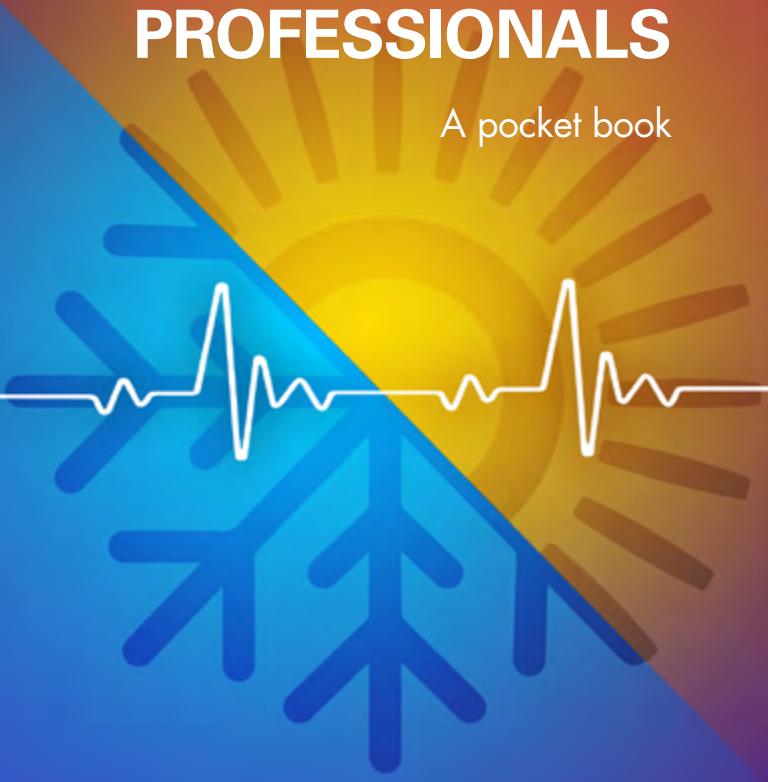
CLIMATE CHANGE FOR HEALTH PROFESSIONALS

A pocket book



PAHO Pan American Health Organization
World Health Organization Americas

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Climate Change for Health Professionals: A Pocket Book

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FOREWORD

The Pan American Health Organization is pleased to present the *Climate Change for Health Professionals: A Pocket Book*. An increasing body of evidence shows the impacts of climate change on health—for example, by changing the spatial and temporal distribution and prevalence of climate-sensitive diseases, by increasing extreme heat and the magnitude and frequency of meteorological events, by causing stress and mental health disorders, by increasing the vulnerability of persons with pre-existing conditions, among others. Managing health risks amidst climate change effects will require that health systems are able to anticipate, prepare, and quickly respond to and recover from existing and new challenges posed by climate change.

This pocket book offers critical information to enable clinical health care providers to recognize medical conditions related to climate change, at the point of delivery. *Climate Change for Health Professionals* is intended to contribute to the daily practice of clinical professionals. It offers up-to-date, evidence-based information on clinical and epidemiological aspects, and prevention measures to confront conditions associated with meteorological risks. This pocket book is not meant to be a substitute for classic references of clinical diagnostics and treatment; instead, it is intended as a quick-reference guide to inform decisions in the context of climate change. Moreover,

this clinical companion can be used to introduce the topic in medical curricula and continuing medical education programs.

Through this most recent addition to the PAHO literature on climate change and health, we hope clinical and other health professionals can increase knowledge about the subject and apply this knowledge in health care services. Identifying health conditions potentially related to climate change will improve patient care management and safety, the surveillance and reporting of climate-sensitive diseases, and increase the capacity of health systems to anticipate and better prepare to provide continued high-quality health services in a rapidly changing-climate world.

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PRESENTATION

This pocket book contains information that will enable physicians and clinicians to recognize the impact of meteorological risks stemming from climate change in their daily practice. It is structured to provide access to up-to-date and concise information that is specific to each clinical area.

The effects of climate change on human health are already being felt throughout the world. Scientific research offers empirical data demonstrating the unequivocal link between climate change, meteorological risks, and health. Many medical conditions, in fact, are the product of exposure to intense heat, storms, droughts, or floods. These conditions, however, are usually nonspecific and their pathophysiology is not evident. Recognizing them requires taking an adequate patient history that includes questions about the potential involvement of meteorological risks. Furthermore, it is known that the side effects of certain medications can exacerbate these conditions. If clinicians are able to identify these conditions and side effects, they can provide better treatment and advice and determine their potential impact on the health services.

The introduction briefly describes the complex mechanisms by which climate change impacts human health, as well as the role of clinicians, public health professionals, and health sector authorities. It also offers guidance on how to use this pocket book in order to maximize patient care.

The first 10 sections summarize the pathophysiology of certain diseases attributable to meteorological risks, classified by clinical area:

CARDIOVASCULAR DISEASES
RESPIRATORY DISEASES
KIDNEY DISEASES
EYE DISEASES
SKIN DISEASES
VECTOR-BORNE AND ZOONOTIC DISEASES
GASTROINTESTINAL DISEASES
NEUROLOGICAL DISORDERS
MENTAL HEALTH DISORDERS
MATERNAL AND PEDIATRIC DISORDERS

The next section, which discusses the factors that modulate the impact of climate change, describes the factors that influence the effects of climate change on health and health services.

The last section, which contains advice for patients and the community, offers recommendations and guidance for reducing exposure to meteorological risks and community collaboration to address climate change.

INTRODUCTION

LINK BETWEEN CLIMATE CHANGE AND HEALTH

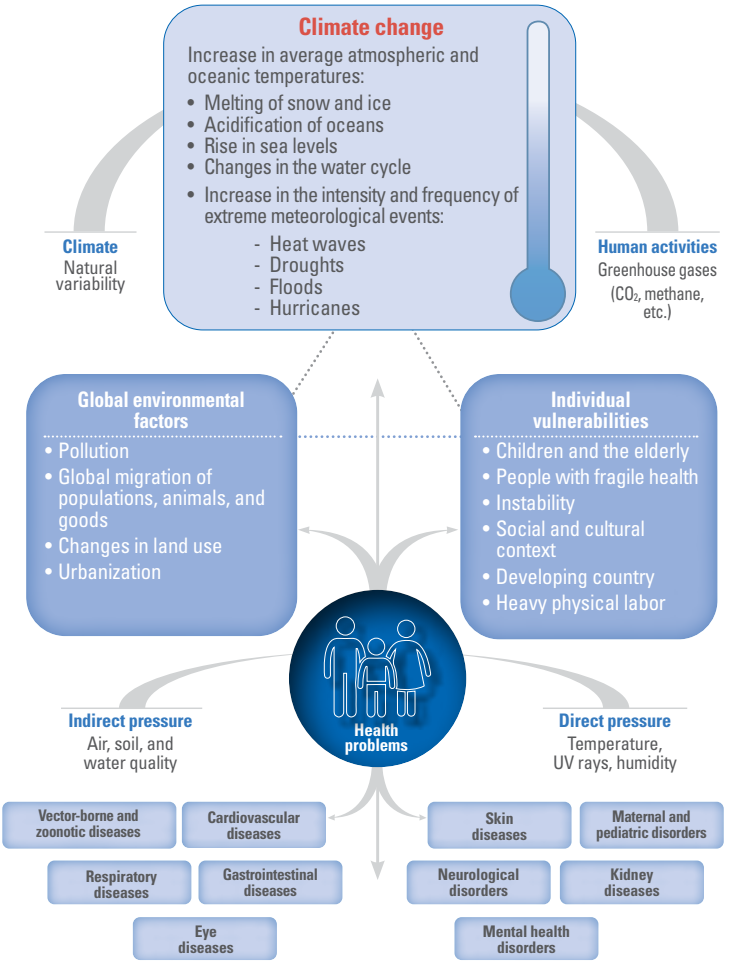
Climate change is a term used to describe complex climate phenomena caused primarily by excessive concentration of greenhouse gases (GHGs) in the Earth's atmosphere. Carbon dioxide, methane, nitrous oxide, and ozone are the primary GHGs. The concentration of these gases in the atmosphere has risen since the 1850s, and today, their concentration is the highest recorded in 800,000 years (IPCC, 2013). This sharp increase is attributed primarily to human activities, such as the burning of fossil fuels, industrial processes, and activities associated with land-use (agriculture, forest burning, and deforestation, which diminish the capacity of ecosystems to absorb these gases).

GHGs trap the heat from the sun reflected on Earth, and when it reaches excessive levels, it causes global warming and ocean acidification (IPCC, 2013). Atmospheric and oceanic warming alters various natural systems, seen in shifting rain patterns and distribution, glacial melting, and changes in the behavior and ecology of species and ecosystems. These, in turn, can lead to rising sea levels, droughts, floods, and heat waves, and changes in the distribution and behavior of vectors and pathogens (see Figure 1). These complex factors directly and indirectly affect human health, especially that of the most vulnerable people (OPS, 2017).

Medical conditions caused by extreme meteorological events, such as floods and hurricanes, are often associated with physical trauma, such as injuries or accidental deaths, but physical trauma represents only a fraction of the health impact of climate change. In reality, most of the impact is due to non-traumatic conditions such as cardiovascular, respiratory, kidney, and vector-borne diseases, mental illness and psychosocial problems (see Figure 1).

Most of the effects of climate change on health are the product of complex mechanisms that attack virtually every organ and system in the human body–for example, gastroenteritis due to water pollution in the wake of heavy rains or floods, an increase in vector-borne diseases due to more favorable conditions for the survival of the pathogen or vector, an increase in cardiovascular disease in response to thermal stress from heat waves, or the psychosocial problems associated with the emotional and social burden stemming from loss of loved ones or employment. Climate change can also worsen an existing situation and make already vulnerable people and communities even more so (see Figure 1).

FIGURE 1. CLIMATE CHANGE AND ITS IMPACT ON HEALTH



Source: Adapted from Pierrefixe (2015).

KEY ROLES IN PROTECTING HEALTH FROM CLIMATE CHANGE

ROLE OF CLINICIANS

This pocket book is intended for healthcare providers and will enable them to:

- Identify medical conditions attributable to climate change.
- Recognize the potential side effects of medications that can exacerbate conditions attributable to climate change and adjust their dosage accordingly.
- Modify procedures for the care and monitoring of patients' health, taking increased risks into account; for example, more frequent hydration, temperature-taking, modification of diet, etc.
- Be aware of available information on early warnings of climate and meteorological events and predictions of outbreaks of climate-sensitive diseases and preparing for them.
- Identify the people most exposed or most sensitive to climate change and give them appropriate advice for reducing or preventing adverse impacts on their health.
- Be available during an extreme weather event to ensure the continuity of health services.
- Participate in continuing education programs to understand the complex relationship between climate change and health.

ROLE OF PUBLIC HEALTH PROFESSIONALS

Public health professionals should be familiar with the empirical data on people's sensitivity and exposure to climate change and the most appropriate interventions. Thus, public health professionals can:

- Educate the population on how to prevent climate change from affecting people's health.
- Conduct epidemiological surveillance of climate-sensitive diseases, such as certain vector-borne diseases (e.g., malaria, dengue, Lyme disease), communicable diseases (e.g., leptospirosis), heat illnesses, asthma, skin cancer, chronic kidney disease of nontraditional etiology (CKDnT), etc.
- Set up warning systems for extreme weather events and the early detection of disease outbreaks, prepare intervention and public awareness plans, and identify the groups at highest risk.
- Prioritize groups that are at risk or do not seek health services for a variety of reasons (limited access, drug addiction, exclusion, migration, etc.) to inform them, using mass media, about the risks associated with climate change and preventive measures.
- Organize epidemiological surveillance (of physical and mental health) following extreme weather events.
- Monitor the physical and mental health of affected populations.
- Collaborate with scientific research aimed at gaining a better understanding of the causes of the health effects of climate change and developing effective prevention measures.
- Lobby government and municipal authorities about the possibility of lowering risks through prevention (urban reforestation, protection of coastal areas, restrictions in flood-prone areas, etc.) and better preparedness for weather emergencies.

ROLE OF HEALTH SECTOR AUTHORITIES

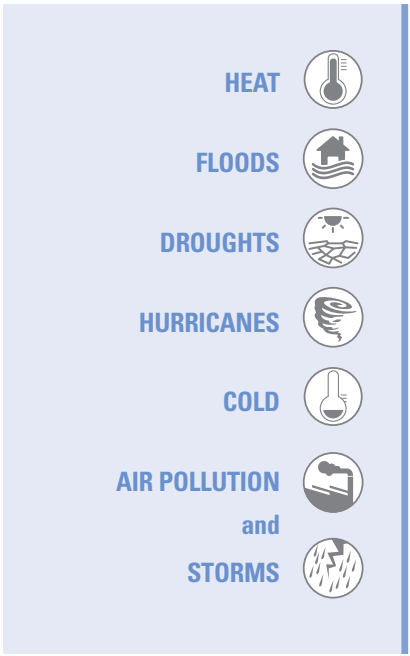
The health authorities, in coordination with the other sectors involved (civil defense, municipal, etc.) should:

- Prepare the health services to adapt to an increasingly hotter climate through creating suitable settings for patient care in hospitals and medical offices, decent working conditions for health professionals, etc.
- Guarantee the continuity of health services during extreme weather events, with emphasis on each risk group.
- Ensure that health facilities are adequately prepared to respond to a higher demand for services: available personnel, emergency rooms, operational health facilities, access to medicines, etc.
- Reduce health sector production of greenhouse gases by evaluating health and parking facilities, internal food procurement processes, energy and transportation use, recycling and use of material resources, supply circuits, employee transportation, etc.

HOW TO USE THIS POCKET BOOK

This book was designed for use by clinicians in their daily practice. Its purpose is to provide information that will enable them to quickly recognize diseases likely related to the meteorological risks associated with climate change, and thus, to provide adequate treatment and advice to exposed populations. The main source of data and references for this pocket book is Bélanger et al. (2019).

The meteorological risks covered in this pocket book are:



The diseases that can be influenced by climate change and climate variability are discussed and organized by clinical area:

- Cardiovascular diseases
- Respiratory diseases
- Kidney diseases
- Eye diseases
- Skin diseases
- Vector-borne and zoonotic diseases
- Gastrointestinal diseases
- Neurological disorders
- Mental health disorders
- Maternal and pediatric disorders

Each section deals with a particular clinical area and contains information on the pathophysiology of the diseases, which are listed in order of severity, from least serious to most serious. The side effects of certain medications and some empirical data are also indicated. This guide is intended as a quick reference for clinicians who need to ascertain whether a patient's illness is related to climate change so that they can choose the right diagnostic tests or treatment. It should be noted that the list of diseases presented is not necessarily exhaustive.

