

REVIEW

Open Access



Climate change impact on the healthcare provided to patients

Sabah Al-Marwani^{1*}

Abstract

Background The last several years have shed light on the fact that changes in the global climate pose one of the greatest dangers to mankind and life on Earth. Even though a growing amount of attention is being paid to the acute consequences of climate change on human health, there is still very little that is recognized or understood about the impacts of climate change events on patient-related aspects, especially patient care and safety.

Aim This study aims to fill the gap in the literature and provide a comprehensive synopsis and critical investigation of the effects of climate change on patient care and safety.

Methodology This research is based on a narrative review which was more appropriate to provide a descriptive analysis of the topic of interest and to be suitable for the wide scope of the study. The research was conducted using several databases with no restriction on the date of the publication of searched documents and resulted in 34 articles which were then further assessed by removing any duplications and repetitions to have by the end 15 publications. The references of all included documents were further checked for additional relevant items. The study lasted for four months starting from 09/09/2022 to the last search date 10/01/2023.

Main results Losing access to healthcare facilities, shortage in drugs due to disruption of supply chains resulting from climate extreme events, infections spread, increasing occurrence of medical errors, the emergence of new diseases, raising many problems with the safety of drug use, increasing patients vulnerability, delay in cancer detection and management, and worsening prognosis of cancer cases, are examples of the catastrophic effects that climate change poses on the health and patients care.

Conclusions This study highlights the catastrophic impacts of climate change on patient care and safety and emphasizes the critical need for immediate action to reduce climate change and build more resilient healthcare systems.

Keywords Climate change, Drugs safety, Patient care, Healthcare, Medical errors, Infection spread, Patient safety, Cancer management

Background

Climate change is defined as long-term changes in temperature and weather patterns. These climatic events may be natural, yet human activities have been the primary

cause of climate change since the 1800s, mostly owing to the combustion of fossil fuels such as coal, oil, and gas, which emits heat-trapping gases (United Nations 2022). Several climate changes have the potential to worsen patients' physical and mental health, as well as expose them to new diseases they were not previously exposed to. According to research that investigated urban air pollution and related mortality trends in over 13,000 cities worldwide, nearly nine out of ten (86%) residents living in urban areas around the world are exposed to harmful

*Correspondence:

Sabah Al-Marwani
saalmarwani20@med.just.edu.jo

¹ Department of Public Health and Community Medicine, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan

particulate matter amounts, contributing to the 1.8 million excess deaths globally in 2019 (Southerland et al. 2022). In addition, abnormally hot weather and extreme heat waves can cause heat stroke and fatigue and aggravate chronic diseases. Globally, more than 5 million deaths each year are due to extreme hot and cold temperatures (Zhao et al. 2021). Global warming has been linked to an exacerbation of severity and increased mortality in patients with severe lung disorders such as asthma or chronic obstructive pulmonary disease (COPD). Respiratory morbidity and death are on the rise due to increases in greenhouse gas concentrations, air pollution, extended heat waves, forest fires, droughts, and floods (Bein et al. 2020). With every 1 °C rise in temperature in Portugal during the 2006 heat wave, COPD morbidity rose by 5.4%, mainly in women and those over 75 years old (Monteiro et al. 2013). However, to date, there has been a lack of studies explaining the outcomes of climate variability on patients, who are considered among the most vulnerable groups in the population. Hence, this study aims to fill the gap and provide a comprehensive synopsis and critical investigation of the effects of climate change on patient care and safety.

Materials and methods

This research is based on a narrative review since the studies assessing and investigating these effects are limited, and this design was highly preferred here for many reasons: (i) In order not to miss any of the articles explaining the impacts of climate change by such inclusion and exclusion criteria of a systematic review; (ii) A narrative review was more suitable to provide descriptive analysis in this understudied area; and (iii) The current review's broad scope, which makes it inappropriate to employ a systematic approach. A literature review was performed using several keywords such as "climate change," "patients' health," "patient care," "climate variability," "global warming," "heat waves," "extreme weather," "patient safety," and "health effects." The search was conducted through the following databases: PubMed, Web of Science, MEDLINE, PubMed Central, and Google Scholar. There were no restrictions on the date of the publication of searched documents in order not to miss any valuable information for this understudied area and to make the review as comprehensive as possible. This resulted in 34 articles which were then further assessed by removing any duplications and repetitions to have by the end 15 publications. The references of all included documents were further checked for additional relevant items. Recent reports of international organizations, as well as regulatory documents produced by environmental and health agencies, were also reviewed. The period of

conducting this research was four months starting from 09/09/2022 to the last date of the search on 10/01/2023.

Main text

The effects of climate change on patient care could be seen in several aspects and extend into different dimensions.

Access and supply chains shortage

Extreme climatic events like storms and floods could destroy or damage healthcare infrastructure, lowering healthcare quality and availability. These incidents also impair service delivery by interrupting supply chains, communication, and transportation, as well as leading to employee shortages (Salas et al. 2020). Affecting patients' access to healthcare and hospital evacuations are also other tragic consequences of extreme climate events. For instance, 6,300 patients were evacuated from New York City when a superstorm hit the East Coast (Gerwig 2022). Furthermore, supply chain shortages can occur due to the climate crisis. In Puerto Rico, home to a large manufacturer of saline, Hurricane Maria destroyed a saline production plant and led to a serious shortage of saline solution in the city and throughout the United States as well (Mazer-Amirshahi and Fox 2018). Such disruptions can lead to profound hospital losses, putting patient safety at great risk and consequently worsening the patients' outcomes. Moreover, power outages during periods of intense heat might result in hazardous scenarios when patients do not have access to cooling devices or medical supplies that require energy. Hospitals are forced to rely on backup generators, which sometimes may only be able to power some elements of an operation (Salas 2020). Individuals with chronic health problems or who need constant care for their disorder therapy and management are highly vulnerable to long-term interruptions in the electricity and supply chains caused by severe weather events.

