The Impact of Climate Change on Global Oncology

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KEYWORDS

• Climate change • Cancer • Disparities • Disaster • Emergency preparedness
• Environmental justice

KEY POINTS

- Climate-driven disasters can damage medical infrastructure, disrupt supply chains, hamper transportation, and interrupt access to life-saving cancer care (from prevention to survivorship care).
- Due to discriminatory policies and practices built on settler colonialism structures, such as austerity measures imposed on former exploited territories that are already grappling with environmental degradation from historical and current extractive economic practices (agriculture, mining, fossil fuel extractions, and so forth), the same communities already experiencing barriers in access to cancer care are also the most vulnerable to the threats of climate change.
- Our continuous reliance on fossil fuels is a shared cause of climate change and increased exposure to environmental hazards in communities targeted for marginalization.
- Engaging in climate change mitigation and adaptation efforts is a fundamental component of professionals committed to reducing the burden of cancer.

INTRODUCTION

Settler colonialism is defined as a system of oppression that involves the appropriation of indigenous life, land, and culture, with the goal of replacing these with settler life and culture. Settler colonialism created a structure of unbalanced resources and hazard distribution,[1,2] which is reflected in global patterns of health disparities, including premature deaths due to cancer. Health disparities are deleterious health differences affecting those subjected to systemic discriminatory or exclusionary social and/or economic obstacles to health[3,4] and includes global differences in premature cancer deaths.[5]

Cancer is one of the leading causes of death in Latin America and the Caribbean.[6] The most frequently discussed approaches for addressing the cancer burden have

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focus on access to screening, availability of diagnostics, delivery of high-quality cancer treatment and supportive care (psychological and survivorship care).[6–8] However, environmental exposures, including air pollution and water and soil contamination, are often overlooked as modifiable factors that worsen cancer risk (through increased exposure to carcinogens) and outcomes (through exposure to other health hazards and disruptions in access to cancer care).[9] For example, air pollution emitted from burning of fossil fuels, a well-established carcinogen,[10,11] is responsible for 1 in 5 deaths worldwide.[12]

Consumption of fossil fuels is also driving climate change, the most pressing environmental hazard of our time,[13,14] with significant implications for cancer control efforts.[9,15] For example, climate change alters the frequency and behavior of extreme weather events,[16] rendering it more difficult for communities to prepare for and respond to increasingly unpredictable circumstances (**Fig. 1**). For instance, warmer atmospheric temperatures increase the water capacity and decrease the speed of hurricanes and tropical storms,[16,17] resulting in unprecedented flooding when these systems stall after making landfall.[18]

Climate-driven extreme weather events can damage medical infrastructure (facilities, electronic medical records, and so forth),[19] break supply chains (such as damage from Hurricane Maria leading to IV bag shortages in the United States),[9] and disrupt transportation of medical staff and patients to health-care facilities,[20] leading to interruptions in access to potentially life-saving cancer care.[21] Patients with lung cancer in the United States whose facility was affected by a hurricane disaster during radiation treatment had worse overall survival than similar patients who completed treatment in the absence of disasters.[22] Cancer prevention and screening are also affected by climate-driven disasters. For example, human papillomavirus (HPV) vaccination

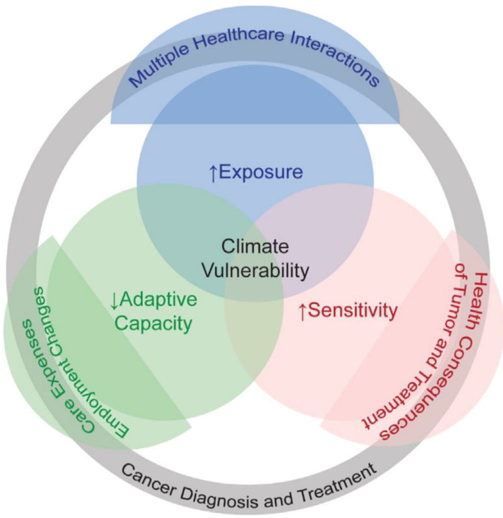

Fig. 1. Climate change and cancer. The physical, psychological, and socioeconomic consequences of cancer diagnosis and treatment exacerbate vulnerability to climate change due to increased risk of *exposure* (time spent outdoors commuting to medical appointments), increased *sensitivity* (cardiorespiratory sensitivities, inhibited thermoregulation as a side effect of some cancer treatment drugs increases sensitivity to extreme temperatures, immunosuppression increases sensitivity to infections common during flooding events, and so forth), and decreased *adaptive capacity* (inability to afford using air conditioner during heat waves, evacuating or stockpiling food, and so forth).