The information on the pathophysiology of diseases attributable to climate change concisely explains the known or probable physiological mechanisms of the signs and symptoms involved. The pathophysiology information provided is not meant to replace a medical textbook, but to provide a quick overview of the mechanisms involved to facilitate clinicians' decisions in their specialty. Furthermore, since the information is presented by clinical area and not by disease, health professionals wishing to know the pathophysiology of the same disease in other

clinical areas can consult the other sections. For example, heatstroke triggers not only cardiac symptoms but neurological, respiratory, and renal symptoms as well.

With regard to the side effects of certain medications, the information in some cases describes how their pharmacokinetics can be altered by climate, especially heat. In most cases, however, the risks associated with certain medications are due to their administration during weather events, not changes in their pharmacokinetics. In fact, the known side effects of certain medications–for example, diuretics and hypotension–can be more dangerous if they continue to be administered without adjustment during a heat wave, which is also associated with hypotension. The purpose of this information is to remind clinicians that many of the medications that are routinely used can exacerbate certain diseases linked with climate change. It is very important to bear this in mind and adjust their dosage, if necessary.

The examples presented on the results of scientific research provide empirical data that demonstrate the association between the diseases and climate change. Although the data are not exhaustive, the authors have tried to provide adequate, relevant, and up-to-date information. Thus, interested clinicians are given access to basic scientific information and can continue their search for other publications.

The last two sections present the theory explaining the factors that modulate the health effects of climate change, such as the fact that some people are more prone to exposure or more sensitive, and a list of advice for patients and communities to enable them to protect their health and address climate change.

CARDIOVASCULAR DISEASES

PATHOPHYSIOLOGY OF CARDIOVASCULAR DISEASES IN RELATION TO CLIMATE RISKS

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN CARDIOLOGY

EMPIRICAL DATA

PATHOPHYSIOLOGY OF CARDIOVASCULAR DISEASES IN RELATION TO CLIMATE RISKS

When exposed to climate risks such as heat or cold, the human body activates compensatory physiological mechanisms to protect itself from the effects of such exposure. These mechanisms can affect the cardiovascular system. *Note:* the list of diseases provided below is not exhaustive.

TACHYCARDIA

HEAT

The heart rate increases and blood vessels expand to increase cutaneous circulation and lower the body's temperature through sweat. One of the undesirable side effects is that this process intensifies and produces an episode of *heatstroke* that lapses into tachycardia.

FLOODING DROUGHT HURRICANES

The sympathetic nervous system also increases the heart rate, given the mental stress and anxiety associated with these meteorological phenomena. Moreover, the physical activity necessary to protect oneself from these phenomena (moving heavy objects, running, etc.) or cleaning up in the aftermath are very demanding and likewise raise the heart rate.

COLD

Cold also causes stress in the human body. Contrary to what occurs with heat exposure, to maintain body temperature, the sympathetic nervous system increases the heart rate and decreases cutaneous circulation to prevent heat loss.

HYPERTENSION

FLOODING DROUGHTS HURRICANES

The acute stress caused by these phenomena activates the sympathetic nervous system and raises blood pressure. When stress is chronic, sleep alteration also occurs, increasing the risk of hypertension. Likewise, the activities necessary to protect oneself from these phenomena (moving heavy objects, running, etc.) or cleaning up in the aftermath can elevate blood pressure.

COLD

Cold activates not only the sympathetic nervous system but the renin angiotensin system, which also elevates blood pressure.

HEAT

In a heatstroke, the first thing that happens is transient hypertension mediated by the sympathetic nervous system and activation of the renin-angiotensin system to minimize urinary fluid loss generated by the increased heart rate and blood flow. The resulting tachycardia also elevates blood pressure in untreated or vulnerable people.

HYPOTENSION

HEAT

The perspiration and vasodilation caused by prolonged heat exposure result in hypovolemia, lowering blood pressure. Vasodilation leads to fluid retention in the extravascular spaces, resulting in edema in the lower limbs. Furthermore, receiving less blood due to vasodilation, the kidneys are unable to retain salts and fluid normally, resulting in greater hypotension. Hypotension is a typical sign of *heatstroke*.

SYNCOPE

HEAT

This is the next step after *heatstroke* and occurs with inadequate control of hypotension. It can lead to loss of consciousness, or syncope, due to inadequate blood flow to the brain.

CARDIAC ARRHYTHMIA

HEAT

The hyperkalemia from severe heat-related dehydration may cause ventricular arrhythmias. During a heat wave there may also be significant potassium loss through sweat or excessive hypotonic fluid intake, with hypokalemia potentially causing arrhythmias, especially at the start of *heatstroke*.

AIR POLLUTION DROUGHT

During a heat wave or wildfires caused by drought, the particulate matter and ozone in the air can increase. The interaction between inhaled contaminants and receptors in the lungs can cause certain changes in the autonomic nervous system, which may trigger alterations in the heart rate.

HEART FAILURE

HEAT

When the heart rate increases, it creates an overload that can trigger heart failure in the elderly or people with chronic heart disease. Furthermore, high body temperature can damage the vascular endothelium and result in coagulation and fibrinolysis that can lead to blockage of the arterioles and capillaries and the collapse of certain organs, including the heart. Likewise, during a heat wave, cutaneous circulation increases while intestinal circulation decreases. This

weakens the intestinal epithelial membrane and allows bacteria and toxins to penetrate the intestinal lumen and pass into the bloodstream; this can trigger systemic inflammatory response syndrome (SIRS), which can lead, among other things, to heart failure. Finally, it should be pointed out that hyponatremia (e.g., which occurs with excessive intake of hypotonic fluids during hot weather) substantially increases the risk of death among people with heart failure. However, it is a relatively rare phenomenon.

 FLOODING  DROUGHT  HURRICANES

The chronic stress experienced by people exposed to these phenomena can lead to SIRS and heart failure.

 AIR POLLUTION  DROUGHT

Inhaling fine particulate matter can trigger an inflammatory vascular and pulmonary reaction and generate SIRS leading to heart failure.

ANGINA PECTORIS AND MYOCARDIAL INFARCTION    

 HEAT COLD

Both increase the heart rate and lead to hemoconcentration and the appearance of arteriosclerotic plaque, thus increasing the risk of coronary arteriosclerosis.

 AIR POLLUTION  DROUGHT

SIRS may be the physiological mechanism that explains the relationship between fine particulate matter and myocardial infarction.

CARDIOMYOPATHY 

 COLD

The levels of certain blood pressure and heart regulators can increase during exposure to cold and activate molecular mechanisms

that can lead to myocardial damage and hypertrophy and to cardiac dysfunction.

HEAT EXHAUSTION

HEAT AND HUMIDITY

People with heat exhaustion exhibit the following cardiovascular signs and symptoms: pallor, tachycardia, weak pulse, and orthostatic hypotension. The leading cause is severe dehydration from heat and inadequate fluid exchange. People with heat exhaustion have a rectal temperature below 40 °C (104 °F) without neurological impairment. Without timely treatment, heat exhaustion can turn into heatstroke.

CARDIOVASCULAR SIGNS AND SYMPTOMS OF HEATSTROKE

HEAT

People with heatstroke exhibit cardiovascular signs and symptoms, such as tachycardia, hypertension and hypotension. An electro-cardiogram may show sinus tachycardia and prolongation of the QT interval. Polycythemia due to dehydration is not uncommon. Direct activation of blood platelets can produce microthrombosis. There may also be disseminated intravascular coagulation and excessive bleeding. Furthermore, people with heatstroke usually have cold skin, perspire profusely (classical heatstroke) or very little (exertional heatstroke) and experience fatigue, dizziness, headache and nausea. Neurological symptoms are very marked, while respiratory signs and symptoms and electrolyte disorders may be as well (see sections on *neurological disorders, respiratory diseases* and *kidney diseases*). All signs and symptoms of heatstroke are associated with poor thermoregulation leading to hyperthermia and SIRS. Without treatment to lower his/her body temperature, a person can have a rectal temperature of 40 °C (104 °F) or higher.

PATHOPHYSIOLOGY OF CARDIOVASCULAR DISEASES IN RELATION TO CLIMATE RISKS

<table>
<tr><th colspan="6">CARDIOVASCULAR DISEASES</th></tr>
<tr><th>Heat</th><th>Hurricanes</th><th>Flooding</th><th>Drought</th><th>Air pollution</th><th>Cold</th></tr>
<tr><td colspan="6">TAQUICARDIA</td></tr>
<tr><td>Increases cutaneous circulation.</td><td colspan="3">Activation of the sympathetic nervous system due to stress.
Increased physical activity.</td><td>Absent in the scientific literature</td><td>Activation of the sympathetic nervous system.</td></tr>
<tr><td colspan="6">HYPERTENSION</td></tr>
<tr><td>Mediated by the sympathetic nervous system and activation of the renin -angiotensin system.</td><td colspan="3">Acute and chronic stress.
Increased physical activity.</td><td>Absent in the scientific literature</td><td>Activation of the sympathetic nervous system and the renin -angiotensin system.</td></tr>
<tr><td colspan="6">HYPOTENSION AND SYNCOPE</td></tr>
<tr><td>Hypovolemia from perspiration and vasodilation.</td><td colspan="5">Absent in the scientific literature</td></tr>
<tr><td colspan="6">CARDIAC ARRHYTHMIA</td></tr>
<tr><td>Hyperkalemia from dehydration or hypokalemia from perspiration.</td><td colspan="2">Absent in the scientific literature</td><td colspan="2">Alteration of the autonomic nervous system.</td><td>Absent in the scientific literature</td></tr>
<tr><td colspan="6">HEART FAILURE</td></tr>
<tr><td>Overload, endothelial damage from heat, SIRS, or hyponatremia.</td><td colspan="2">SIRS from chronic stress.</td><td>SIRS from chronic stress and fine particulate matter.</td><td>SIRS from fine particulate matter.</td><td>Absent in the scientific literature</td></tr>
<tr><td colspan="6">ANGINA PECTORIS AND MYOCARDIAL INFARCTION</td></tr>
<tr><td>Sclerotic plaque from tachycardia and blood concentration.</td><td colspan="2">Absent in the scientific literature</td><td colspan="2">Unknown physiological mechanism
Possible SIRS.</td><td>Sclerotic plaque from tachycardia and blood concentration.</td></tr>
<tr><td colspan="6">CARDIOMYOPATHY</td></tr>
<tr><td colspan="5">Absent in the scientific literature</td><td>Molecular mechanisms and myocardial damage.</td></tr>
<tr><td colspan="6">HEAT EXHAUSTION</td></tr>
<tr><td>Dehydration</td><td colspan="5">Absent in the scientific literature</td></tr>
<tr><td colspan="6">CARDIOVASCULAR SIGNS AND SYMPTOMS OF HEATSTROKE</td></tr>
<tr><td>SRIS from hyperthermia.</td><td colspan="5">Absent in the scientific literature</td></tr>
</table>

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN CARDIOLOGY

The dosage of certain medications used in cardiology should be managed very carefully when administered during certain meteorological phenomena. For example, medications with diarrhea as a side effect can worsen the dehydration caused by a heat wave, and that dehydration, in turn, can alter the pharmacokinetics of the medication and intensify its side effects.

WARNING

- Each case should be assessed individually, since there is little available literature and medications can be an aggravating factor, although with no causal relationship.
- This list of medications is not exhaustive.
- Dehydration can generally alter the pharmacokinetics of any medication.
- Most of the information comes from pharmaceutical companies and very little from specific studies on meteorological phenomena and the use of medications.
- Side effects may only appear at the start of treatment.
- Side effects can be more serious in dependent elderly people (people who are bedridden or suffer from dementia, etc.) or people with chronic diseases or conditions treated with multiple medications.
- This list does not include medications whose physicochemical and pharmacological properties are altered when they are exposed to light (photosensitive medications).

DIURETICS

- Dehydration: the majority of diuretics.
- Hypotension and loss of consciousness: the majority of diuretics.
- Hyponatremia: loop-acting diuretics.
- Hypokalemia: loop-acting or thiazide diuretics.
- Hyperkalemia: potassium-sparing diuretics.
- Phototoxic or photoallergic skin reactions if the person is exposed to sunlight (UV rays): furosemide, torasemide.

ANTIARRHYTHMICS

- Dehydration from nausea and vomiting: amiodarone, quinidine, and procainamide.
- Hypotension in children: intravenous amiodarone.
- Hyperthermia due to heat loss: disopyramide.

CARDIOTONICS

- Dehydration from nausea and vomiting: clinical digitalis toxicity. Use of diuretics, coupled with heat-induced dehydration can result in acute and chronic digitalis toxicity.
- Hypertension: digoxin.

CALCIUM CHANNEL BLOCKERS

- Dehydration from nausea, vomiting, and diarrhea: amlodipine, bepridil, and diltiazem.
- Hyperthermia: nifedipine.
- Hypotension: nifedipine, amlodipine, felodipine, verapamil, and diltiazem.
- Phototoxic or photoallergic skin reactions if the person is exposed to sunlight (UV rays): amlodipine.

NITRATES

- Hypotension: isosorbide dinitrate.
- Dehydration from nausea and vomiting: isosorbide dinitrate.

AGENTS THAT ACT ON THE RENIN-ANGIOTENSIN SYSTEM

- Hyponatremia: angiotensin-converting enzyme (ACE) inhibitors.
- Hypothermia from peripheral thermoregulation impairment due to the reduction of peripheral vasoconstriction: ACE inhibitors and angiotensin-receptor antagonists (ARA) or angiotensin-receptor blockers (ARB).
- Phototoxic or photoallergic skin reactions if the person is exposed to sunlight (UV rays): enalapril, losartan.

BETA-BLOCKERS

- Hypotension: the majority of beta-blockers.
- Hyperthermia caused by reduced expansion of the cutaneous blood vessels, which diminishes the body's capacity to dissipate heat by convection: the majority of beta blockers.
- Dehydration from nausea, vomiting, and diarrhea: the majority of beta-blockers.

ORAL ANTICOAGULANTS

- Hypotension: warfarin.
- Dehydration from nausea, vomiting, and diarrhea: warfarin.
- Significant dehydration during a heat wave could theoretically alter the kinetics of the anticoagulant and lead to medicinal poisoning: the majority of anticoagulants.

