

Health Effects of Climate Change

Chapter 473 | Disorders Associated with Environmental Exposures

KEY CLINICAL POINTS

- 1 Climate change is a health emergency impacting human health, medical practice, and the stability of healthcare systems.
- 2 Air pollution (PM_{2.5}, ozone, sulfur dioxide, nitrogen dioxide) is a major driver of cardiovascular and respiratory diseases; short-term exposure to PM_{2.5} increases acute CV risk by 1-3%, while long-term exposure increases it by ~10%.
- 3 LMICs bear a disproportionate burden of climate-related impacts, with an estimated 250,000 additional deaths from undernutrition, malaria, diarrhea, and heat stress between 2030-2050.
- 4 Air pollution causes approximately 7 million premature deaths annually; coal-burning power plants are associated with double the mortality risk compared to other PM_{2.5} sources.
- 5 Heat-related illnesses (cramps, exhaustion, heatstroke) are increasing in incidence due to rising temperatures and the urban heat island effect.
- 6 Plant-based diets may reduce diet-related greenhouse gases by 29-70% by 2050 compared with reference diets.
- 7 Pregnancy outcomes (preterm birth, low birth weight, stillbirth) are significantly impacted by PM_{2.5}, ozone, and extreme heat through mechanisms like systemic inflammation and placental injury.
- 8 Mesoamerican nephropathy is a specific form of CKD in agricultural workers caused by the synergy of heat exposure (dehydration/hyperthermia) and agrochemical/heavy metal toxicity.
- 9 Medication integrity is compromised by extreme heat, specifically for epinephrine injections, naloxone, insulin, and albuterol inhalers.
- 10 Climate change impacts are multi-vector, affecting water/food safety, vector ecology, and respiratory health.

DEFINITION & OVERVIEW

- **Definition (Harrison's 22e):** *Climate change refers to the effects of accumulated greenhouse gases (GHGs) in the atmosphere on long-term weather patterns.*
- **Drivers:** Anthropogenic emissions (fossil fuel burning, land conversion) → increased mean global temperatures by approximately 1.1°C above preindustrial levels.
- **Consequences:**
 - Increased frequency of extreme weather (heatwaves, wildfires, droughts, floods)
 - Resource scarcity (drinking water, food)
 - Environmental degradation and pollution
 - Conflict and migration
- **Clinical Status:** Recognized as a health emergency affecting human health, medical practice, and healthcare system stability.

- **Mitigation Potential:** Plant-based diets may reduce diet-related GHGs by 29-70% by 2050 compared with reference diets.
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EPIDEMIOLOGY

- **Air Pollution Impact:**
 - 7 million premature deaths annually from ambient/indoor air pollution.
 - Coal-burning power plants → double the mortality risk compared to other PM_{2.5} sources.
 - Risk factors: Respiratory (asthma, rhinosinusitis, COPD, lung cancer) and Cardiovascular (MI, stroke, heart failure, hypertension, arrhythmias, VTE).
 - **Climate Projections:**
 - 250,000 additional deaths (2030-2050) from undernutrition, malaria, diarrhea, and heat stress.
 - Impact disproportionately affects LMICs due to weakened infrastructure.
 - **Displacement:**
 - 108.4 million people (1.4% of humanity) forcibly displaced as of 2022.
 - Over half the world's population lives within 60 km of the ocean → risk from rising sea levels to infrastructure and water supplies.
 - **Health Disparities:**
 - Climate change amplifies existing disparities (e.g., in the US, impacts on Black, Indigenous, and Latinx populations).
 - Failure to meet WHO air pollution guidelines (10 µg/m³) compounds structural racism.
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ETIOLOGY & PATHOPHYSIOLOGY

- **Cardiovascular Disease:**
 - PM_{2.5} is a primary risk factor for MI, cerebrovascular disease, heart failure, hypertension, DM, arrhythmias, and VTE.
 - Short-term exposure → 1-3% increased risk of acute CV events.
 - Long-term exposure → ~10% increased risk (exacerbation of chronic conditions).
 - Mechanisms: Oxidative stress, inflammation (NF-κB), endothelial dysfunction, impaired EPC function, eNOS uncoupling, NADPH oxidase, Nitric Oxide, Peroxynitrite, TLR activation, adhesion molecules, platelet activation, thrombosis, and smooth muscle proliferation.

Respiratory Disease Pathophysiology

- **Climate Impact:** Higher temperatures increase burden of asthma, rhinosinusitis, COPD, and lung cancer.
- **Ultrafine Particle Mechanisms (PM_{0.1}):**
 - Innate Immunity: TNF-α → Cell barrier damage.
 - Adaptive Immunity: Activated T-cell.
 - Oxidative Stress: ROS + Fe²⁺ → MAPK, NF-κB, AP-1 activation.
 - Resulting conditions: Asthma, COPD, lung cancer, interstitial lung disease, lung fibrosis, acute lung injury.

Renal Disease Pathophysiology

- **Mesoamerican Nephropathy:** CKD in agricultural workers without standard risk factors (DM, HTN, HIV).

- **Pathways to Kidney Injury:**
 - Dehydration/Volume Loss → Hyperosmolarity (increased vasopressin and aldose reductase) + Crystalluria (urate) + Proximal tubular uptake of toxins from low renal blood flow.
 - Hyperthermia → Rhabdomyolysis + Primary organ dysfunction.
- **Contributing Factors:** Toxins (pesticides, heavy metals, silica) and heat-associated injury.