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decreased significantly in the months after Hurricane Maria made landfall in Puerto Rico,[23] and Hurricane Harvey flooded several chemical plants, oil refineries, and Superfund sites in the Houston ship channel, releasing large amounts of carcinogens and other environmental toxicants in the community.[24] Cervical cancer screening rates were also affected by climate-driven disasters in Puerto Rico.[25]

In addition to disruptions in access to care, individuals diagnosed with cancer are at an increased risk to the health threats invoked by climate change due to the physical, psychological, and socioeconomic consequences of cancer diagnosis and treatment (see **Fig. 1**).[9] For example, some cancer treatment modalities can result in a weakened immune system, which makes individuals more vulnerable to infections during flooding events.[26,27] Further, the psychological consequences of cancer diagnosis and treatment (stress, anxiety, depression, and so forth)[28,29] are similar to the psychological consequences of exposure to disasters (posttraumatic stress, anxiety, and depression),[30] leading to compounding mental health risks when patients with cancer and survivors are exposed to disasters.[31,32] Cancer diagnosis and treatment can also have socioeconomic consequences resulting from care-related expenses as well as changes in the ability of individuals diagnosed with cancer to maintain employment and income levels during and after cancer treatment.[33,34]

Moreover, our continuous reliance on fossil fuels is a shared cause of climate change and increased exposure to environmental hazards (including carcinogens), which undermine cancer control efforts. For example, individuals residing near natural gas extraction sites are exposed to air contaminated with benzene,[35–38] polycyclic aromatic hydrocarbons (PAHs),[39,40] and fine particulate matter,[41–44] all of which are established human carcinogens.[11,45,46] Crude oil processing, too, includes separation, distillation, and various types of cracking, blending, and extractions,[47] which can release benzene, arsenic, lead, chromium, PAHs, cadmium, and nickel into surrounding communities.[48,49]

In this commentary, we discuss how climate change threatens numerous steps of the cancer care continuum, how the unbalanced distribution of hazards and resources exacerbates cancer disparities and climate vulnerabilities, and how oncology professionals may work to mitigate such inequities, through identifying and implementing solutions with climate mitigation, cancer control, and health equity cobenefits. Throughout the article, we use content and language in line with environmental justice principles. We use terminology (such as “communities targeted for marginalization”) that centers the conditions imposed on communities as the root cause of disparities and avoids further oppressing these communities by implying that these are defining characteristics (as terms such as “marginalized communities” would).

CLIMATE CHANGE VULNERABILITY

Vulnerability to climate hazards is determined by differing levels of *exposure*, *sensitivity*, and *adaptive capacity* in the population.[50] As mentioned above, the physical, psychological, and socioeconomic consequences of cancer diagnosis and treatment can influence vulnerability to climate change. In addition to medical conditions, some sociopolitical structures also influence the determinants of climate vulnerability, placing some groups of people at higher risk for the threats of climate change. For example, a history of settler colonialism resulted in the current sociopolitical and economic structures that perpetuate the colonial reliance on extraction and dispossession for the production of capital and accumulation of wealth among privileged minorities.[2] These neocolonial structures of power and market practices uphold disparities in the distribution of hazards and resources, resulting in increased vulnerability (ie, increased

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exposure, increased sensitivity, and decreased adaptive capacity)[51] to the threats posed by climate change among individuals from communities targeted for marginalization.[52,53]

The compounding challenges posed by increased exposure, increased sensitivity, and decreased adaptive capacity among individuals diagnosed with cancer who are members of communities targeted for marginalization were exemplified by the impact of Hurricane Maria on cancer care in Puerto Rico,[54] as well as by the global challenges observed throughout the 2017 Hurricane season.[18]

Systemic disinvestment in the Puerto Rican community enabled the complete collapse of the electrical grid, communication infrastructure, and transportation network when Hurricane Maria made landfall.[54] Access to cancer care was disrupted throughout the island,[55] and without access to food, water, and shelter,[20] patients would not have been able to tolerate treatment, even if it was available.[56] Transferring care to other localities was problematic, too, due to geographic restrictions in state-sponsored health insurance coverage and out-of-network costs in private-sponsored insurance.[19] For each component of vulnerability to climate hazards (exposure, sensitivity, and adaptive capacity), we will discuss the compounding challenges posed by cancer and the historical influence of colonialism.