ANTIPLATELETS

- Hypotension: acetylsalicylic acid, clopidogrel and acetylsalicylic acid in combination in dipyridamole.
- Dehydration from nausea, vomiting, and diarrhea: acetylsalicylic acid, clopidogrel and acetylsalicylic acid in combination in dipyridamole.
- Serious dehydration during a heat wave could theoretically alter the kinetics of antiplatelet medication and lead to medicinal poisoning: acetylsalicylic acid, clopidogrel and acetylsalicylic acid in combination in dipyridamole.

ALPHA BLOCKERS AND OTHER PERIPHERAL VASODILATORS

- Hypothermia from peripheral thermoregulatory impairment, as peripheral vasoconstriction is reduced: doxazosin, prazosin, terazosin.

HYPOLIPIDEMICS

- Phototoxic or photoallergic skin reactions if the person is exposed to sunlight (UV rays): simvastatin, lovastatin, atorvastatin.

EMPIRICAL DATA

HEAT

- The risk of hospitalization for myocardial infarction increases by 1.6% with each 1°C (1.8°F) increase in temperature (Sun et al., 2018).
- There is a clear association between heat and mortality from cardiovascular disease (Liu et al., 2015).
- Heat exhaustion is the most common heat-related condition and is not associated with signs of organic damage (Health Canada, 2011).
- In some 85% of people who experience heatstroke, their electrocardiogram shows alterations such as sinus tachycardia (40%-80%) and prolongation of the QT interval (60%) (Mimish, 2012).

Diuretics

- More than 30% of people whose health was affected during a heat wave in Australia and in France had been under treatment with diuretics and most were 70 years old or more (Faunt et al., 1995; Argaud et al., 2007).
- Hyponatremia in people with heart failure increases the risk of death by 40%-70% (Rusinaru et al.; 2012).

Antiarrhythmics

- Some 10%-26% of people treated with antiarrhythmics (amiodarone, quinidine, and procainamide) experience nausea and vomiting (Sinha et al., 1992; Nygaard et al., 1986).
- More than one third of children under 15 given intravenous amiodarone develop hypotension (Saul et al., 2005).

Digoxin

- Nearly 11% of elderly people (average age: 81) experience nausea and vomiting associated with clinical digitalis toxicity (Boman, 1983).

Calcium channel blockers

- Some 3%-22% of adults who receive diltiazem or bepridil develop nausea and diarrhea as side effects (Singh, 1991).
- Treatment with amlodipine for angina pectoris increases the prevalence of diarrhea by 6% and nausea by 5% (White et al., 2003).

Nitrates

- Taking isosorbide dinitrate is associated with a 56% prevalence of nausea and a 24% prevalence of vomiting (Kosoglou et al., 1995).

Agents that act on the renin-angiotensin system

- Taking angiotensine-converting enzyme inhibitors is closely associated with hyponatremia in the elderly (Passare, 2004).

Beta-blockers

- Almost all beta-blockers are associated with hypotension and gastrointestinal problems such as nausea, vomiting, and diarrhea (Blachère and Perreault, 2012).

HURRICANES FLOODING

- After the floods of Hurricane Katrina, victims showed a substantially higher prevalence of cardiovascular disease than did a control group (Jiao et al., 2012).

AIR POLLUTION

- Every 1 ppm increase in CO is associated with a 3.25% increase in hospitalizations or deaths from heart failure (Shah et al., 2013).
- Every 10 μg/m^3 increase in fine particulate matter (PM2.5) is associated with a 2.12% increase in hospitalizations or deaths from heart failure (Shah et al., 2013).

DROUGHT

- Droughts are associated with wildfires, whose smoke contaminates the air with fine particulate matter (CARPHA et al., 2019) and increases the risk of cardiovascular disease (Shah et al., 2013).

COLD

- There is a clear connection between intense cold and mortality from cardiovascular disease (Liu et al., 2015).

RESPIRATORY DISEASES

PATHOPHYSIOLOGY OF RESPIRATORY DISEASES IN RELATION TO CLIMATE RISKS

EFFECTS SIDE OF CERTAIN MEDICATIONS USED IN THE TREATMENT OF RESPIRATORY DISEASES

EMPIRICAL DATA

PATHOPHYSIOLOGY OF RESPIRATORY DISEASES IN RELATION TO CLIMATE RISKS

Climate change is causing an increase in flooding, storms, droughts, and rising temperatures, and thus, greater exposure to contaminants, fungi, and microbes, with the resulting respiratory problems. The biological mechanisms that trigger respiratory diseases when a person is exposed to climate risks are still unclear; however, several hypotheses have been suggested. *Note:* the list of conditions provided below is not exhaustive.

GENERAL SYMPTOMS OF THE UPPER RESPIRATORY TRACT

FLOODING AND HUMIDITY

Mold triggered by flooding can cause general irritation and inflammation of the upper respiratory tract, such as nasal congestion, throat irritation, and cough. Furthermore, flooding aside, the significantly higher humidity in some regions also promotes the proliferation of mold.

ALLERGIES

HEAT STORMS AIR POLLUTION DROUGHTS AND DRY CLIMATES

High temperatures trigger the production and release of allergens into the air, increasing cases of allergic rhinitis. Suspended particulates and Saharan dust intrusions can heighten the risk of allergic rhinitis and eye irritation. Furthermore, the high winds associated with heat and storms cause the spread of allergens and make their inhalation more likely. Likewise, low humidity in the dry season coupled with higher temperatures increases the presence of microparticles, pollen, bacteria, and micellar elements (mold and fungi) in the air. High carbon dioxide

(CO_2) levels can trigger the release of allergens, as it promotes plant growth and pollen production.

FLOODING AND HUMIDITY

Mold triggered by flooding or humidity can cause serious respiratory symptoms (e.g., cough or dyspnea) in both allergic and non-allergic people as a reaction to the toxins it produces.

DYSPNEA

HEAT DROUGHTS AND DRY CLIMATES

Intense heat can trigger hyperventilation, especially in children or elderly people with chronic obstructive pulmonary disease (COPD). Tachypnea is also one of the symptoms of heatstroke and can trigger respiratory alkalosis and metabolic acidosis. Furthermore, higher temperatures, coupled with low humidity, as seen during droughts, can lead to imperceptible fluid loss in the respiratory tract and insidious dehydration, accompanied by dizziness, asthenia, adynamia, and dyspnea, with the risk of damage to the upper respiratory tract from mucosal dryness.

AIR POLLUTION FLOODING AND HUMIDITY

The upper respiratory irritation and inflammation caused by air pollutants and mold from flooding or humidity can result in dyspnea. Climate change is causing the release of abundant pollen (e.g., from ragweed, grasses and trees) into the atmosphere, triggering dyspnea in people with asthma.

ASTHMA AND BRONCHIAL HYPERREACTIVITY

HEAT STORMS

Heat waves are often accompanied by thunderstorms that can trigger an epidemic of asthma attacks, known as "thunderstorm asthma". Pollen rupture is accelerated during these storms due to water absorption. This phenomenon, added to high winds, increases the range of the pollen grains and their inhalation.

AIR POLLUTION DROUGHT

Air pollution from ozone and fine particulate matter, driven by high temperatures, can exacerbate or trigger symptoms of bronchial hyperreactivity and asthma. These contaminants can trigger irritative and inflammatory changes in the lungs and irritation of the smooth muscles of the bronchial wall. Likewise, Saharan dust intrusions can heighten the risk of worsening asthma in susceptible people.

FLOODING AND HUMIDITY

Mold triggered by flooding can cause asthma symptoms, even in healthy people. Furthermore, flooding aside, the significant increase in humidity in some regions leads to the proliferation of mold and, thus, asthma attacks.

COLD

Inhaling cold dry air, especially during exertion, can activate a series of mechanisms that trigger asthma attacks: contraction of the smooth muscles responsible for bronchoconstriction, a significant increase in blood flow, release of histamine and pulmonary vasoconstriction mediators.

RESPIRATORY INFECTIONS

AIR POLLUTION

DROUGHT AND DRY CLIMATES

Ozone lowers the defenses of the respiratory tract and increases its susceptibility to infections. In the dry season and droughts, low humidity increases the presence of microparticles, pollen, bacteria, and micellar elements (fungi and mold) in the air, and heightens the risk of infections from mucosal dryness.

FLOODING AND HUMIDITY

Mold triggered by flooding or humidity can cause mycotic respiratory infections, as well as infections in general.

COLD

Exposure to cold may diminish upper respiratory response mechanisms, undermine the immune system's resistance to respiratory infections, and accelerate the spread of influenza. Furthermore, imperceptible fluid loss related to prolonged exposure to the cold dries out the mucous membranes, promoting infections.

LUNG CANCER

AIR POLLUTION

Over time, particles accumulate in the respiratory tract and trigger the onset of lung cancer.

RESPIRATORY SIGNS AND SYMPTOMS OF HEATSTROKE

CLASSICAL HEATSTROKE

Classical heatstroke is customarily seen in children, people with chronic diseases, or elderly people who have been exposed to an excessively hot environment. People with classical heatstroke perspire little or not at all and display the following respiratory signs and symptoms: tachypnea, increased ventilation rate, and respiratory alkalosis. In serious cases, classical heatstroke can trigger pulmonary edema, pulmonary infarction, or acute respiratory distress syndrome (ARDS).

EXERTIONAL HEATSTROKE

Exertional heatstroke is seen in people who have engaged in intense physical activity in a very hot environment. People with exertional heatstroke perspire profusely and display the following respiratory signs and symptoms: tachypnea, increased ventilation rate, and respiratory alkalosis that can progress to metabolic acidosis with high levels of lactate from tissue damage. In serious cases, exertional heatstroke can trigger pulmonary edema, pulmonary infarction, or ARDS.

The main diagnostic criteria for heatstroke are a rectal temperature of 40°C (104°F) or higher (if steps have not been taken to lower the patient's temperature) and neurological signs, such as incoherence or altered consciousness. The signs and symptoms of heatstroke are related to systemic inflammatory response syndrome (SIRS). Neurological symptoms are very marked (see the section on *neurological disorders*), as cardiovascular signs and symptoms and electrolyte disorders may also be important (see sections on *cardiovascular diseases* and *kidney diseases*).

PATHOPHYSIOLOGY OF RESPIRATORY DISEASES IN RELATION TO CLIMATE RISKS

RESPIRATORY DISEASES					
Heat	Storms	Flooding and humidity	Drought and dry climates	Air pollution	Cold
GENERAL SYMPTOMS IN THE UPPER RESPIRATORY TRACT					
Absent in the scientific literature		The respiratory tract is irritated and inflamed due to mold.	Absent in the scientific literature		
ALLERGY					
Heat and wind trigger the production, release, and spread of allergens.	Pollen absorbs water and ruptures more easily, and wind facilitates its spread and inhalation.	Allergic reactions to mold or its toxins.	Suspended particulates, Saharan dust intrusions, and low humidity increase the risk of allergic rhinitis and other diseases.	CO_2 increases the production and release of plant allergens.	Absent in the scientific literature
DYSPNEA					
Hyperventilation from intense heat.	Absent in the scientific literature	The respiratory tract is irritated and inflamed due to mold.	Mucous membranes dry up.	The respiratory tract is irritated and inflamed.	Absent in the scientific literature
ASTHMA AND BRONCHIAL HYPERREACTIVITY					
Pollen absorbs water and ruptures more easily, and wind facilitates its spread and inhalation.		Mold causes bronchial irritation.	Saharan dust irritates the respiratory tract.	Ozone and fine particles trigger pulmonary and bronchial irritation and inflammation.	Cold dry air triggers bronchial constriction.
RESPIRATORY INFECTIONS					
Absent in the scientific literature		Mold can cause mycotic, bacterial, and viral infections.	Low humidity and mucosal dryness increase the risk of respiratory infections.	Ozone inflames the respiratory tract and undermines defense mechanisms.	Cold reduces response mechanisms and lowers the resistance of the immune system.
LUNG CANCER					
Absent in the scientific literature				Fine particles accumulate.	Absent in the scientific literature
RESPIRATORY SIGNS AND RESPIRATORY SYMPTOMS OF HEATSTROKE					
SIRS are triggered by hyperthermia.	Absent in the scientific literature				

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN THE TREATMENT OF RESPIRATORY DISEASES

The dosage of certain medications used in the treatment of respiratory diseases should be managed very carefully when administered during certain meteorological phenomena. For example, dehydration due to a heat wave can be aggravated by taking antibiotics with diarrhea as a side effect, and the use of certain antibiotics can trigger a serious skin reaction if the person is exposed to sunlight.

WARNING

- Each case should be assessed individually, since there is little available literature and medications can be an aggravating factor, although with no causal relationship.
- This list of medications is not exhaustive.
- In general, dehydration can alter the pharmacokinetics of any medication.
- Most of the information comes from pharmaceutical firms and very little from specific studies on meteorological phenomena and the use of medications.
- Side effects may only occur at the start of treatment.
- Side effects can be more serious in dependent elderly people (people who are bedridden or suffer from dementia, etc.) or people with chronic diseases or conditions treated with multiple medications.
- This list does not include medications whose physical-chemical and pharmacological properties are altered when exposed to light (photosensitive medications).

ANTIBIOTICS

- Dehydration from diarrhea: amoxicillin-clavulanate in combination.
- Dehydration from nausea: doxycycline.
- Phototoxic or photoallergic skin reactions if the person is exposed to sunlight (UV rays): azithromycin, gentamicin, ciprofloxacin, levofloxacin, doxycycline.

ANTIMYCOTICS

- Dehydration from diarrhea, nausea, and vomiting: fluconazole, itraconazole, ketoconazole, posaconazol, voriconazole, terbinafine.

BRONCHODILATORS

- Tachycardia: salbutamol.
- Hypokalemia: salbutamol.

EMPIRICAL DATA

HEAT DROUGHTS AND DRY CLIMATES

- Several publications have described an increase in mortality and morbidity from heat-related respiratory causes (Patz et al., 2014; Cheng et al., 2014).
- Seasonal allergic rhinitis from pollen has substantially increased in North America (Demers and Gosselin, 2019).
- Epidemics of thunderstorm asthma attacks have been reported among people with allergic rhinitis (D'Amato et al., 2015).
- People with heatstroke may develop pulmonary edema, pulmonary infarction, or ARDS (Bouchama and Knochel, 2002).
- There is a demonstrable association between low humidity in the dry season and acute respiratory diseases in children (Santos et al., 2017).

ANTIBIOTICS

- Almost 50% of children treated with amoxicillin-clavulanate develop diarrhea (Tähtinen et al., 2011).

ANTIMYCOTICS

- Some antimycotics can have side effects such as nausea, vomiting, and diarrhea, which increases the risk of dehydration during heat waves (Blachère and Perreault, 2013).