Pregnancy Pathophysiology

- **Environmental Exposure:** PM2.5, ozone, and heat exposure linked to preterm birth, low birth weight, and stillbirth.
- **Preterm Birth Mechanism:** Hematogenous transport of inhaled PM/chemicals → systemic inflammation.
- **Low Birth Weight Mechanism:** Altered maternal cardiac/pulmonary/renal function + placental inflammation + oxidative stress.
- **Stillbirth Mechanism:** Derangements in oxygen transport, DNA damage, and direct placental injury.
- **Heat-Specific Impacts:** Dehydration → altered thermoregulation, blood viscosity, uterine blood flow, placental-fetal exchange, and hormone release (prostaglandin/oxytocin).

CLINICAL FEATURES

- **Heat-Related Illnesses:**
 - Includes heat cramps, exhaustion, and heatstroke.
 - Urban Heat Island Effect: Driven by historical policies (redlining, racial covenants) → higher local temperatures.
- **Injury & Trauma:**
 - Higher frequency of intense storms → increased drowning, transportation accidents (due to impaired driving at high temps), and assaults (linked to alcohol/drug use).
 - Note: These are partially offset by fewer falls among the elderly in warmer years.
- **Mental Health Impacts:**
 - Displacement leads to anxiety, depression, and PTSD.
 - High temperatures linked to increased suicide rates and domestic violence.
 - Risk Factor: Psychoactive drugs can interfere with thermoregulation during heat events.
- **Medication Integrity:**
 - Extreme heat degrades active ingredients or impairs delivery in: Epinephrine, Naloxone, Insulin, and Albuterol inhalers.

DIFFERENTIAL DIAGNOSIS

- **Heat-related illness** vs. other causes of dehydration/electrolyte abnormalities.
- **CV events (air pollution)** vs. standard causes of MI, stroke, heart failure, HTN, DM, arrhythmias, and VTE.
- **Adverse pregnancy outcomes** vs. other causes of preterm birth, low birth weight, and stillbirth.
- **CKD in agricultural communities** vs. DM, HTN, glomerular disease, or HIV.

DIAGNOSTIC APPROACH

1. Air Pollution Exposure Assessment:

- Monitor ambient/indoor levels → assess PM2.5, ozone, and NO₂.
- Respiratory assessment: Pulmonary function tests, chest imaging (asthma, COPD, ILD).
- CV assessment: ECG, cardiac enzymes, echocardiography.

2. Heat-Related Illness Diagnosis:

- Clinical assessment of core temperature → hydration status → electrolyte balance.

3. Pregnancy Exposure Assessment:

- Standard obstetric assessment → assess PM2.5, ozone, and heat exposure history.

4. CKD in Agricultural Communities:

- Renal function tests + Urinalysis + Imaging → evaluate for heat/toxin exposure (pesticides, heavy metals).

MANAGEMENT & TREATMENT

1. Social Ecological Interventions:

- Face masks and air purifiers → Wear face masks and install air purifiers in homes.
- Reduce in-traffic exposures → Avoid commutes during rush hour.
- Reduce in-home penetration of outdoor air pollution → Use indoor air purifiers, close windows, use air conditioners.
- Lifestyle changes and preventive medicine → Exercise, healthy diet, screening programs.

2. Clinical Management Strategies:

- Heart Failure: Proactively adjust diuretics (especially diuretic-ACE inhibitor combinations) and increase potassium intake before summer or in heatwave areas → prevent dehydration.
- Medication Safety: Ensure proper storage for epinephrine, naloxone, insulin, and albuterol inhalers to prevent degradation/failure.
- Continuity of Care: Address risks of displacement interrupting access to medications and clinical care.

PROGNOSIS & COMPLICATIONS

- **Respiratory:** Increased hospital admissions and premature death from asthma, COPD, and lung cancer due to air pollution.
- **Cardiovascular:** Chronic low-grade inflammation → progression of heart failure and other cardiometabolic diseases.
- **Renal:** Progression to permanent kidney damage (Mesoamerican nephropathy) in agricultural workers.
- **Pregnancy:** Increased incidence of preterm birth, low birth weight, and stillbirth due to environmental stressors.

SPECIAL CONSIDERATIONS

- **Pregnancy:** High risk for adverse outcomes (preterm birth, low birth weight) from PM2.5, ozone, and heat.
- **Elderly:** Increased risk of heat-related illness; however, some data shows fewer falls in warmer years.

- **LMICs:** Disproportionately affected by undernutrition, malaria, and diarrheal diseases due to climate change.
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KEY PEARLS & HIGH-YIELD POINTS

- **PM2.5 Impact:** Short-term (1-3%) vs. Long-term (~10%) risk for acute CV events.
- **Mesoamerican Nephropathy:** Specific CKD in agricultural workers; caused by heat → dehydration/hyperthermia + toxins (pesticides, heavy metals).
- **Medication Safety:** Albuterol inhalers can explode or degrade in extreme heat; insulin and epinephrine are also compromised.
- **Proactive Management:** Adjust diuretics and potassium for heart failure patients *before* summer months to mitigate heat-related risks.