Exposure

Exposure is defined as human contact with environmental hazards.[50] Cancer prevention, screening, diagnosis, treatment, and survivorship care require several interactions with medical facilities, which increase the risk of exposure to climate-driven disasters.[9]

As such, the threats posed by exposure to climate-driven disasters vary by geographic region.[57,58] Disruptions in access to care due to hurricanes, for instance, are a prevalent threat for individuals residing in coastal areas and island territories in the Atlantic and Pacific tropical basins[59,60] because these geographic areas are more likely to be affected by hurricanes,[61] whereas wildfire activity, which is closely tied to temperature and drought (both altered by climate change), is increasing and expanding eastward in the United States,[62] leading to unanticipated circumstances in these affected communities.[63] Similarly, with climate-driven weakening of the temperature differential that stabilizes the polar vortex,[64] severe ice and snow storms are becoming more frequent, intensified, and posing threats (such as power outages) to communities farther south.[65]

However, geographic location is not the only factor contributing to the risk of exposure to environmental hazards.[66] Due to discriminatory policies and practices,[67] hazardous and polluting infrastructure is frequently sited in proximity to communities targeted for marginalization,[52,68] who have been deprived of the resources and political power necessary to oppose these developments.[69–73] For example, in the United States, regulatory governmental agencies are more likely to waive established environmental and public health safety criteria for siting of hazardous waste facilities in predominantly Black and Latinx communities.[74]

When disaster strikes, the hazards posed by extreme weather events are compounded by the hazards posed by environmental contaminants released from such polluting infrastructure.[24,75–78] For example, Hurricane Harvey's record water capacity (which climate change made 3.5 times more likely)[79] flooded chemical plants, oil refineries, and Superfund sites, releasing vast amounts of carcinogens and other contaminants into the surrounding predominantly Black and Latinx communities.[80,81] In the aftermath of Harvey, the Texas General Land Office (the state government entity responsible for distributing the US$9.3 billion in federal aid for communities could rebuild and better prepare for the next storm) implemented discriminatory practices

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that restricted access to these resources in predominantly Black and Latinx communities,[82] who still continue to be at higher risk of exposure to environmental hazards.[78]

Sensitivity

Sensitivity refers to the degree to which climate hazards affect humans.[50] Chronic diseases, such as cancer, and the side effects of its treatments, can increase sensitivity to the health hazards of climate change.[83] For example, some chemotherapy agents can inhibit thermoregulation, making patients with cancer more vulnerable to heatwaves.[84] Immunosuppression, another common side effect of cancer treatment, also increases the risk of infections, which are common during flooding events.[26,27]

Inequities in the distribution of health hazards and resources leads to disparities in prevalence of chronic health conditions associated with increased sensitivity to the threats of climate change in communities targeted for marginalization.[4,54] For example, colonial violence (including land theft, imposition of the reservation system, and damage of existing food systems) resulted in dramatic shifts in food consumption (including increased consumption of unhealthy food items distributed initially through rations and later through the commodity food program) among native peoples.[85,86] Similarly, systemic disinvestment resulted in limited access to healthy food outlets in predominantly Black neighborhoods.[87] Lack of access to health resources (such as nutritional foods), combined with increased exposure to health hazards (including hazardous infrastructure, as mentioned above, as well as a concentration of tobacco and alcohol outlets),[88–90] resulted in an increased prevalence of chronic health conditions among individuals in communities targeted for marginalization.[91]

Exacerbated sensitivity due to the increased prevalence of chronic health conditions (such as diabetes and chronic kidney disease)[92] among individuals in Puerto Rico,[93] for example, was a main contributor to the significant increase in illness and mortality in these populations in the aftermath of the 2017 Hurricane Maria.[94]

Adaptive Capacity

Adaptive capacity is the ability to cope with climate hazards.[50] Costs associated with cancer treatment and survivorship care, combined with challenges to participate in the workforce, are some of the ways in which a cancer diagnosis is associated with decreased adaptive capacity through increased financial hardship.[34] For example, financial hardship makes it harder for individuals to prepare and respond to disasters, such as securing the resources necessary for evacuating, stockpiling food, or improving housing infrastructure (using air conditioner during heatwaves or installing special air filters during wildfires).[50,95]