BRONCHODILATORS

- Hypokalemia is a common side effect in asthmatic adults treated with adrenergic beta 2 receptor agonists (Hung et al., 1999).
- Just under 40% of adults treated with doxycycline experience nausea (Donta et al., 2004).

COLD

- With each degree centigrade (1.8°F) drop in temperature, there is a 3.3% increase in the number of deaths from respiratory diseases (Analitis et al., 2008).
- Mortality from respiratory causes can increase by up to 62% during periods of intense cold (Zhou et al., 2014).
- Transmission of the influenza virus is heightened by overcrowding in dwellings during heavy rains (Tamerius et al., 2013).

AIR POLLUTION

- The respiratory health of a population is inversely proportional to the level of air pollution (WHO, 2018a).
- The increasingly frequent episodes Saharan dust intrusion in the Caribbean heighten the risk of allergic rhinitis and asthma (CARPHA et al., 2019).

- In Barbados, Saharan dust is related to the increase in the number of patients with asthma since 1973 (Manna and Bandyopadhyay, 2019).
- Ozone is associated with 700,000 annual deaths from respiratory causes worldwide (Anenberg et al., 2010).
- In three cities Latin American cities, an air pollution control policy would prevent 156,000 deaths, 4,000,000 asthma attacks, 300,000 medical consultations, and almost 48,000 cases of chronic bronchitis (Bell et al., 2006).
- Climate change aside, smoke from fuel-burning stoves can further complicate the situation (Ahui et al., 2016).

FLOODING

- The frequency and intensity of rains will increase in several regions of the world in the coming years (IPCC, 2013). This means that there will be more flooding (Berkeley Lab, 2017) and, thus, proliferation of mold in dwellings.
- Humidity and mold in the home can trigger or exacerbate asthma, as well as respiratory infections, coughing, wheezing, and dyspnea (WHO, 2009).

KIDNEY DISEASES

PATHOPHYSIOLOGY OF KIDNEY DISEASES IN RELATION TO CLIMATE RISKS

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN NEPHROLOGY

EMPIRICAL DATA

PATHOPHYSIOLOGY OF KIDNEY DISEASES IN RELATION TO CLIMATE RISKS

Climate change is resulting in greater exposure to heat and cold, causing certain physiological mechanisms of the human body or assaults on the renal system to trigger the development of kidney diseases. *Note:* the list of conditions provided below is not exhaustive.

NEPHROLITHIASIS

HEAT

Increased urinary concentration as a result of heat-induced chronic dehydration leads to the concentration of insoluble salts and the formation of crystals in the urine, leading to the development of kidney stones.

ACUTE KIDNEY FAILURE

HEAT

Several mechanisms are involved in the relationship between heat and kidney failure. Hyperthermia directly affects the renal tubular cells. At the same time, hypotension and dehydration reduce glomerular filtration and predispose the individual to tubular necrosis. Finally, rhabdomyolysis from exertional heatstroke causes myoglobinuria, which affects kidney function. All of these phenomena can lead to acute kidney failure.

CHRONIC KIDNEY FAILURE

HEAT

The same mechanisms intervening in acute renal failure can, over time, lead to chronic kidney failure.

COLD

If hypertension related to cold exposure becomes chronic and is not treated properly, it can lead to kidney failure.

CHRONIC KIDNEY DISEASE OF NONTRADITIONAL ETIOLOGY (CKDnT)

HEAT

The mechanisms intervening in CKDnT are related to occupational thermal stress with inflammatory reactions, repeated dehydration with hyperosmolarity, subclinical rhabdomyolysis, high body temperature with uricosuria and crystalluria, and direct kidney damage. One of the groups particularly subject to these diseases are workers who perform heavy labor in very hot environments.

ELECTROLYTE DISORDERS DUE TO HEATSTROKE

HEAT

Kidney damage is the result of the hypovolemia, rhabdomyolysis, and disseminated intravascular coagulation caused by heatstroke. Heatstroke, in turn, is linked with systemic inflammatory response syndrome (SIRS). Creatine kinase levels are elevated. Dehydration may result in hypercalcemia and hyperalbuminemia. Hypokalemia and hypophosphatemia are possibly due to losses through sweat, the effects of catecholamines, and hyperventilation. Hyperkalemia and uremia may then appear. The passage of phosphate to the extracellular space caused by damage to the tissue cells can cause hypocalcemia and hyperphosphatemia. Neurological symptoms are very marked (see section on *neurological disorders*), as respiratory and cardiovascular signs and symptoms may also be (see sections on *respiratory diseases* and *cardiovascular diseases*).

PATHOPHYSIOLOGY OF KIDNEY DISEASES IN RELATION TO CLIMATE RISKS

KIDNEY DISEASES	
Heat	**Cold**
NEPHROLITHIASIS	
Urinary concentration of insoluble salts due to dehydration.	Absent in the scientific literature
ACUTE KIDNEY FAILURE	
Damage to the renal tubular cells due to hyperthermia, diminished glomerular filtration due to hypotension, dehydration, and myoglobinuria due to rhabdomyolysis.	Absent in the scientific literature
CHRONIC KIDNEY FAILURE	
Chronic damage to the renal tubular cells due to hyperthermia, diminished glomerular filtration due to hypotension, dehydration, and myoglobinuria due to rhabdomyolysis.	Inadequately treated chronic hypertension.
CHRONIC KIDNEY DISEASE OF NONTRADITIONAL ETIOLOGY (CKDNT)	
Possible occupational thermal stress related to inflammatory reaction, repeated dehydration with hyperosmolarity, subclinical rhabdomyolysis, elevated body temperature with uricosuria and crystalluria.	Absent in the scientific literature
ELECTROLYTE DISORDERS DUE TO HEATSTROKE	
SIRS due to hyperthermia.	Absent in the scientific literature

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN NEPHROLOGY

The dosage of certain medications used in nephrology should be managed very carefully when administered during certain meteorological phenomena. Dehydration caused by a heat wave can be exacerbated by taking antibiotics with diarrhea as a side effect, and the use of certain antibiotics can also cause a serious skin reaction if the person is exposed to sunlight.

WARNING

- Each case should be assessed individually, since there is little available literature and medications can be an aggravating factor, although with no causal relationship.
- This list of medications is not exhaustive.
- In general, dehydration can alter the pharmacokinetics of any medication.
- Most of the information comes from pharmaceutical companies and very little from specific studies on meteorological phenomena and the use of medications.
- Side effects may appear only at the start of treatment.
- Side effects can be more serious in dependent elderly people (people who are bedridden or suffer from dementia, etc.), or people with chronic diseases or conditions treated with multiple medications.
- This list does not include medications whose physical-chemical and pharmacological properties are altered with exposure to light (photosensitive medications).

ANTIBIOTICS

- Dehydration from diarrhea: amoxicillin.
- Dehydration from vomiting: doxycycline.
- Phototoxic or photoallergic skin reactions if the person is exposed to sunlight (UV rays): norfloxacin, ciprofloxacin, levofloxacin, doxycycline.

EMPIRICAL DATA

HEAT

- Nephrolithiasis prevalence is likely to increase by more than 10% by 2050 due to global warming (Brikowski et al., 2008).
- Various electrolyte disorders are due to heatstroke (Bouchama and Knochel, 2002).
- During heatwaves, kidney function is frequently altered in elderly people (Santé publique France, 2016) and children (Xu et al., 2014).
- Among sugarcane workers, the cumulative incidence of acute kidney failure associated with dehydration and low consumption of hydroelectrolyte solutions increases by more than 50% from February to April (Butler-Dawson et al., 2019).
- Among sugarcane workers, kidney function in 27% of burned-cane cutters, who perform the heaviest labor, substantially decreased over the course of the six-month harvest. This reduction was 12 times more common than among sugarcane workers whose jobs involved less physical labor, such as the repair of drip irrigation tubing and tasks to support the harvest (Hansson et al., 2019).
- CKDnT is closely related to working and living in a hot environment, but it has not yet been determined whether it is caused by a toxin, an infectious agent, heat damage, or a combination of factors (Johnson et al., 2019).

EYE DISEASES

PATHOPHYSIOLOGY OF EYE DISEASES IN RELATION TO CLIMATE RISKS

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN OPHTHALMOLOGY

EMPIRICAL DATA

PATHOPHYSIOLOGY OF EYE DISEASES IN RELATION TO CLIMATE RISKS

In certain circumstances, climate change can increase exposure to solar UV rays or air pollutants, causing serious eye damage. *Note:* the list of conditions provided below is not exhaustive.

EYE IRRITATION

DROUGHT AND DRY CLIMATES

Saharan dust intrusion can irritate the eyes. It can also cause dryness of the eyes during the dry season when humidity is low.

PHOTOCONJUNCTIVITIS AND PHOTOKERATITIS

HEAT

Increased blinking, the sensation of having a foreign body in the eyes, conjunctival infection, vision loss, tearing, or photophobia can be signs of photoconjunctivitis (usually accompanied by photokeratitis, or corneal ulcers) due to an inflammatory reaction of the conjunctiva to acute exposure to solar UV rays.

PTERYGIUM

HEAT

Degeneration of the conjunctiva appearing in young people, known as pterygium, may be related to excessive prolonged exposure to solar UV rays. The mechanism that causes this is unknown.

CATARACTS

HEAT

Lens opacity is the result of prolonged exposure to solar UV rays.

PATHOPHYSIOLOGY OF EYE DISEASES IN RELATION TO CLIMATE RISKS

EYE DISEASES	
Heat and solar UV rays	Drought and dry climates
EYE IRRITATION	
Absent in the scientific literature	Exposure to sand from Saharan dust intrusion and dryness of the eyes.
PHOTOCONJUNCTIVITIS AND PHOTOKERATITIS	
Acute exposure to solar UV rays.	Absent in the scientific literature
PTERYGIUM	
Unknown mechanism.	Absent in the scientific literature
CATARACTS	
Prolonged exposure to solar UV rays.	Absent in the scientific literature

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN OPHTHALMOLOGY

The dosage of certain medications used in ophthalmology should be managed very carefully when administered during certain meteorological phenomena. Dehydration linked to a heat wave, for example, can be exacerbated by medications with diarrhea or vomiting as a side effect.

WARNING

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- This list of medications is not exhaustive.
- In general, dehydration can alter the pharmacokinetics of any medication.
- Most of the information comes from pharmaceutical companies and very little from specific studies on meteorological phenomena and the use of medications.
- Side effects may appear only at the start of treatment.
- Side effects can be more serious in dependent elderly people (people who are bedridden or suffer from dementia, etc.) or people with chronic diseases or conditions treated with multiple medications.
- This list does not include medications whose physical-chemical and pharmacological properties are altered when they are exposed to light (photosensitive medications).

CARBONIC ANHYDRASE INHIBITORS (general use)

This medication for treating glaucoma can heighten some heat-related effects:

- Dehydration from nausea, vomiting, and diarrhea: acetazolamide.
- Hypokalemia due to metabolic acidosis: acetazolamide.

EMPIRICAL DATA

HEAT AND UV RAYS

- Climate change and higher temperatures encourage outdoor activities and greater exposure to solar UV rays (Thomas et al., 2012).
- Approximately 20% of cataract cases may be caused or accelerated by exposure to solar UV rays (WHO, 2019a).

DROUGHT AND DRY CLIMATES

- In 2018, consultations in the ophthalmology service of Brasilia's health department increased by 25% during the dry season. The leading causes were allergies and dry eye (Serviço de Oftalmologia da Secretaria de Saúde de Brasília, 2019).

SKIN DISEASES

PATHOPHYSIOLOGY OF SKIN DISEASES IN RELATION TO CLIMATE RISKS

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN DERMATOLOGY

EMPIRICAL DATA

PATHOPHYSIOLOGY OF SKIN DISEASES IN RELATION TO CLIMATE RISKS

Climate change can alter people's behavior, causing them to spend more time outdoors in warm weather and increase their exposure to solar UV rays. In tropical climates, the opposite may be true. Heat-related humidity can damage the skin and result in cutaneous infections. *Note:* the list of conditions provided below is not exhaustive.

SOLAR ERYTHEMA

HEAT AND UV RAYS

Acute and excessive exposure to solar UV rays causes the skin to become inflamed, leading to solar erythema (sun rash).

SUNBURN

HEAT AND UV RAYS

Prolonged exposure to solar UV rays causes the skin to become very red and painful to the touch, with a burning sensation and even blisters. If the conditions are right, there may even be burns caused by convection.

CANCER

HEAT AND UV RAYS

Chronic high exposure to solar UV rays is a risk factor for skin cancer. The empirical data unequivocally confirm this relationship, although the precise mechanisms involved are unknown.

DERMATOMYCOSIS

HEAT AND HUMIDITY

Heat and humidity encourage the growth of fungi.

CUTANEOUS LEISHMANIASIS

HEAT AND HUMIDITY

Promotes survival of the mosquitoes that transmit the parasitic protozoan of the genus *Leishmania*.

PATHOPHYSIOLOGY OF SKIN DISEASES IN RELATION TO CLIMATE RISKS

SKIN DISEASES
Heat, solar UV rays, and humidity
SOLAR ERYTHEMA
Inflammation of the skin caused by acute and excessive exposure to solar UV rays.
SUNBURN
Prolonged exposure to solar UV rays. Burn caused by convection.
CANCER
Chronic high exposure to solar UV rays: mechanisms unknown.
DERMATOMYCOSIS
Humidity encourages the growth of fungi.
CUTANEOUS LEISHMANIASIS
Humidity promotes survival of the mosquito vector.

SIDE EFFECTS OF CERTAIN MEDICATIONS USED IN DERMATOLOGY

The dosage of certain medications used in dermatology should be managed very carefully when administered during certain meteorological phenomena. The use of certain medications can cause a serious skin reaction if the person is exposed to sunlight.

WARNING

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- In general, dehydration can alter the pharmacokinetics of any medication.
- Most of the information comes from pharmaceutical companies and very little from specific studies on the relationship between meteorological phenomena and the use of medications.
- Side effects may appear only at the start of treatment.
- Side effects can be more serious in dependent elderly people (people who are bedridden or suffer from dementia, etc.) or people with chronic diseases or conditions treated with multiple medications.
- This list does not include medications whose physical-chemical and pharmacological properties are altered with exposure to light (photosensitive medications).

PHOTOSENSITIZING MEDICATIONS

Photosensitizing medications, which are not necessarily used in dermatology, can cause phototoxic or photoallergic skin reactions when the person who takes them is exposed to solar UV rays. A list of photosensitizing medications, classified by type, is provided below:

- Antiacne: isotretinoin, retinoic acid.
- Antibiotics: azithromycin, gentamicin, norfloxacin, ciprofloxacin, levofloxacin, doxycycline.

