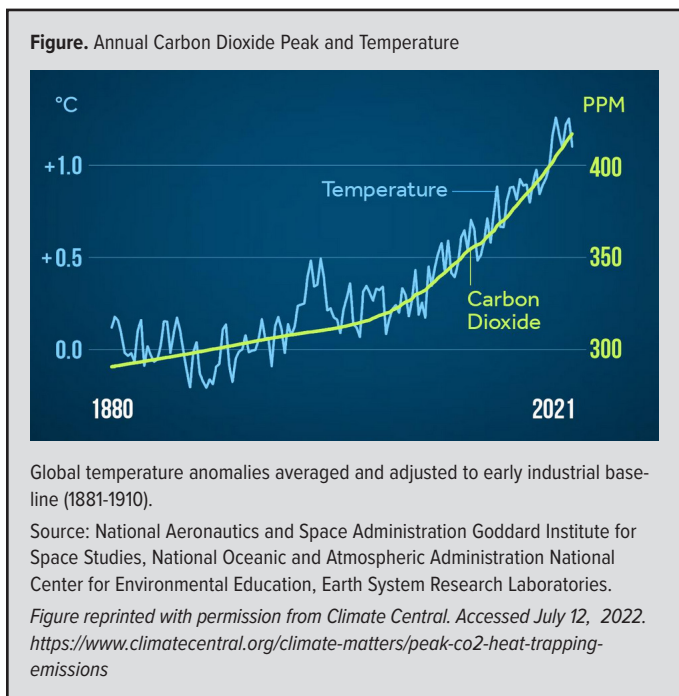
Particular events tend to amplify global heating.

- When ice melts and exposes water or land, less sunlight reflects back to space and more heat is retained on Earth, because ice reflects sunlight while water and ground absorb it. Melting of the Arctic Ocean during summer increases heat accumulation in the Arctic by exposing more water to sunlight. This may explain why the Arctic is heating up faster than tropical and temperate regions.
- Melting of permafrost in the Arctic releases frozen CO₂ stored in the ground, adding extra CO₂ to the atmosphere.
- Increased Earth temperatures permit higher average water vapor concentrations. Since water vapor is a greenhouse gas, this leads to more heating.
- Global heating causes more wildfires, which, in turn, cause deforestation, which, in turn, accelerate global heating by impeding CO₂ removal by trees. In recent years, wildfires have been a destabilizing force in the United States, Russia, and Australia.

Because of these amplifiers, climate destabilization may progress more rapidly than predicted in some climate models.

Oceans and Lakes

Oceans and lakes face two different threats from CO₂ emissions: heating and acidification. Presently, about 30% of CO₂ emissions dissolve into water. Some of the absorbed CO₂ reacts with water to form carbonic acid (H₂O + CO₂ → H₂CO₃ → H⁺ + HCO₃⁻), causing pH to decline. This extra acid makes it more difficult for marine organisms to form calcium carbonate skeletons and is directly harmful to organisms with shells. In addition, oceans and lakes become hotter as Earth becomes hotter. As ocean and lake waters warm, oxygen becomes less soluble and oxygen concentrations in water decline. The combination of lower oxygen concentrations, acidification, and heating is more harmful to marine life than any one factor alone. The Great Barrier Reef north of



Australia—the largest shallow water reef system in the world and home to approximately a million marine species—already has lost half its corals.⁷

Hunger

Global hunger and undernutrition are expected to increase because of climate destabilization. Tropical and subtropical farmers will experience greater difficulty growing crops due to heat and drought. While farmers in northern latitudes may experience a longer growing season and higher yields, the net effect is expected to be an agricultural decline. The IPCC has predicted an 8% to 14% reduction in corn production at 2°C (3.6°F) of warming.⁷ If this warming occurs, central Europe, the Mediterranean and Amazon regions, and most of Africa are expected to experience more hunger and undernutrition, while drought may reduce farm yields in the western US.⁷

Literature

The novel *Never Let Me Go* by Kazuo Ishiguro is a science fiction story about adolescents becoming aware of terrible information that their adult caregivers are trying to conceal.¹² This tale may offer insight into how a 10- or 12-year-old child may perceive climate change as they hear information fragments from different sources. This is a powerful story read from a climate change perspective and may be easy to bring into a conversation.