Similarly, individuals from communities targeted for marginalization have diminished adaptive capacity due to inequities in distribution of social, cultural, and economic capital and power.[96] For example, the economic and social circumstances imposed by austerity measures in Puerto Rico,[97] such as the Jones Act, which requires all maritime vessels arriving in Puerto Rico to come from US territories, increases prices of goods imported to the island by approximately 25% compared with mainland, one of the main factors contributing to the estimated 43% of individuals in Puerto Rico living under the US federal poverty line.[98] These policies, built on colonial laws,[99] also limit the ability of other nations to provide aid when disaster strikes, restricting the amount of resources that can be mobilized during crises and complicating disaster preparedness and response in the territory.[99]

In the United States, aid provided by the Federal Emergency Management Agency (FEMA), the government agency responsible for responding to and recovering from crises, is especially relevant for individuals diagnosed with cancer.[19] However, discriminatory

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policies and practices in FEMA's response and resource allocation abound,[54] with privileged communities being more likely to receive federal assistance following a disaster,[100] exacerbating disparities in adaptive capacity in the United States.

Similar inequities in adaptive capacity exist between countries.[68] As explained by Mia Mottley, the Prime Minister of Barbados, at the 26th Conference of Parties on climate (COP26), a history of colonialism created the current structure of economic dependence on tourism and imported goods that hinders the adaptive capacity of island territories in the Atlantic tropical basins (such as Puerto Rico, Barbados, and the Bahamas).[54,59,68] As mentioned previously, these territories are already at increased risk of exposure to climate-driven disasters,[101] and a legacy of settler colonialism structures of power and market forces resulted in former colonies being less likely to have access to the resources required for completing essential climate adaptation projects.[102,103]

Importantly, because communities targeted for marginalization are affected first and most from the threats of climate change, the solutions proposed by individuals in these communities are crucial for global climate mitigation and adaptation strategies.

PROPOSED SOLUTIONS

In November 2022, the United Nation agreed to establish a loss and damage fund in which historically exploitative economies would pay into to help exploited nations cope with the threats of climate change. Although major hurdles remain (eg, there is no guarantee exploitative economies will contribute to the fund, which exploited economies will receive the funds first, how will the money be used), this is an important step toward recognizing how to mitigate ways in which current structures of power perpetuate disparities in climate vulnerability.[2]

Of note, solutions proposed within the settler colonialism framework, such as those relating to carbon credit (through projects that enable land theft and force displacement of native populations)[2] and the new green agricultural revolutions (which enable environmental degradation through deforestation, contamination of soil and water with pesticides and fertilizers, as well as displacement and impoverishment of native communities),[104] will continue to exploit the vulnerabilities of disenfranchised communities,[105] propagate environmental injustice and health disparities,[106] and institutionalize exposure to environmental contaminants.[107] For example, all climate models uphold overconsumption of energy and goods by the privileged.[108] In order to sustain this overconsumption, proposed solutions (such as expanding rare mineral mining,[109] carbon credit, and carbon capture) will continue to amplify cancer disparities through disproportionate exposure to environmental hazards, increased sensitivity, and decreased adaptive capacity of individuals from exploited communities.[2]

Therefore, it is crucial that we center environmental justice and health equity in our climate mitigation and adaptation efforts.[103,110,111] One important component of just environmental and public health efforts (which include global climate treaties and large national policies but also climate-relevant efforts at our own institutions, communities, and personal lives), involves shifting from pathologized narratives of vulnerable populations as powerless (ie, needing solutions prescribed onto them) toward valuing the ingenious strategies and solutions coming from these communities because these solutions present potential benefits for the entire population.[51,53]

THE ROLE OF ONCOLOGISTS IN IDENTIFYING AND IMPLEMENTING SOLUTIONS

Given the significant threats posed by climate change to cancer control efforts, engaging in climate change mitigation and adaptation efforts is a fundamental component of all oncology-related professional activities (Fig. 2).