- Antidepressants: nortriptyline, fluoxetine, paroxetine, sertraline.
- Nonsteroidal anti-inflammatory medications: all.
- Antihistamines: ebastine, loratadine, cetirizine, chlorpheniramine, diphenhydramine, promethazine.
- Oral contraceptives: estradiol, ethinyl estradiol, levonorgestrel.
- Antihypertensives: enalapril, losartan, amlodipine.
- Antiulcer agents: omeprazole, ranitidine.
- Topical corticoids: dexamethasone, hydrocortisone.
- Diuretics: furosemide, torasemide.
- Hypolipidemics: simvastatin, lovastatin, atorvastatin.
- Psychoactive medications: alprazolam, diazepam.

IMMUNOTHERAPY

- Fever: interferon.
- Hypotension: interleukins.

DIRECTED THERAPY

- Fever: oncolytic virus.
- Nausea: oncolytic virus.

PENTAVALENT ANTIMONIALS

- Dehydration from vomiting: meglumine antimoniate.
- Dehydration from nausea, vomiting, and diarrhea: sodium stibogluconate.
- Fever: meglumine antimoniate.

EMPIRICAL DATA

HEAT AND UV RAYS

- Solar erythema is the best-known acute effect of excessive exposure to solar UV rays (WHO, no date).
- The number of cases of spinocellular and basal cell carcinoma increase by 5.6% and 2.9%, respectively, for each degree centigrade (1.8 °F) increase in temperature (van der Leun et al., 2008).
- In 2018, there were 549 new cases of skin melanoma in the Caribbean (WHO, 2019b).
- Exposure to solar UV rays is the most significant risk factor for skin cancer (carcinomas and melanomas) (Haut Conseil de la santé publique, 2019).

VECTOR-BORNE AND ZOONOTIC DISEASES

PATHOPHYSIOLOGY OF THE VECTOR AND ZOONOTIC DISEASES IN RELATION TO CLIMATE RISKS

SIDE EFFECTS OF CERTAIN ANTIBIOTICS AND ANTIMALARIALS

EMPIRICAL DATA

PATHOPHYSIOLOGY OF VECTOR-BORNE AND ZOONOTIC DISEASES IN RELATION TO CLIMATE RISKS

Heat, humidity, and flooding can alter the range, period, and intensity of certain infectious diseases by simultaneously acting on pathogens and vectors. Furthermore, climate change can alter the contact between pathogens, human beings, and vectors, in addition to changing the behavior of the latter two. *Note:* the list of conditions provided below is not exhaustive.

DENGUE, CHIKUNGUNYA, ZIKA, MALARIA, YELLOW FEVER, AND LEISHMANIASIS

HEAT AND HUMIDITY DROUGHTS STORMS FLOODING

Climate change influences the pathogenic factors of vector-borne diseases in different ways, all of them significant.

Pathogen development and survival depends on the existence of a certain temperature range: very high temperatures can increase mortality in some pathogens. In contrast, higher temperatures and humidity promote reproduction and shorten the extrinsic incubation period of pathogens. If their extrinsic cycle is short, their vector's bite can become infective faster; if it is long, the vector can die before becoming infective.

Temperature can influence the range of vectors. Higher temperatures can further the migration of certain vectors toward regions that were once colder. At the same time, high temperatures can also limit the distribution of the vector because of the associated increase in the mortality of its larvae. Furthermore, higher temperatures and rainfall contribute to larval development in certain vectors, but if the rains are extreme, they can destroy breeding sites. Flooding, in contrast, facilitate the stagnation of water, which leads to an increase in breeding sites. Finally, although drought can limit the number of breeding sites, wet

areas can increase them, because stream currents slow down, causing the water to stagnate. Drought can also facilitate the breeding of vectors when water storage receptacles are not properly cleaned or protected. The wind that accompanies storms can also increase the distance that mosquitoes fly, but at the same time reduce the opportunities for them to bite. The time it takes some mosquitoes to reach maturity is inversely proportional to the increase in temperature.

With regard to hosts, climate change can cause changes in human behavior that facilitate the transmission of pathogens. For example, the drought-driven migration of farmers from rural to urban areas is linked with the reemergence of leishmaniasis in cities. Furthermore, the lower crop production and decreased access to food associated with climate change can alter the immunity and susceptibility of humans, promoting the transmission of vector-borne diseases. In addition, storms can destroy mosquito nets and increase human exposure to vectors.

PLACENTAL MALARIA

HEAT FLOODING DROUGHTS

Heat and flooding, as well as drought, are factors that promote malaria, which can infect the placenta and increase the risk of stillbirths (see section on *maternal and pediatric disorders*).

BORRELIOSIS, LYME DISEASE OR CHRONIC ERYTHEMA MIGRANS

HEAT

Creates a favorable habitat for the vector of borreliosis, or Lyme disease (transmitted by ticks infected with the *Borrelia burgdorferi* bacterium), facilitating the transmission of this disease.

LEPTOSPIROSIS AND HANTAVIRUS

HEAVY RAINS

Heavy rains cause rodents to seek new shelter, which increases the risk of food and utensils contamination with the *Leptospire interrogans* bacterium or hantavirus.

PATHOPHYSIOLOGY OF VECTOR-BORNE AND ZOONOTIC DISEASES IN RELATION TO CLIMATE RISKS

<table>
<tr><th colspan="3">VECTOR-RELATED DISEASES</th></tr>
<tr><th>Heat and humidity</th><th>Drought</th><th>Storms, heavy rains, and flooding</th></tr>
<tr><td colspan="3">DENGUE, CHIKUNGUNYA, ZIKA, MALARIA, YELLOW FEVER, LEISHMANIASIS, AND PLACENTAL MALARIA</td></tr>
<tr><td>Heat and humidity increase the reproduction and incubation period of the virus or parasite. Heat extends the breeding range of mosquitoes. In the case of malaria, however, very high temperatures can increase mortality of the parasite.</td><td>Inadequately protected water storage receptacles can foster mosquito breeding during drought. Drought in humid areas can increase breeding sites. Drought-driven human migration from rural to urban areas increases transmission of these diseases in cities. Less access to food can increase human susceptibility to these infections.</td><td>Stagnant flood waters encourage mosquito breeding. Wind can extend the flight range of these insects or destroy mosquito nets.</td></tr>
<tr><td colspan="3">BORRELIOSIS, LYME DISEASE OR CHRONIC ERYTHEMA MIGRANS</td></tr>
<tr><td>Heat creates favorable habitats for the vector and facilitates transmission of the disease.</td><td colspan="2">Absent in the scientific literature</td></tr>
<tr><td colspan="3">LEPTOSPIROSIS AND HANTAVIRUS</td></tr>
<tr><td colspan="2">Absent in the scientific literature</td><td>Rodent vectors seek shelter during the rains, increasing transmission of the bacterium or virus.</td></tr>
</table>

SIDE EFFECTS OF CERTAIN ANTIBIOTICS AND ANTIMALARIALS

The dosage of certain medications used in the treatment of vector-borne diseases should be managed very carefully when administered during certain meteorological phenomena. For example, dehydration associated with a heat wave can be exacerbated with the use of antibiotics or antimalarials with diarrhea as a side effect, and the use of certain antibiotics can trigger a serious skin reaction if the person is exposed to sunlight.

WARNING

- Each case should be assessed individually, since there is little available literature and medications can be an aggravating factor, although with no causal relationship.
- This list of medications is not exhaustive.
- In general, dehydration can alter the pharmacokinetics of any medication.
- Most of the information comes from pharmaceutical companies and very little from specific studies on the relationship between meteorological phenomena and the use of medications.
- Side effects may appear only at the start of treatment.
- Side effects may be more serious in dependent elderly people (people who are bedridden or suffer from dementia, etc.) or people with chronic diseases or diseases treated with multiple medications.
- This list does not include medications whose physical-chemical and pharmacological properties are altered with exposure to light (photosensitive medications).

ANTIBIOTICS

- Dehydration from diarrhea: amoxicillin-clavulanate.
- Dehydration from vomiting: doxycycline.
- Phototoxic or photoallergic skin reactions if the person is exposed to solar UV rays: doxycycline.

ANTIMALARIALS

- Dehydration from diarrhea or vomiting: chloroquine, mefloquine, primaquine.
- Arrhythmias: pyrimethamine.

EMPIRICAL DATA

HEAT AND HUMIDITY DROUGHTS FLOODING

- The altered temperature ranges caused by climate change can create optimal conditions (such as a sufficiently high minimum temperature) for a change in the malaria transmission model in regions where the disease is not endemic, such as the Caribbean (Nurse et al., 2014).
- In the Caribbean, the risk of leptospirosis increases in May, when major flooding can occur, especially in The Bahamas, the Greater Antilles, and the Guianas. The risk increases, since vectors (such as rodents) seek shelter in dwellings, elevating the risk that surfaces in homes and food stocks will be contaminated (CARPHA et al., 2019).
- It has been determined that the number of leishmaniasis cases increases by 5% each time the relative humidity increases by 1% above 58% (Toumi et al., 2012).
- The risk of stillbirth from placental malaria is 2.5 times higher than in normal pregnancies (N'Dao et al., 2006).

- After a natural disaster, wild creatures draw closer to human settlements in search of food and shelter, increasing the risk of transmission of diseases such as hantavirus hemorrhagic fever (OPS, 2000).

ANTIBIOTICS

- Almost 50% of children treated with amoxicillin-clavulanate develop diarrhea (Tähtinen et al., 2011).
- Almost 40% of adults treated with doxycycline experience vomiting (Donta et al., 2004).

GASTROINTESTINAL DISEASES

PATHOPHYSIOLOGY OF GASTROINTESTINAL DISEASES IN RELATION TO CLIMATE RISKS

SIDE EFFECTS OF CERTAIN DIGESTIVE SYSTEM DRUGS

EMPIRICAL DATA

PATHOPHYSIOLOGY OF GASTROINTESTINAL DISEASES IN RELATION TO CLIMATE RISKS

Climate risks such as heat, humidity, or flooding may lead to infections, poisoning, or diseases of the digestive system. *Note:* The list of conditions provided below is not exhaustive.

GASTROINTESTINAL SYMPTOMS

HEAT

Hyponatremia caused by excessive intake of hypotonic fluids during a period of heat intense may cause loss of appetite, nausea and vomiting. Hypernatremia due to dehydration may induce intense thirst.

GASTROINTESTINAL INFECTIONS

HEAT AND HUMIDITY DROUGHTS FLOODING

In terms of the physiological effects of pathogens, higher temperatures, humidity, drought, and flooding may contribute to the development and survival of certain pathogens or promote their reproductive cycles and proliferation.

In terms of effects on the spread of pathogens, a period of severe drought could compact soils so much that when there is heavy rainfall, the ground is not able to absorb the water, which flows toward rivers and leaches contaminated soils, increasing the risk of river pollution.

Regarding effects on personal hygiene, drought may also restrict access to water and adversely affect hygiene practices.

As regards the risk of contamination, drought may increase the concentration of contaminants in water. It may also decrease water pressure in drinking water systems and cause cross-contamination. Limited access to water may lead to the use of alternative sources of

water that are less safe (reservoirs/tanks). During a flood, the risk of contact with polluted water increases, as does the risk of eating foods contaminated by stagnant water.

FOOD POISONING, CIGUATERA, AND CYANOBACTERIA

HEAT

Because temperature fluctuations contribute to volatility, contaminants found in the soil such as the chemicals and pesticides used in agriculture end up in rivers and the food chain, which leads to food poisoning.

The incidence of ciguatera (food poisoning from fish) appears to be related to climate change. High sea water temperatures seem to lead to the proliferation of the microalgae *Gambierdiscus toxicus* and its toxins. The consumption of large carnivorous fish contaminated by these toxins causes gastrointestinal symptoms such as abdominal cramps, diarrheal diseases, nausea, and vomiting. Neurological disorders may occur in the most serious cases, although this is rare (see section on *neurological disorders*).

Regarding cyanobacteria, when the climate is hotter and rains are abundant, harmful algal blooms flourish, along with cyanobacteria and related toxins, which end up in drinking water, recreational bodies of water, and the food chain. Several cases of gastroenteritis and liver disease have been attributed to the consumption of water contaminated by cyanobacterial blooms, especially when the bloom decays naturally or is intentionally destroyed, which releases large quantities of cyanotoxins. Children and people who have hepatitis, cirrhosis of the liver, or kidney damage are more susceptible to the harm caused by cyanotoxins.

LIVER DYSFUNCTION

HEAT

Direct thermal damage and decreased splanchnic perfusion (flow of blood to the periphery to reduce body heat) may cause liver damage. When intestinal permeability increases, endotoxins can pass into the blood, which triggers an inflammatory response. Liver function tests usually produce abnormal results.

PATHOPHYSIOLOGY OF GASTROINTESTINAL DISEASES IN RELATION TO CLIMATE RISKS

GASTROINTESTINAL DISEASES		
Heat and Humidity	Drought	Flooding
GASTROINTESTINAL SYMPTOMS		
Hyponatremia from excessive intake of hypotonic fluids causes nausea and vomiting. Hypernatremia induces thirst.	Absent in the scientific literature	
GASTROINTESTINAL INFECTIONS		
Heat and humidity are conducive to the development, survival, reproduction, and proliferation of certain pathogens.	Dry, compacted ground does not absorb rainwater, which ends up leaching contaminated soils and polluting water sources. In addition, a lack of water reduces hygiene practices and leads to the use of less safe water. Drought increases the concentration of contaminants.	Flooding is conducive to the development, survival, reproduction, and proliferation of certain pathogens. Contact with polluted water increases during floods, as does the consumption of contaminated food.
FOOD POISONING, CIGUATERA, AND CYANOBACTERIA		
Heat contributes to volatility and the removal of harmful contaminants from the soil, as well as the proliferation of harmful algae that end up contaminating the food chain.	Absent in the scientific literature	
LIVER DYSFUNCTION		
Heat-related liver damage and inflammatory response.	Absent in the scientific literature	

SIDE EFFECTS OF CERTAIN DIGESTIVE SYSTEM DRUGS

The dosage of certain medications used to treat gastrointestinal diseases should be managed very carefully when they are administered during certain climate-related events. For example, heat wave-related dehydration may be aggravated by taking antibiotics or antiemetics that cause diarrhea as a side effect.