QUICK ACCESS TO CLIMATE DATA

During a conversation, finding weather data quickly and easily may be helpful, but these data are vast and may require specialized knowledge to locate. One site that permits easier and faster searches is www.climatecentral.org. The climate scientists and

Box. Suggested Talking Points About Health and Climate Change^a

- Global heating-climate destabilization directly affects human health. (See Table 1)
- Crossing boundaries diminishes Earth's ability to sustain life. (See Table 2)
- Greenhouse gases heat Earth by absorbing and emitting photons of infrared energy trapping them in the atmosphere.
- Climate change causes geopolitical instability and population migration
- Individual choices can lessen global heating.
- National and international cooperation can curtail global heating.
- Particulate air pollution accumulates in the human body.
- The climate crisis can be solved by drastically lowering fossil fuel combustion.
- Some factors such as reduced ice cover speed up global heating.
- Acidification and lower oxygen concentrations in oceans and lakes reduce seafood harvests.
- Extreme heat, droughts, and floods reduce agricultural harvests.
- Literature may address global heating-climate destabilization in ways that are more powerful than science.

^aAlthough disparate, these messages are all about human health.

meteorologists who maintain this website have tried to create a user-friendly site for nonspecialists.

To search for a temperature change in a particular city, click on “resources,” then “graphics,” then type in the name of the city. The website provides the state. When you click on the state, the website repeats the city name. Click on the city name and graphs of data from that city appear below. Graphs are labeled and easy to understand.

To search for information on weather disasters or climate science, go to “resources,” then “graphics,” then “search for topics.” Click on a topic and related graphs appear below.

To search by keyword, go to “resources,” then “graphics,” then “keyword” and enter your word. Related graphs will appear. The figure is an example of a climate central graph of Earth temperatures and atmospheric CO₂ concentration over time.

ACTIONS TO MITIGATE CLIMATE CHANGE

Acting as an individual²⁸

- Use your vote to protect children.
- Reduce personal carbon emissions (see below).
- Study climate change, talk about the weather.
- Create an emergency plan and kit (planning varies by location, prepare for floods in Wisconsin).
- Participate in or donate to an organization that advocates for climate stability.
- Plant a garden or trees

Reducing personal carbon footprint^{30,31}

- Avoid flying.
- Reduce driving and/or drive a high gas mileage or electric vehicle.
- Use and support investment in public transportation.
- Bike or walk when possible.

- Choose renewable energy whenever possible.
- Eat less beef or, if possible, eat grass-fed beef.
- Use light emitting diode (LED) light bulbs.
- Replace old appliances at the end of their lifecycle with Energy Star appliances.
- Weatherize your home.

Global and national goals to mitigate climate destabilization³²⁻³⁴

- Produce electric trucks, buses, cars, and ships.
- Build electrically powered buildings.
- Restore topsoil with cover crops and reduced tillage; use less synthetic fertilizers.
- Raise grass-fed, rather than crop-fed, animals.
- Protect half of the oceans and land as nature sanctuaries.
- Produce all plastic to be recycled/no single-use plastic.
- Reduce CO₂ emissions from steel and cement production.
- Remove greenhouse gases from the atmosphere by both natural means (forest, land, and soil restoration) and engineering methods (carbon capture and storage).
- Maintain a stable (not increasing) human population.

CONCLUSIONS

The key message about health and climate change is that a drastic reduction in the burning and mining of fossil fuels solves the problem. Otherwise, the health of people will suffer from agricultural and seafood declines, geopolitical instability, lack of potable fresh water, and heat and weather extremes. Droughts and floods are expected to be a frequent manifestation of climate breakdown, more powerful cyclones will probably destroy infrastructure and create enormous expense, and heat waves will likely cause many human deaths. On the other hand, everyone would live a healthier life in a world that has a clean energy economy.

Sadly, the cumulative emissions of greenhouse gases are a key factor in determining the health and quality of life today and for future generations. Preserving as much climate stability as possible reduces the health effects of global heating, air pollution, and ocean acidification. This can be accomplished with drastic reductions in atmospheric greenhouse gas concentrations. It may not seem like one person can make a difference; however, discussing climate change may be one way an individual can address the climate crisis. Although lives are busy, climate and health conversations are possible. It is also possible that taking action to reduce the climate crisis will reduce one's personal fear about climate destabilization. Action has been called the antidote to despair.

Health care providers are among the trusted voices in our society and can be an effective voice for children and future generations. Consider talking about the scientific consensus on climate change and why scientists and physicians have recommended drastic reductions in greenhouse gas emissions. Swedish environmental activist Greta Thunberg, who started school strikes for climate, says that no one is too small to make a difference.³⁵

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