

CLIMATE DRIVERS	HAZARD	EXPOSURES	VULNERABLE GROUPS	HEALTH RISKS
Heat All Regions	Heat Events: <ul style="list-style-type: none">More frequentLonger durationMore extreme	Elevated temperatures	<ul style="list-style-type: none">People over age 65People over age 65 and living aloneChildren under age 5People with preexisting conditions:<ul style="list-style-type: none">DiabetesCardiovascular diseaseRenal system diseasePeople of color¹People working or exercising outdoorsPeople with limited English proficiency	<ul style="list-style-type: none">Heat ExhaustionHeat StrokeIllness or death due to cardiovascular diseaseIllness or death due to renal system failure
	Poor Outdoor Air Quality: <ul style="list-style-type: none">Increases in ozoneIncreases in particulate matterIncreased pollen productionLonger pollen season	Ozone, Particulate Matter	<ul style="list-style-type: none">People over age 65Children under age 5People with pre-existing conditions: asthma, COPD, respiratory allergies, cardiovascular diseasePeople working or exercising outdoorsPeople with limited English proficiency	<ul style="list-style-type: none">Respiratory arrestExacerbation of asthma and other lung diseaseExacerbation of allergies and respiratory infectionsReduction in childhood lung function development²
		Pollen	<ul style="list-style-type: none">People with allergiesPeople with asthma	<ul style="list-style-type: none">Exacerbation of asthmaAllergy symptoms
	Food-borne Illness	Spoiled food from refrigeration failure in transport/storage	<ul style="list-style-type: none">People over age 65Children under age 5Pregnant womenPeople with compromised immune systems	<ul style="list-style-type: none">Gastrointestinal illness
		Changes in patterns of <i>salmonella</i> growth	<ul style="list-style-type: none">People over age 65Children under age 5Pregnant womenPeople with compromised immune systems	<ul style="list-style-type: none"><i>Salmonella</i> infection
	Drought	Water quality degradation	<ul style="list-style-type: none">People over age 65Children under age 5Pregnant womenPeople with compromised immune systems	<ul style="list-style-type: none">Gastrointestinal IllnessNitrate exposureNaturally occurring arsenic and uranium exposure³
	Vectorborne Disease: <ul style="list-style-type: none">Longer seasonsExpanding rangesIncreased habitatHigher breeding rates	Ticks	<ul style="list-style-type: none">People working or exercising outdoorsPeople with pets that go outdoors	<ul style="list-style-type: none">Tick-borne illnesses (e.g. Lyme, Babesiosis, Anaplasmosis)
		Mosquitoes	<ul style="list-style-type: none">People working or exercising outdoors	<ul style="list-style-type: none">West Nile VirusEastern Equine Encephalitis
Heat and Increased Precipitation Combined All Regions	Biological Contamination of Water	Contact with water contaminated with fecal bacteria (e.g. <i>E. Coli</i> or <i>salmonella</i>) from runoff, flooding, or sewer overflow discharge ⁴	<ul style="list-style-type: none">People over age 65Children under age 5Pregnant womenPeople with compromised immune systems	<ul style="list-style-type: none">Skin infectionsEye infectionsWound infectionsGastrointestinal Illness
		Water or shellfish contaminated with Vibrio bacteria (e.g. <i>Vibrio vulnificus</i> , <i>Vibrio parahaemolyticus</i>) ⁵	<ul style="list-style-type: none">People over age 65Children under age 5Pregnant womenPeople with compromised immune systemsPeople with liver disease or ThalassemiaPeople who consume raw shellfishPeople who take medications that decrease stomach acid levels	<ul style="list-style-type: none">Gastrointestinal illnessWound infectionSepticemia (bloodstream infection)
		Contact with Algae Blooms (Cyanobacteria) ⁶	<ul style="list-style-type: none">Children under age 5People who boat or swim in fresh water lakes, ponds, and riversPets	<ul style="list-style-type: none">Gastrointestinal symptomsSkin and eye irritationNeurological damageLiver damage
		Contact with chemically contaminated water from flooding and runoff	<ul style="list-style-type: none">People over age 65Children under age 5Pregnant women	<ul style="list-style-type: none">Skin reactionsChronic Illness
	Chemical Contamination of Water			

Massachusetts Department of Public Health		Bureau of Environmental Health Climate Project		
CONCEPTUAL PATHWAYS FOR CLIMATE CHANGE HAZARDS AND HEALTH				
CLIMATE DRIVERS	HAZARD	EXPOSURES	VULNERABLE GROUPS	HEALTH RISKS
Flooding (inland and coastal) All Regions	All Flooding	Contaminated flood water (direct contact or flood-contaminated drinking water)	<ul style="list-style-type: none">• People over age 65• Children under age 5• Pregnant women• People with compromised immune systems• People with limited English proficiency	<ul style="list-style-type: none">• Skin infections• Eye infections• Wound infections• Trench foot• Gastrointestinal illness