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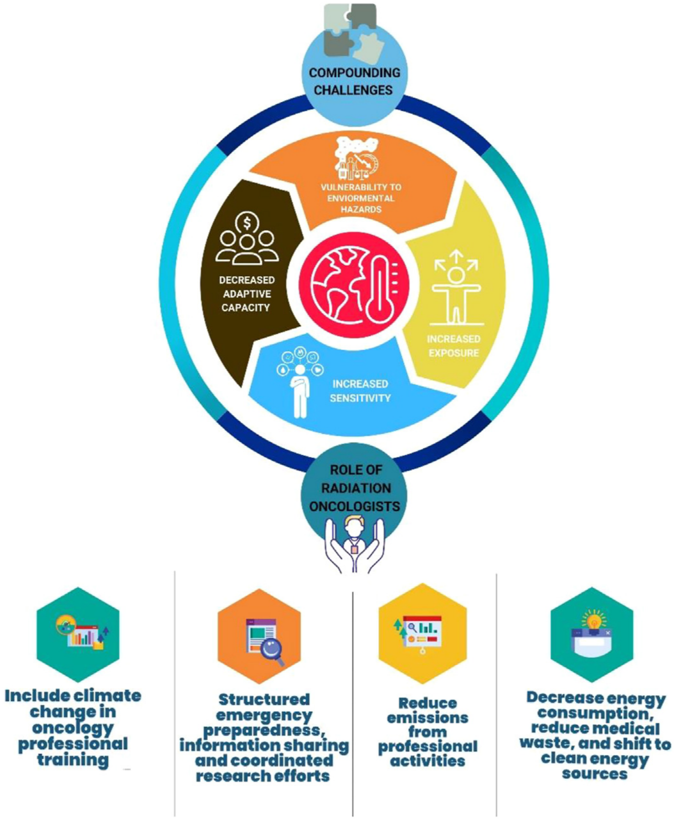

Fig. 2. Oncologists' contributions to climate mitigation efforts.

First, including climate change in all oncology professional training (from basic research to mental health,[31,112] from undergraduate programs to professional conferences)[113] would facilitate recognition of contemporary climate threats and accelerate knowledge advancement at the speed needed to tackle such a rapidly evolving crisis.[114]

Second, information sharing is extremely important. Structured approaches for sharing emergency preparedness and response information, including insights from postdisaster evaluation, are required to build on lessons learned from previous experiences and continuously improve climate adaptation efforts that protect the health and safety of patients, caregivers, and health-care providers.[19,55,115] Here again, lessons learned from communities affected first and most by the threats of climate change are vital. For example, the modifications in radiation oncology regimens that were developed to cope with electricity scarcity in the aftermath of Hurricane Maria in Puerto Rico were later adopted throughout the continental United States when the health-care system was overwhelmed with the demands of the coronavirus disease 2019 pandemic.[32,55]

Third, coordinated interdisciplinary multi-institutional research efforts focused on emergency preparedness for patients with chronic health conditions is urgently needed. For example, patients with cancer in Puerto Rico reported receiving no emergency preparedness plan information before Hurricane Irma or Hurricane Maria made

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landfall.[20] There is currently no ongoing research or funding opportunities for research focused on cancer-specific emergency preparedness, and less than 25% of National cancer Institute Designated Cancer Centers in the United States provide any emergency preparedness information on their websites.[116]

Importantly, emergency preparedness research must center the patients' needs (ie, patient-centered research questions and outcome measures) instead of centering specific cancer treatment modalities (ie, surgery vs, chemotherapy, vs, radiation therapy). For example, individuals undergoing breast and colorectal cancer treatment in Puerto Rico when Hurricane Maria hit reported that lack of access to basic needs (food, water, and shelter) resulted in patients choosing to delay resuming treatment even as health-care services were reinstated,[117] which was also reported by oncologists, who noted that without access to basic needs and under the severe physical and psychological stressors present in the aftermath of Hurricane Maria,[98] patients would not be able to withstand treatment even if it was available.[56] Further, Hurricane Maria was one of the deadliest disasters in US history due partly to interruptions in access to medical care, such as breathing machines, which failed when power was lost.[118] Since Hurricane Maria struck Puerto Rico and Hurricane Dorian struck the Bahamas (with similar detrimental consequences),[112] both nations have made strides in the construction of storm-resistant solar power installations, which would have allowed residents to maintain food and medicines safely refrigerated and have continuous access to medical devices that require electricity.

Therefore, centering the patients' needs and engaging with communities that have been developing expertise on adaptation to climate hazards for decades (ie, impacted first and most),[83] are both important for advancing knowledge on how to better protect the health and safety of cancer patients during disasters. Such patient-centered and inclusive research initiatives would avoid perpetuating disparities in epistemic power (ie, how ideas developed by a few privileged individuals shape efforts and interventions),[119] promote interdisciplinary collaboration (different oncology specialties working together to improve patient health instead of competing for resources), and expand the pool of knowledge available to identify solutions relevant to the entire population. For example, the strategy championed in Puerto Rico and the Bahamas to developed community-owned cooperatively managed microgrids, informed the recent waiver issued by the Centers for Medicare and Medicaid Services allowing health-care facilities to use microgrids as emergency power sources in the United States. Unlike diesel-power generators, microgrids do not rely on transportation of fuel (improving institutional resilience), have lower emissions, and decrease exposure of nearby communities to air pollution from burning diesel.