WARNING

- Each case should be individually evaluated, since in general there is little available literature and taking drugs may be an aggravating condition, even if there is no causal relationship.
- This list of drugs is not exhaustive.
- In general, dehydration may alter the pharmacokinetics of any drug.
- Most of the information comes from pharmaceutical companies and there are very few specific studies on climate-related events and the use of drugs.
- Side effects may only occur at the beginning of treatment.
- Side effects may be worse in the elderly who depend on another person (bedridden people or those with dementia, etc.), or in those with chronic diseases or polymedicated patients.
- This list does not include medications with physicochemical and pharmacological properties that are altered when exposed to light (photosensitive drugs).

ANTIBIOTICS

- Dehydration due to diarrhea: combination of amoxicillin/clavulanate.
- Dehydration due to nausea: doxycycline.
- Phototoxic or photoallergic skin reactions if the person is exposed to the UV rays of the sun: norfloxacin.

ANTIEMETICS

- Dehydration due to diarrhea: dolasetron, ondansetron, granisetron.

PROKINETICS

- Dehydration due to diarrhea: metoclopramide.

SEROTONIN RECEPTOR BLOCKERS

- Dehydration due to nausea, vomiting, and diarrhea: domperidone, prucalopride.

H2 BLOCKERS

- Phototoxic or photoallergic skin reactions if the person is exposed to the UV rays of the sun: ranitidine.

PROTON-PUMP INHIBITORS

- Dehydration due to diarrhea, nausea, and vomiting: dexlansoprazole, esomeprazole, lansoprazole, omeprazole, pantoprazole, rabeprazole.
- Phototoxic or photoallergic skin reactions if the person is exposed to the UV rays of the sun: omeprazole.

EMPIRICAL DATA

HEAT AND HUMIDITY DROUGHTS FLOODING

- Many diarrheal diseases are seasonal, suggesting sensitivity to climate (WHO et al., 2004).
- Between 2030 and 2050, rising temperatures will cause approximately 48,000 additional deaths from diarrhea per year among children under 15 (WHO, 2016).
- The emergence of *Campylobacter* and *Cryptosporidium* is frequently preceded by rain and flooding linked to intense heat (Sterk et al., 2013).
- Torrential rains and polluted water are the main causes of diarrhea and related diseases: cholera, cryptosporidiosis, *E. coli* infection, giardiasis, shigellosis, typhoid fever, and viral diseases such as hepatitis A (WHO et al., 2004).
- In the Caribbean, cases of gastroenteritis due to increased contact with polluted floodwater increase during the month of May. This is especially true in the Bahamas, the Greater Antilles, and the Guianas (CARPHA et al., 2019).
- Flooding and drought increase the risk of diarrheal diseases (WHO et al., 2004).
- A heat stroke can alter liver function (Burt et al., 2016).
- Food poisoning from ciguatera is the non-bacterial disease most commonly associated with tropical regions (Nurse et al., 2014).
- Farm workers are regularly exposed to high levels of pesticides due to higher temperatures and changing rainfall patterns caused by climate change (Delcour et al., 2015; Gatto et al., 2016).

ANTIBIOTICS

- Nearly 50% of children treated with the combination of amoxicillin/clavulanate have diarrhea (Tähtinen et al., 2011).
- Slightly less than 40% of adults treated with doxycycline have nausea (Donta et al., 2004).

NEUROLOGICAL DISORDERS

PATHOPHYSIOLOGY OF NEUROLOGICAL DISORDERS IN RELATION TO CLIMATE RISKS

SIDE EFFECTS OF CERTAIN CENTRAL NERVOUS SYSTEM DRUGS

EMPIRICAL DATA

PATHOPHYSIOLOGY OF NEUROLOGICAL DISORDERS IN RELATION TO CLIMATE RISKS

Certain weather events related to climate change such as heat, air pollution, or flooding attack the nervous system and may increase the incidence of certain neurological disorders. In addition, the presence of toxins in drinking water caused by climate change may lead to diseases such as Alzheimer's or Parkinson's disease. *Note:* the list of conditions provided below is not exhaustive.

STROKE

HEAT

Hemoconcentration and hyperviscosity of the blood that accompany sweating and decreased intravascular space may lead to thromboembolism and ischemic stroke. In addition, severe hypernatremia caused by heat-induced dehydration may cause a rapid contraction of brain volume, tear meningeal vessels, and induce hemorrhagic stroke.

AMBIENT AIR POLLUTION DROUGHT

The epidemiological relationship between fine particles and stroke is very clear, although the biological mechanisms behind it are not precisely known. Systemic inflammatory response syndrome (SIRS), a decrease in intravascular space, and thromboembolism have been considered.

COLD

Hypertension linked to cold increases the risk of a hemorrhagic stroke. Vasoconstriction induced by the cold may also lead to hemoconcentration and hyperviscosity of the blood, and thus ischemic stroke. Finally, ongoing exposure to the cold may lead to an increase in total cholesterol and ultimately arteriosclerotic plaque and the risk of ischemic stroke.

PARKINSON'S DISEASE

FLOODING

During a flood and heavy rainfall, water can leach agricultural soils and carry certain toxins (e.g. manganese) to rivers and end up in drinking water. Exposure to these toxins may lead to the onset of Parkinson's disease and cause neurodegeneration. The exact mechanism behind this is unknown.

ALZHEIMER'S DISEASE AND OTHER TYPES OF DEMENTIA

FLOODING

During a flood and heavy rainfall, water can leach agricultural soils and carry certain heavy metals into rivers and end up in drinking water. Exposure to heavy metals is related to Alzheimer's disease. The exact mechanism of how this occurs is unknown.

LEARNING DISORDERS

FLOODING

Floods and rainfall may lead to the presence of heavy metals in drinking water. Exposure to these metals is conducive to the onset of learning disorders in children.

EPILEPSY

FLOODING DROUGHTS HEAT

After an extreme weather event, the stress that gradually sets in as a result of economic hardship or forced displacement may lead to post-

traumatic stress (see section on *mental health disorders*). This stress profoundly affects the neurological function of exposed populations and may cause an epilepsy crisis. Intense heat is another important factor that contributes to these crises. The exact mechanisms behind this are unknown.

MULTIPLE SCLEROSIS

HEAT FLOODING DROUGHTS

High temperatures and the stress associated with flooding and drought are thought to be two important factors in the exacerbation of certain neurological symptoms of patients with multiple sclerosis, especially fatigue. The exact mechanism behind this is unknown.

NEUROLOGICAL SYMPTOMS

HEAT

Dehydration-related hypernatremia caused by heat may lead to thirst, confusion, an altered state of consciousness, and coma. Severe hyponatremia caused by the excessive intake of hypotonic fluids (water intoxication) during a period of intense heat may cause irritability, confusion, a progressive decline in state of consciousness, convulsions, and coma. Hyponatremia and hypernatremia may be confused with a heat stroke.

Climate change seems to be related to the incidence of ciguatera. High sea water temperatures appear to lead to the proliferation of the microalgae Gambierdiscus toxicus and its toxins. In serious cases, which rarely occur, the consumption of large carnivorous fish contaminated by these toxins produces neurological symptoms such as muscular paralysis, respiratory paralysis, and coma. In mild cases, food poisoning may occur (see section on *gastrointestinal diseases*).

NEUROLOGICAL SYMPTOMS OF HEAT STROKE

HEAT

Stroke causes several neurological symptoms such as irritability, delirium, hyperventilation, convulsions, encephalopathy, and coma. The signs and symptoms of heat stroke are related to a SIRS that could cause a combination of cerebral edema, cerebral ischemia, and metabolic disorders. Neurological impairment and hyperthermia (> 40 °C or 104 °F) are the two symptoms that must not be missed when diagnosing heat stroke. Cardiovascular and respiratory signs and symptoms and electrolyte disorders may also be important (see sections on *cardiovascular diseases, respiratory diseases* and *kidney diseases,* respectively).

GUILLAIN-BARRÉ SYNDROME

HEAT FLOODING DROUGHTS

Heat and flooding, as well as drought, are conducive to the spread of the Zika virus (see section on *vector-borne diseases*), which increases the risk of Guillain-Barré syndrome. The mechanism behind this is unknown.

MENINGOCOCCAL MENINGITIS

DROUGHTS AIR POLLUTION COLD

Drought may contribute to the transmission of meningococcus in the sub-Saharan region, which could then spread to Europe and probably the Caribbean. During the dry season, dust-laden winds, cold nighttime temperatures, and upper respiratory infections could damage the nasopharyngeal mucous membrane, thereby increasing the risk of contracting meningococcal disease.

PATHOPHYSIOLOGY OF NEUROLOGICAL DISORDERS IN RELATION TO CLIMATE RISKS

NEUROLOGICAL DISORDERS				
Heat	Flooding	Drought	Air Pollution	Cold
STROKE				
Hemoconcentration and hyperviscosity may lead to thromboembolism. Hypernatremia may cause a hemorrhagic stroke.	Absent in the scientific literature	SRIS, decreased intravascular space, and thromboembolism could be related to stroke.		Hypertension, hemoconcentration, hyperviscosity, and hypercholesterolemia may lead to stroke.
PARKINSON'S DISEASE				
Absent in the scientific literature	Exposure to toxins. Unknown mechanism.	Absent in the scientific literature		
ALZHEIMER'S DISEASE AND OTHER TYPES OF DEMENTIA				
Absent in the scientific literature	Exposure to heavy metals. Unknown mechanism.	Absent in the scientific literature		
LEARNING DISORDERS				
Absent in the scientific literature	Exposure to heavy metals is conducive to these disorders.	Absent in the scientific literature		
EPILEPSY				
Unknown mechanism. Post-traumatic stress and heat are related.			Absent in the scientific literature	
MULTIPLE SCLEROSIS				
Heat and stress from extreme weather phenomena cause significant fatigue in patients with multiple sclerosis. Unknown mechanism.			Absent in the scientific literature	
NEUROLOGICAL SYMPTOMS				
Hypernatremia and hyponatremia.	Absent in the scientific literature			
NEUROLOGICAL SYMPTOMS FROM HEAT STROKE				
SIRS from hyperthermia.	Absent in the scientific literature			
GUILLAIN-BARRÉ SYNDROME				
Unknown mechanism.		Absent in the scientific literature		
MENINGOCOCCAL MENINGITIS				
Absent in the scientific literature		Damage to the nasopharyngeal mucous membrane from dust, cold nigh time temperatures, and upper respiratory infections.		

SIDE EFFECTS OF CERTAIN CENTRAL NERVOUS SYSTEM DRUGS

The dosage of certain medications used to treat neurological disorders should be managed very carefully when they are administered during certain climate-related events. For example, hyperthermia associated with a heat wave may be aggravated by taking anticonvulsants that have fever as a side effect, and heat wave-related dehydration may alter the pharmacokinetics of the drug and amplify its side effects.

WARNING

- Each case should be individually evaluated, since in general there is little available literature and taking medicines may be an aggravating condition, even if there is no causal relationship.
- This list of drugs is not exhaustive.
- In general, dehydration may alter the pharmacokinetics of any drug.
- Most of the information comes from pharmaceutical companies and there are very few specific studies on climate-related events and the use of medicines.
- Side effects may only occur at the beginning of treatment.
- Side effects may be worse in the elderly who depend on another person (bedridden people or those with dementia, etc.), or in those with chronic diseases or polymedicated patients.
- This list does not include medications with physicochemical and pharmacological properties that are altered when exposed to light (photosensitive drugs).

ANTICONVULSANTS

- Fever: topiramate.
- Difficulty lowering body temperature through oligohidrosis: topiramate.
- Hyponatremia: carbamazepine, oxcarbazepine.

CHOLINESTERASE INHIBITORS

- Dehydration due to nausea, vomiting, and diarrhea: donepezil, galantamine, rivastigmine.

GLUTAMATE INHIBITORS

- Dehydration due to diarrhea: memantine.

ANTI-PARKINSONIAN DRUGS

- Dehydration due to vomiting, diarrhea, and hyperhidrosis: anticholinergics.

FUMARIC ACID ESTERS

- Dehydration due to diarrhea and nausea: dimethyl fumarate.

EMPIRICAL DATA

HEAT

- For each degree centigrade (1.8 °F) that raises the temperature in summer, the risk of death from a disease of the nervous system increases by 4.6% (Gasparrini et al., 2012).
- Neurons and glial cells may undergo pathological changes after the person is exposed to moderate heat (Sharma and Hoopes, 2003).
- People with psychiatric disorders have a higher risk of heat-induced illnesses, partly because of the medications they take, their limited ability to care for themselves, or social isolation; they are among those most likely to die from heat stroke during a heat wave (Health Canada, 2011).

- Exposure to neurotoxins may have a significant effect on the onset and severity of Alzheimer's and Parkinson's disease (Portier et al., 2010).
- In patients with multiple sclerosis, exposure to high temperatures is reportedly related to increased fatigue and other symptoms of the disease, which forces them to cut back their social activities and reduces their ability to work (Summers et al., 2012).

HEAT FLOODING DROUGHTS

- High temperatures at home or at work, a lack of social support, and stress can be important factors that trigger epilepsy crises during a heat wave or other extreme meteorological events (Bélanger et al., 2019).
- Post-traumatic stress may have profound neurological effects in populations exposed to stress caused by extreme meteorological events, displacement, and the hardships resulting from climate change (Naeem et al., 2005).
- In several countries that have experienced Zika outbreaks, an increase in the number of patients with Guillain-Barré syndrome has been reported (CDC, 2016).
- People who work in surface mines as well as farm workers, especially those that work in vineyards, have a significant risk of exposure to high concentrations of heavy metals due to the use of pesticides containing those metals, as well as to ambient heat and changes in rainfall patterns (Rocha et al., 2015; Phillips, 2016).

FLOODING DROUGHTS

- Pesticide exposure as well as exposure to other factors could increase the risk of Parkinson's disease (Costello et al., 2009).

DROUGHT

- About 30,000 cases of meningococcal meningitis are reported annually in sub-Saharan Africa (WHO, 2018).
- Meningococcus could potentially spread from the Sahara to the Caribbean (Sakhamuri and Cummings, 2019).

FLOODING

- Exposure to heavy metals exacerbates learning problems in children (Kozma et al., 2005).
- It is suspected that exposure to heavy metals may be related to the onset and exacerbation of Alzheimer's disease (Kotermanski and Johnson, 2009).
- Exposure to manganese may cause the onset of Parkinson's disease (Harischandra et al., 2019).