		Debris/Physical hazards	<ul style="list-style-type: none">• Adolescents and Young Adults⁷• Utility workers• Rescue workers	<ul style="list-style-type: none">• Injury or death from debris, downed wires, drowning, falls, and motor vehicle crashes
		Loss of electricity, heat	<ul style="list-style-type: none">• People over age 65• People living alone• Children under age 5• People using medical equipment that requires electrical power or medications that require refrigeration	<ul style="list-style-type: none">• Carbon Monoxide (CO) Poisoning• Falls and injuries in the home• Medical emergencies due to loss of medical equipment function• Medical emergencies due to spoiled medications
		Relocation/Displacement	<ul style="list-style-type: none">• People over age 65• People with limited mobility• People under age 18• People with low socioeconomic status• People who rent their homes• People with limited English proficiency• People of color	<ul style="list-style-type: none">• Psychological stress• Financial loss stress• Loss of employment• Substance abuse
		Mold	<ul style="list-style-type: none">• Children under age 5• People with compromised immune systems or respiratory disease• People with Allergies• People with Asthma	<ul style="list-style-type: none">• Allergic reactions• Respiratory illness
	Tidal Flooding	Salinization of land leading to loss of shade cover and green space	<ul style="list-style-type: none">• People susceptible to heat-related illness (see groups vulnerable to heat events, page 1)	<ul style="list-style-type: none">• Heat-related illnesses (see heat related health risks, page 1)
		Salt intrusion into drinking water supplies	<ul style="list-style-type: none">• People with hypertension or other salt-sensitive illnesses/medications	<ul style="list-style-type: none">• Hypertension• Medication interactions
Extreme Weather All Regions	Damage to critical infrastructure	Loss of electricity, heat	<ul style="list-style-type: none">• People over age 65• People living alone• Children under age 5• People using medical equipment that requires electrical power or medications that require refrigeration	<ul style="list-style-type: none">• Hypothermia• Carbon Monoxide (CO) Poisoning• Falls and injuries in the home• Medical emergencies due to loss of medical equipment function• Medical emergencies due to spoiled medications
		Loss of water and sewer/septic utilities	<ul style="list-style-type: none">• People over age 65• Children under age 5• Pregnant women• People with compromised immune systems• People with limited English fluency	<ul style="list-style-type: none">• Gastrointestinal illness• Dehydration
		Damage to roadways	<ul style="list-style-type: none">• People over age 65• People living alone• Children under age 5• Pregnant women• People with limited mobility• People with chronic medical conditions requiring frequent care	<ul style="list-style-type: none">• Death or injury due to delayed emergency response• Motor vehicle accidents/injuries
	Direct storm impacts	Debris/Physical hazards	<ul style="list-style-type: none">• Adolescents and Young Adults⁷• Utility workers• Rescue workers	<ul style="list-style-type: none">• Injury or death from debris, downed wires, falling trees, falls, and motor vehicle crashes
<div>1. Hattis D, Ogneva-Himmelberger Y, Ratick S. The spatial variability of heat-related mortality in Massachusetts. Applied Geography 33 (2012) 45-52.</div> <div>2. Gauderman WJ, Avol E, Gilliland F, Vora H, Thomas D, Berhane K, McConnell R, Kuenzli N, Lurmann F, Rappaport E, Margolis H, Bates D, Peters J. The effect of air pollution on lung development from 10 to 18 years of age. N Engl J Med. 2004 Sep 9;351(11):1057-67.</div> <div>3. USGS Uranium and Arsenic Bedrock Well Study for Massachusetts on Mass.gov: https://www.mass.gov/service-details/arsenic-uranium-bedrock-well-study-location-lookup-for-arsenic-and-uranium</div> <div>4. Flood Waters or Standing Waters: Health Risks. Available from the US Centers for Disease Control: https://www.cdc.gov/healthywater/emergency/extreme-weather/floods-standingwater.html</div> <div>5. Vibrio vulnificus Infections and Disasters: Disaster Recovery Fact Sheet. Available from the US Centers for Disease Control: https://www.cdc.gov/disasters/vibriovulnificus.html</div> <div>6. Harmful algal blooms in fresh water bodies (Massachusetts DPH fact sheet). Available at Mass.gov: https://www.mass.gov/files/documents/2016/08/ww/algae-fresh-water-english.pdf</div> <div>7. Lowe D, Ebi KL, Forsberg B. Factors Increasing Vulnerability to Health Effects before, during and after Floods. Int. J. Environ. Res. Public Health 2013, 10, 7015-7067.</div>				