Oncology professionals can contribute to these climate mitigation and adaptation efforts, such as enhancing emergency preparedness efforts and reducing emissions from our professional activities.[114] This is especially relevant for oncologists residing in the United States. In fact, the United States remains the largest historical emitter of greenhouse gases,[120] and emissions from the US health-care system alone surpass emissions from the entire United Kingdom.[121] The UK National Health Service has been leading efforts in delivering environmentally responsible health-care services, and more than 50 countries committed to decreasing emissions at the COP26 meeting.[122] It is hopeful that recent legislation advancements in the United States, such as the Inflation Reduction Act, provide incentives and a path for reducing emissions from health care.[123]

Oncologists are well positioned to champion efforts that reduce emissions from health care because climate mitigation strategies have health cobenefits through reduction in exposure to fossil-fuel pollution in the population.[42,124,125] Such efforts

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include reducing energy consumption in health-care facilities (improving energy efficiency, implementing occupation-based strategies for heating, ventilation, and air conditioning, and so forth); conducting procurement and waste audits (such as those aimed at reducing plastic consumption); seeking environmentally responsible food manufacture, shipment, and waste options, and so forth.[9] Further, engaging and funding research innovation that ameliorates cost, environmental impact, and accessibility of cancer care (such as screening and diagnostic procedures) has tremendous climate and cancer control potential.[119]

Additionally, decreasing energy consumption, reducing medical waste, and other climate mitigation strategies also cut cost and are financially beneficial.[126] Gundersen Health, the first health-care system in the United States to achieve energy independence, also reduced waste management costs 10-fold by implementing sustainable practices.[126] At the University of Minnesota Medical Center, a waste reduction initiative that began by removing unnecessary items from IV port kits for chemotherapy, was later scaled up to the Operating Room, removing unused items from surgery kits with net savings of US$104,000 annually. Albert Einstein Hospital in Brazil significantly reduced institutional emissions and costs by diminishing the use of nitric oxide and fluorinated anesthetic gases that worsen the greenhouse effect more than a 1000-fold compared with carbon dioxide.

Finally, the siting of fossil fuel infrastructure is an environmental justice issue especially relevant to cancer control because it contributes to increased cancer risk (through increased exposure to carcinogens), worse cancer outcomes (through disruptions in access to care and increased exposure to health hazards),[22] and intensifies climate change (through greenhouse gas emissions).[127,128] Therefore, championing efforts to diminish our reliance on fossil fuels within the oncology profession,[129] such as decreasing consumption of petrochemical derivatives,[121] including plastics used in research and clinical care,[130,131] can decrease exposure to hazardous compounds that disproportionately impact communities targeted for marginalization,[52,132,133] and have implications for the entire population.[134] Further, adding a "climate lens" to basic science, epidemiologic, community, or clinical oncology research (eg, biomarkers of exposure, intermediate cancer outcomes, health consequences of exposure to pollution and proximity to fossil fuel infrastructure)[135–138] can expand the evidence base that informs decisions on whether to support local development of fossil fuel infrastructure.[77,139] Finally, supporting environmentally responsible policies, such as the global plastic treaty and the Clean Air Act in the United States,[140,141] is imperative for advancing cancer control and health equity efforts globally.[124]

SUMMARY

Climate change threatens cancer control efforts throughout the globe. Climate-driven extreme weather events lead to disruptions in access to cancer care, and individuals diagnosed with cancer are a vulnerable population to the health hazards of climate change. A legacy of settler colonialism in current power structures perpetuates inequities in the distribution of health hazards and resources through increased exposure, increased sensitivity, and reduced adaptive capacity, compounding the vulnerabilities of patients with cancer in communities targeted for marginalization. Therefore, engaging in climate mitigation and adaptation efforts, including enhancing emergency preparedness efforts and reducing emissions from the health-care system, are fundamental components of oncologists' missions in the era of climate change.

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CLINICS CARE POINTS

- Climate-driven disasters can result in disruptions in access to cancer care.
- Individuals diagnosed with cancer are a vulnerable population to the health threats of climate change due to the physical, psychological, and socioeconomic consequences of cancer diagnosis and treatment.
- There are no cancer-specific emergency preparedness resources for patients, caregivers, or providers.

DISCLOSURE

Nothing to disclose.

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