MENTAL HEALTH DISORDERS

PATHOPHYSIOLOGY OF MENTAL HEALTH DISORDERS IN RELATION TO CLIMATE RISKS

SIDE EFFECTS OF CERTAIN MEDICINES USED FOR MENTAL HEALTH DISORDERS

EMPIRICAL DATA

PATHOPHYSIOLOGY OF MENTAL HEALTH DISORDERS IN RELATION TO CLIMATE RISKS

In general, all extreme weather events linked to climate change such as flooding, drought, or hurricanes may cause mental health disorders before, during, and after the event itself. Extreme weather events put a heavy emotional and psychosocial burden on people, related to the loss of loved ones, forced displacement, or the loss of personal property. These situations are particularly stressful for the elderly, and also for adults and young people, especially those who already have a mental illness. Indeed, people with mental health problems are one of the groups at the highest risk of suffering the negative consequences of climate change. Mental health disorders may persist for several months, even years, and affect individuals, entire families, and even the community (solastalgia[1]). Some of the factors that modulate these effects include the level of risk of a weather event, as well as the existence of previous social and mental health problems, although it is still not precisely known how this is linked to the onset of mental health problems related to climate-related phenomena. *Note:* The list of disorders provided below is not exhaustive.

ANXIETY AND DEPRESSION 

 FLOODING  DROUGHTS  HURRICANES

Persistent stress related to economic hardship or forced displacement causes mental health disorders such as anxiety and depression. These disorders put a significant burden on the general public and are risk factors associated with other mental illnesses. Anxiety and depression are probably the most common disorders related to climate change.

1 For more information on solastalgia and climate change, visit http://www.climateinstitute.org.au/verve/_resources/tci_aclimateofsuffering_august2011_web.pdf.

HEAT COLD

People with mental illnesses do not adapt well when temperatures are very high or very low, which increases the likelihood of emergency room admissions. The reasons that explain these problems are related to taking psychiatric drugs that may change thermoregulation, as well as social isolation or living in poverty. The exact mechanism behind this is unknown.

POST-TRAUMATIC STRESS

FLOODING DROUGHTS HURRICANES

Post-traumatic stress is the only mental health disorder that is diagnosed based on having experienced a traumatic event. This is the mental health problem that is studied most often in victims of floods, drought, and storms.

PSYCHOSOCIAL PROBLEMS

FLOODING DROUGHTS HURRICANES

The psychosocial problems associated with climate-related events represent a social and financial burden that may impair the mental health of people or lead to harmful health behaviors such as alcoholism or drug addiction. In some cases, psychosocial problems may even lead to suicide. Psychosocial problems linked to climate change include loss of employment, a decrease in household income, decreased access to food or health services, or forced displacement.

PATHOPHYSIOLOGY OF MENTAL HEALTH DISORDERS IN RELATION TO CLIMATE RISKS

MENTAL HEALTH DISORDERS	
Flooding, drought, and hurricanes	Heat and cold
ANXIETY AND DEPRESSION	
Persistent stress due to flooding, drought, and hurricanes may lead to depression and anxiety.	Factors involved: taking medications, social isolation, or living in poverty. The exact mechanism is unknown.
POST-TRAUMATIC STRESS	
Stress due to situations that occur before, during and after a flood.	Absent in the scientific literature
PSYCHOSOCIAL PROBLEMS	
Weather-related events may entail a significant social and financial burden that leads to certain psychosocial problems.	Absent in the scientific literature

SIDE EFFECTS OF CERTAIN MEDICINES USED FOR MENTAL HEALTH DISORDERS

The dosage of certain medications used to treat mental health disorders should be managed very carefully when they are administered during certain climate-related events. For example, hyperthermia associated with a heat wave may be aggravated by taking antipsychotic drugs, and the use of benzodiazepines could cause a severe dermatological reaction if the person is exposed to the sun.

WARNING

- Each case should be individually evaluated, since in general there is little available literature and taking drugs may be an aggravating condition, even if there is no causal relationship.
- This list of drugs is not exhaustive.
- In general, dehydration may alter the pharmacokinetics of any drug.
- Most of the information comes from pharmaceutical companies and there are very few specific studies on climate phenomena and the use of drugs.
- Side effects may only occur at the beginning of treatment.
- Side effects may be worse in the elderly who depend on another person (bedridden people or those with dementia, etc.), or in those with chronic diseases or polymedicated patients.
- This list does not include medications with physicochemical and pharmacological properties that are altered when exposed to light (photosensitive drugs).

ANTIDEPRESSANTS

- Hyponatremia: selective serotonin reuptake inhibitors (SSRIs).
- Phototoxic or photoallergic skin reactions if the person is exposed to the UV rays of the sun: nortriptyline, fluoxetine, paroxetine, sertraline.

LITHIUM SALTS

- Heat-induced dehydration may cause lithium poisoning.

ANTI-PSYCHOTICS

- Hyperthermia: almost all anti-psychotic drugs.

BENZODIAZEPINES

- Phototoxic or photoallergic skin reactions if the person is exposed to the UV rays of the sun: alprazolam, diazepam.

EMPIRICAL DATA

- People with mental health problems are one of the groups with the highest risk of suffering the negative consequences of climate change (Patz et al., 2014).
- Psychosocial problems commonly related to extreme weather events are alcoholism and drug abuse (Silove and Steel, 2006).
- The resources needed to meet the psychological needs of people affected by extreme weather events may be insufficient immediately after the event occurs (Tapsell et al., 2002).
- The relationship between mental health disorders and extreme weather events is increasingly being studied, but there are still many gaps in the scientific literature (Portier et al., 2010).
- Problems related to access to mental health services after a disaster have recently started to be studied (Portier et al., 2010).
- It is estimated that around 143 million people will experience forced displacement related to climate change between now and 2050 (Rigaud et al., 2018).

FLOODING DROUGHTS HURRICANES

- Post-traumatic stress is the mental health disorder that is most frequently related to flooding (Alderman et al., 2012).
- The effects of extreme weather events, including forced displacement or the loss of loved ones, entail a heavy emotional and psychosocial burden (Portier et al., 2010).
- Between 30% and 40% of people directly affected by an extreme weather event suffer post-traumatic stress, compared to only 5% to 10% in the general population (Goldmann and Galea, 2014).
- Depression and anxiety are also related to extreme weather events (Boyer and Town, 2011).
- Psychological consequences may persist for several months, even years, and affect individuals and entire families (The Climate Institute, 2011).

HEAT COLD

- People with mental disorders do not adapt well when temperatures are very high or very low, which increases the likelihood that they will go to the emergency room (Vida et al., 2012).
- It has been observed that hospitalization admissions due to mental health problems increase by 7% during heat waves (Khalaj et al., 2010).
- Psychotropic drugs may interfere with a person's ability to thermoregulate and increase the risk of heat-related disorders during a heat wave (Martín-Latry et al., 2007).

DROUGHT

- The severe drought that occurred in 2004 in Australia resulted in nearly 25% of rural workers losing their jobs (The Climate Institute, 2011).
- The drought that occurred in 2007 in that country resulted in an average loss of annual income of US$12,000 per person (The Climate Institute, 2011).
- During the most severe droughts, a 15% increase in the relative risk of suicide has been observed in men (Hanigan et al., 2012).

MATERNAL AND PEDIATRIC DISORDERS

THE IMPACT OF CLIMATE RISKS ON MATERNAL AND PEDIATRIC DISORDERS

SIDE EFFECTS OF CERTAIN MEDICINES USED IN MATERNAL AND PEDIATRIC DISORDERS

EMPIRICAL DATA

THE IMPACT OF CLIMATE RISKS ON MATERNAL AND PEDIATRIC DISORDERS

Certain weather events linked to climate change such as heat, flooding, or drought may be harmful to women during pregnancy, which may lead to several maternal and pediatric disorders. However, it should be noted that there are few studies on the relationship between climate change and maternal and pediatric health. *Note:* The list of disorders provided below is not exhaustive.

MATERNAL MALNUTRITION

DROUGHT

Women in general, but especially pregnant women, may have a greater risk of malnutrition during a drought due to food scarcity.

PREMATURE BIRTHS

HEAT FLOODING DROUGHT

Heat, flooding, and drought are conducive to malaria and arboviral diseases such as dengue (see section on *vector-borne diseases*), which increases the risk of a placental infection that may induce premature labor.

HURRICANES

It has been observed that the number of premature births increases in women who were pregnant before a hurricane or in the six months after and were highly exposed to the disaster. The mechanism behind this is unknown, but it is probably unrelated to post-traumatic stress.

HEAT

Independently of vector-borne diseases, heat may also be related to premature births. The mechanism behind this is unknown, but it is thought that heat may stimulate uterine contractions, that heat sensitivity is higher at the end of the pregnancy when thermoregulation is less efficient, or that heat-related dehydration may reduce uterine blood flow, which may stimulate the secretion of pituitary hormones and trigger labor.

MICROCEPHALY

HEAT FLOODING DROUGHTS

Heat, flooding, and drought are conducive to the spread of the Zika virus (see section on *vector-borne diseases*), which increases the likelihood of a Zika infection occurring during pregnancy and thus a child born with microcephaly.

LOW BIRTHWEIGHT

DROUGHT

Maternal malnutrition due to drought increases the likelihood of a child with low birthweight. Furthermore, neglecting hygiene during a drought and the diarrheal diseases caused by it may also affect maternal malnutrition and induce low birthweight.

HEAT FLOODING

Heat, flooding, and drought (see section on *vector-borne diseases*) are conducive to malaria and dengue, which may cause a placental infection and low birthweight.

HURRICANES

The mechanism behind this is unknown, but women who are more highly exposed to a hurricane have low birthweight babies.

PERINATAL MORTALITY

HEAT FLOODING DROUGHT

Heat, thermoregulation, and maternal metabolism may be related, but the exact mechanism is unknown. A study conducted in Quebec, Canada found that the risk of perinatal mortality at term is higher if temperatures are high in the last few days before delivery. However, another study conducted in Brisbane, Australia did not find any correlation between the two phenomena. Heat, flooding, and drought are also conducive to malaria (see section on *vector-borne diseases*), which may cause a placental infection and a greater risk of perinatal mortality.

SUDDEN INFANT DEATH

HEAT

A study conducted in Quebec, Canada showed a strong correlation between high outside temperatures the day before childbirth and the probability of sudden infant death, especially within the first two months of life. The pathophysiology is unknown. Another study conducted in Taiwan found no correlation.

PLACENTAL SEPARATION

HEAT

A study conducted in Quebec, Canada concluded that in full-term births, exposure to intense heat is related to placental separation. The pathophysiology is unknown.

PATHOPHYSIOLOGY OF MATERNAL AND PEDIATRIC DISORDERS IN RELATION TO CLIMATE RISKS

<table>
<tr><th colspan="3">MATERNAL AND PEDIATRIC DISORDERS</th></tr>
<tr><th>Drought</th><th>Heat and flooding</th><th>Hurricanes</th></tr>
<tr><td colspan="3">MATERNAL MALNUTRITION</td></tr>
<tr><td>Pregnant women are at risk of malnutrition from limited availability of food during a drought.</td><td colspan="2">Absent in the scientific literature</td></tr>
<tr><td colspan="3">PREMATURE BIRTHS</td></tr>
<tr><td colspan="2">Heat, flooding, and drought are conducive to malaria and dengue, which may cause a placental infection. An injury to the placenta may lead to premature birth. Heat may also have a direct effect, independently of vector-borne diseases: stimulation of uterine contractions, high sensitivity at the end of pregnancy, or dehydration, which stimulates hormone secretion of the pituitary and triggers labor.</td><td>Unknown mechanism. Stress does not seem to be involved.</td></tr>
<tr><td colspan="3">MICROCEPHALY</td></tr>
<tr><td colspan="2">Heat, flooding, and drought are conducive to the spread of the Zika virus and thus an increase in the risk of microcephaly.</td><td>Absent in the scientific literature</td></tr>
<tr><td colspan="3">LOW BIRTHWEIGHT</td></tr>
<tr><td>Maternal malnutrition due to food scarcity or diarrhea from neglecting hygiene may induce low birth weight in newborns.</td><td>Heat, flooding, and drought are conducive to malaria, which may cause placental infection and low birthweight.</td><td>Unknown mechanism.</td></tr>
<tr><td colspan="3">PERINATAL MORTALITY</td></tr>
<tr><td colspan="2">The mechanism regarding heat is unknown, but thermoregulation and maternal and fetal metabolism could be involved. Heat, flooding, and drought are conducive to malaria, which may cause placental infection and increase the risk of perinatal mortality.</td><td>Absent in the scientific literature</td></tr>
<tr><td colspan="3">SUDDEN INFANT DEATH</td></tr>
<tr><td>Unknown mechanism.</td><td colspan="2">Absent in the scientific literature</td></tr>
<tr><td colspan="3">PLACENTAL SEPARATION</td></tr>
<tr><td>Absent in the scientific literature</td><td>Unknown mechanism.</td><td>Absent in the scientific literature</td></tr>
</table>

SIDE EFFECTS OF CERTAIN MEDICINES USED TO TREAT MATERNAL AND PEDIATRIC DISORDERS

The dosage of certain medicines used to treat maternal and child health problems should be managed very carefully when they are administered during certain climate-related events. In fact, taking diuretics or oral contraceptives may cause a serious dermatological reaction if the person is exposed to the sun.

WARNING

- Each case should be individually evaluated, since in general there is little available literature and taking drugs may be an aggravating condition, even if there is no causal relationship.
- This list of drugs is not exhaustive.
- In general, dehydration may alter the pharmacokinetics of any drug.
- Most of the information comes from pharmaceutical companies and there are very few specific studies on climate-related events and the use of drugs.
- Side effects may only occur at the beginning of treatment.
- Side effects may be worse in the elderly who depend on another person (bedridden people or those with dementia, etc.), or in those with chronic diseases or polymedicated patients.
- This list does not include medications with physicochemical and pharmacological properties that are altered when exposed to light (photosensitive drugs).

ANTIMALARIAL

- Dehydration due to nausea, vomiting, and diarrhea: chloroquine.
- Dehydration due to nausea and vomiting: mefloquine, primaquine.
- Arrhythmia: pyrimethamine.

DIURETICS

- Phototoxic or photoallergic skin reactions if the person is exposed to the UV rays of the sun: furosemide, torasemide.

ORAL CONTRACEPTIVES

- Phototoxic or photoallergic skin reactions if the person is exposed to the UV rays of the sun: estradiol, ethinylestradiol, levonorgestrel.

EMPIRICAL DATA

DROUGHT

- Weather events related to climate change such as drought make women vulnerable, especially because of malnutrition (Rylander et al., 2013).

HEAT FLOODING

- In the United States, 6% of children whose mothers had a Zika infection during pregnancy (confirmed by laboratory tests) have microcephaly (Rice et al., 2018).
- The odds ratio (OR) for premature delivery due to a placental malaria infection is 3.51 (1.84-6.68) (N'Dao et al., 2006).
- The odds ratio for premature delivery due to a dengue infection is 2.4 (1.3-4.4) (Paixão et al., 2019).
- The odds ratio for low birthweight due to a placental malaria infection is 2.06 (1.72-2.57) (N'Dao et al., 2006). The odds ratio for low birthweight due to a dengue infection is 2.1 (1.1-4.0) (Paixão et al., 2019).

- In Quebec, Canada, the risk (odds ratio) for perinatal mortality at term when the maximum temperature the previous day is 28° C (82° F) is 1.16 times greater than when the temperature is only 20° C (68° F) (Auger et al., 2017). However, a study conducted in Brisbane, Australia did not find any correlation between temperature and the risk of perinatal mortality (Strand et al., 2012).
- The odds ratio for perinatal mortality in pregnancies with placental infection malaria is 2.5 times higher than in pregnancies with no infection (N'Dao et al., 2006).
- When the maximum temperature the same day is equal to or greater than 29°C (84° F), the risk of sudden infant death is 2.78 times higher than when it is 20° C (68° F) (Auger et al., 2015). However, two studies (one conducted in Taiwan and the other in Vienna, Austria) found no correlation between high temperatures and the risk of sudden infant death (Chang et al., 2013; Waldhoer and Heinzl, 2017).
- In full-term births, exposure to a temperature of 30°C (86° F) the previous week is associated with a 12% increase in the relative risk (RR) of placental separation (2%-24%) (He et al., 2018).

HURRICANES

- It has been observed that 14% of women who were pregnant before Hurricane Katrina or in the following six months and were highly exposed to the disaster had premature deliveries, compared to only 6% of less exposed women (Xiong et al., 2008).
- Low birthweight is more frequent (14%) in newborns of women who were highly exposed to the hurricane than in those who were less exposed (4.7%) (Xiong et al., 2008).

FACTORS THAT MODULATE THE IMPACT OF CLIMATE CHANGE

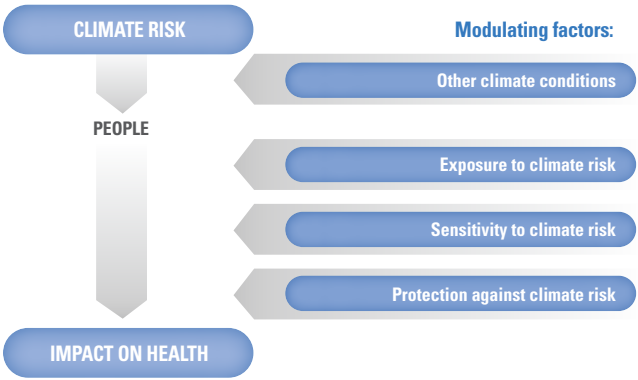
IMPACT ON HEALTH

IMPACT ON HEALTH SERVICES

IMPACT ON HEALTH

The impact of climate change on health clearly depends on the intensity or duration of the weather event, or the concomitant occurrence of other similar phenomena such as the humidity that frequently occurs during heat waves, or the air pollution that comes with drought. In addition, ongoing moderate climate changes may be conducive to certain vectors and vector-borne diseases, while greater exposure to ultraviolet rays may lead to certain diseases, and prolonged exposure to heat could cause chronic kidney disease. However, given a single climate risk, the health impact is not the same for all people, since different factors modulate the final impact. Some people will be more or less exposed depending on whether, for example, they live in flood-prone areas or have access to air-conditioned environments. Other people will be more or less sensitive depending on whether they have a chronic disease or are in good physical condition. Finally, people may be properly or poorly protected depending on if they know how to prevent the effects or have access to relevant advice (see Figure 2).

FIGURE 2. FACTORS THAT MODULATE THE IMPACT OF CLIMATE RISKS ON HEALTH



Source: Adapted from Bustinza and Demers-Bouffard (2019).

EXPOSURE TO CLIMATE RISK

Certain groups are usually more exposed to certain climate risks. The factors linked to the degree of exposure also are related to social environment. For example, people who live in poverty or work outdoors for long periods of time tend to have greater exposure to climate risks, so the impact on their health may be worse. Knowing who these groups are enables health professionals to provide specific advice to help them protect themselves against health impacts or to organize an institutional response.

In general, those who are more exposed are:

- People living in poverty.
- People who are bedridden or have limited mobility.
- People who live in urban heat islands.
- People who live in flood-prone areas.
- People who live in coastal areas at risk of hurricanes.
- People who do not have air conditioning in their homes.
- People who do not have access to air-conditioned environments.
- People who live in highly-populated cities.
- Jobbers who work in very hot climates.
- People with more than one of these exposure factors (who have a greater risk).

Interesting empirical data:

- Regions with a high poverty index have a greater exposure to very high or very low temperatures (EEA, 2019). This is primarily due to inadequate housing conditions and a lack of protection resources.
- Young male Salvadorian farm workers who tend to live in poverty in rural areas suffer from CKDnT more frequently (Orantes, 2018).

- Salvadorian men who work in sugarcane and cotton fields in coastal areas present signs of significant renal dysfunction; those who work at an elevation of more than 500 meters or in subsistence farming do not present renal dysfunction (Peraza et al., 2012).
- Elderly people who live in an urban heat island are more likely to go to the emergency room than people in a control group (Laverdière et al., 2016).
- A study conducted in the United States concluded that there is a lower risk of dying during a period of heat if people have access to air conditioning (Nordio et al., 2015).
- Another study confirmed that the risk of dying during a heat wave is 34% higher in more densely populated areas than in less dense areas (Kosatsky et al., 2012).

SENSITIVITY TO CLIMATE RISK

There are other groups that are more sensitive to the effects of weather. The factors associated with a person's sensitivity stem from individual characteristics that may modulate the impact on their health. For example, children, the elderly, or the chronically ill are physiologically more sensitive to health effects. By knowing who these groups are, the clinical professional can give them advice and help them reduce the impact.

Particularly sensitive people:

- Children and the elderly.
- Pregnant women.
- People with a very small social circle.
- People in poor physical condition or overweight.
- People with chronic diseases.
- Persons with mental disabilities or mental health problems.

- People who take specific medications (see sections on drugs).
- People who use illegal drugs or alcohol.
- People with several of these sensitivity factors (and who therefore have greater risk).

Interesting empirical data:

- Children and the elderly are more sensitive to heat and cold due to the physiological difficulty of temperature regulation and age-related mobility issues (Hattis et al., 2012).
- Poor physical condition and excess weight increase sensitivity to heat and cold, since the heart is not in sufficient shape to handle the stress caused by climate-related events (WHO, 2018c; CDC, 2017).
- People who have chronic diseases or take certain medications (see sections on drugs) are more sensitive to intense heat (CDC, 2017).
- People with mental health problems constitute a group that is particularly at high risk of suffering the consequences of climate change (Patz et al., 2014).
- Breastfeeding infants in extremely hot and dry conditions do not need additional water if they are exclusively breast-fed on demand (Almroth and Bidinger, 1990; Beaudry et al., 2007).
- People with substance abuse problems (alcohol, etc.) have a higher risk of dying during a heat wave (Page et al., 2012).

The possibility of some people having several simultaneous exposure and sensitivity factors must be mentioned, since this makes them even more vulnerable to the health impacts of climate change.

IMPACT ON HEALTH SERVICES

Climate change may cause ongoing natural and human disasters that are even worse than what we have seen so far. This situation may exceed the capacity of health systems to respond to the growing demands of society, so preventing these disasters is essential. A few examples of the possible effects of climate change on health services are:

- Inability of health services to properly respond to the constant increase in the demand for care due to the effects of climate change on the population's health.
- Power outages due to extreme weather events may jeopardize the delivery of services in health facilities.
- During extreme weather events, the air conditioning system in health facilities may stop working.
- Certain health facilities are not constructed to withstand climate change-related events such as high winds, excessive indoor heat, or flooding, and/or cannot provide safe services due to damage to critical systems, mold, etc.

ADVICE FOR PATIENTS AND THE COMMUNITY

ADVICE TO REDUCE CLIMATE CHANGE

ADVICE TO REDUCE EXPOSURE TO CLIMATE-RELATED EVENTS

This advice for reducing climate change or exposure to climate risks is simple and can help protect health. It is appropriate for all people, but especially those who are *more exposed* or *particularly sensitive* to climate risks.

ADVICE TO REDUCE CLIMATE CHANGE

Everyone can help reduce greenhouse gases and stop climate change. Every individual can help reduce the long-term occurrence of weather events that could threaten their own or their children's health:

- Use your car less: walk, ride a bike, or share a car.
- Use public transportation more.
- Eat less meat.
- Take advantage of your city's environmental support programs.
- Participate in community or family gardens and your city's environmental programs.
- Reduce consumption of nonessential goods and services.
- Ask your elected officials to implement programs to fight climate change.

ADVICE TO REDUCE EXPOSURE TO CLIMATE-RELATED EVENTS

Although it is impossible to control the imminent occurrence of weather events that threaten human health, you can try to avoid them. For example, if you are well informed of the weather forecast, you can decide to either evacuate the danger zone or make the appropriate preparations.

HEAT, UV RAYS, AND HUMIDITY

At home:

- Open the windows early in the morning and at night so that air can circulate.
- Close the curtains or blinds as soon as the sun comes up.
- Close the windows if it is hotter outside than inside.
- Drink water or non-alcoholic liquids (minimum 2 liters), even if you are not thirsty.
- Wear light-weight, light-colored, and loose-fitting clothes.
- Mist your skin with water.
- Take cool showers frequently and before sleeping.
- Eat cold, light foods such as salads and fruit.
- Use an electric fan if the humidity is not high.
- Find out who is most exposed or sensitive.

If you go out:

- Apply sunscreens with an SPF of 50 or higher before leaving and re-apply every 90 minutes.
- Apply mosquito repellents if needed.[2]
- Cover your head when you are in the sun and wear sunglasses with UV protection.
- Try to stay in a cool area, in the shade, or in an air-conditioned environment.
- Avoid all physical activity during the hottest hours of the day (from 11:00 a.m. to 3:00 p.m.).

2 Sweat and water reduce the effectiveness of these solutions. NOTE: Be careful when applying to children if the solution contains DEET or picaridin, since serious cases of overdose have been reported.

- Take frequent breaks in the shade and stay well-hydrated if you work in the sun.
- Do not stay in a parked vehicle for long.
- Properly protect water tanks.

If you go to work:

- Cover your head when you are in the sun and wear sunglasses with UV protection.
- Take frequent breaks in the shade and stay well-hydrated.
- Do not work in the sun if you already have some degree of kidney damage.

HURRICANES

- Try to evacuate the risk area.
- Reinforce doors and windows.
- Secure window panes with adhesive tape and close the curtains.
- Cut down tree branches.
- Clear the land around your house.
- Choose the safest room, far away from windows.
- Prepare an emergency kit, including medicines.
- Prepare a stash of canned food and purified water.
- Keep a flashlight and a battery-operated radio on hand.
- Turn off gas and water.
- Turn off the circuit breaker.
- Use electricity generators or propane gas or charcoal grills at least six meters (20 feet) away from the house.
- Find out who are the most exposed or sensitive people in your neighborhood.

FLOODING

- Do not live in flood-prone areas.
- Do not remain in flood-prone areas when heavy rainfall is forecast.
- Try to evacuate the risk area.
- Prepare a stash of canned food and purified water.
- Do not drink or use flood water.
- Properly protect water tanks.
- Do not drive during a flood.
- Use electricity generators at least six meters (20 feet) away from the house.
- Find out who are the most exposed or sensitive people in your neighborhood.
- Use mosquito repellents if needed[3].

DROUGHT

- Do not waste water and protect water sources.
- Keep a reserve supply of purified water.
- Store rainwater to use for crop irrigation and in toilets.
- Find out who is the most exposed or sensitive.
- Use mosquito repellents if needed[4].

AMBIENT AIR POLLUTION

- Do not go out when there is air pollution alert.
- Do not go out particularly if there is a heat wave at the same time.
- Avoid streets with more traffic.

3, 4 Sweat and water reduce the effectiveness of these solutions. NOTE: Be careful when applying to children if the solution contains DEET or picaridin, since serious cases of overdose have been reported..

- Use stroller covers.
- Do not exercise outdoors.
- Find out who are the most exposed or sensitive people in your neighborhood or at work.
  - In the case of workers who live in cities with higher levels of air pollution and who are exposed to airborne pollutants for work reasons: wear a good protective mask, i.e. one that has a suitable filter for the type of pollution, is properly adjusted, and works correctly (consult an expert and ask your employer to provide the mask). See the following website of the Canadian Centre for Occupational Health and Safety for information on the different types of masks: https://www.ccohs.ca/oshanswers/prevention/ppe/surgical_mask.html.

COLD

- Do not go out if it is very cold.
- Dress appropriately for the cold.
- Cover your head when outdoors and if the cold is extreme, cover your mouth and nose as well.
- Be outside as little as possible or take breaks in warm places with little wind.
- Stay active when outdoors but avoid vigorous physical exercise.
- Do not wear wet clothes.
- Do not smoke and/or drink alcoholic beverages, since this can lower body temperature.
- Find out who are the most exposed or sensitive people in your neighborhood or at work.

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The effects of climate change on human health are unequivocal and can already be perceived worldwide. Phenomena such as heat waves, cold waves, floods, droughts, hurricanes, storms, and other extreme weather events can impact health both directly and indirectly, as well as trigger or exacerbate certain conditions and, consequently, put pressure on health services and their infrastructure. These include vector-borne, waterborne, and foodborne diseases—due to changes in the behavior and distribution of vectors and pathogens—and mental health disorders induced by mounting social unrest and forced displacement.

Climate change for health professionals is a pocket book based on empirical data that offers essential information for medical personnel and other health professionals to realize the impacts of climate change on their daily practice. With this quick reference guide, providers can easily recognize diseases and side effects related to climate change, implement appropriate management and provide guidance to exposed populations, provide up-to-date information on the relationship between the adverse effects of certain drugs and the worsening of climate-sensitive health conditions, and determine the possible consequences of climate change for health services.

This book addresses key meteorological risks, as well as the health conditions which they may influence, grouped by specific clinical areas. With this publication, the Pan American Health Organization aims to help build knowledge on the subject and strengthen the capacity of health systems to predict, prevent, and prepare, with a view to offering continuous high-quality health services in a world where climate is changing rapidly.

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