Cancer management and prognosis

The most significant threat to the worldwide cancer burden may arise from the disruption of the intricate and integrated healthcare systems necessary for the detection, monitoring, and management of cancer (Nogueira et al. 2020). For instance, climate change is expected to indirectly affect HPV (Human Papilloma Virus) infection; which is believed to be one of the risk factors for cervical cancer. Extreme climatic disasters might easily interrupt and halt HPV screening, early diagnosis, and vaccination, particularly in low and middle-income countries where cervical cancer is most common (Hiatt and Beyeler 2020). In addition, radiation oncology services are often unable to function on backup generators; thus, power outages

arising from severe events or deliberate interruptions of the power supply, like those that occurred to reduce the danger of wildfires in California, might disrupt or delay cancer therapy. Climate-related interruptions in cancer therapy and patient care are also linked with lower treatment and survival results. Persons exposed to Hurricane Katrina, for example, had a lower 10-year breast cancer survival rate than those who were not exposed, and patients with locally advanced non-small-cell lung cancer had a lower overall life expectancy due to hurricane-related disruptions (Nogueira et al. 2019), as well as an increased risk of disease progression and mortality following storms and floods (Ryan et al. 2016).

Infection spread

A functionally effective ability to isolate patients with serious infections to protect others from becoming infected is required for successful infection control management; this infection is known as hospital-acquired or other treatment-related infections. During natural disasters such as floods or storms, patients' isolation may be difficult, and some patients may become infected by others. Furthermore, it is debatable whether the current critical care system is equipped to meet the increased needs associated with climate change, such as increased ICU bed capacity and supplies, as well as staff's quantitative and qualitative ability to deal with large numbers of patients and difficult scenarios, such as those with chronic diseases and heat stroke. All these obstacles will cause poor care quality and unprotected patient safety.

Medical errors

The way patient safety is managed in the caregiving unit significantly depends on the workplace environment. Patient safety depends on a positive work atmosphere. Improvements in working circumstances are required for boosting patient safety because the characteristics of hospital units are strongly connected with the unit's safety climate scores (Brubakk et al. 2021). And it is also well known that extreme climate events lead to increased admission rates and length of stay (Wondmagegn et al. 2021), which in turn would harm psycho-social working conditions by adding more load on health workers, reducing adequate supervision, having negative effects on the working environment, and further exposing them to greater risk of burnout and increasing medical errors (Bari et al. 2016), as well as finally deteriorating patient safety climate and competence. It is also noteworthy to indicate that climate change may lead to negative impacts on sleep. According to a systematic review digging into the association between global warming and sleep, including articles from many databases such as PubMed, Cochrane, and Scopus, for the period between 1980 and

2017, climate change presents a potentially major hazard to human sleep, from stress due to disaster leading to insomnia and poor air quality leading to breathing issues during sleep (Rifkin et al. 2018). This undoubtedly will raise other threats to the quality of life and health of people, medical professionals, workers, and patients in particular. Also, this might drop the concentration and relaxing mode of medical staff, leading to poor care services and more risks of making preventable medical errors.

The emergence of new diseases

Climatic events are also linked to some new emerging diseases. A recent study showed that in Central America, there was an outbreak of Mesoamerican Nephropathy, a chronic kidney disease with unknown causes that has been linked to repeated dehydration brought on by heat stress (Correa-Rotter et al. 2014). As a result, the emergence of such new, unknown diseases where medical staffs lack a clear idea and good practice to deal with and provide urgent care and support to patients will pose a tremendous challenge and seriously jeopardize the safety and lives of many patients.

Drugs safety

Drugs are always recommended to be stored under good conditions. During extreme heat waves, drugs, particularly those in non-well-powered care settings, may spoil due to the heat. When patients use those medicines, they put themselves in danger, either because they are less effective at treating them or because they cause unexpectedly serious adverse effects and consequences (Salas 2020). There are a lot of other deep and hidden issues linked to the impacts of extreme climatic events on medicines that might be given to patients. For instance, a recent study has linked rising temperatures to increasing antibiotic resistance in bacteria (MacFadden et al. 2018). Since climate change can also have negative effects on mental and physical health (WHO 2022), this might affect the compliance of many patients to take their prescribed, necessary medications regularly and correctly. Consequently, this might deteriorate their health, worsen their conditions, sometimes lead to premature death, and violate patients' safety (Kumar et al. 2021). The risk of heat-related diseases seems to increase during heat waves (Hopp et al. 2018). Extreme heat waves could highly threaten some patients, especially those with chronic diseases and comorbidities who have to use drugs to help them control their conditions. Some of these medications, such as diuretics and antipsychotics, may disrupt thermoregulation by, for instance, decreasing sweating or increasing urine

to regulate some chemicals inside the blood circulation (fluid and electrolyte balance). Consequently, this makes patients more sensitive, unable to withstand heat waves, and more likely to be at higher risk of heat-related hospitalization (Layton et al. 2020).

Patients' vulnerability

Heat waves can overwhelm the physiological adaptability of susceptible populations. Elderly people, who tend to have more diseases, have repeatedly been identified as the most vulnerable group (Fouillet et al. 2006). Heat-related mortality risks are exacerbated for persons with chronic diseases such as cardiovascular disease, respiratory disease (Ishigami et al. 2008), and obesity (Bar-Or et al. 1969). These problems lower the body's capacity to accommodate changes in the environment. Additionally, heat-related morbidity and mortality are more likely to occur when patients must conduct physical work in the heat. Therefore, heat waves might restrict the movements and physical activities of patients, which in turn might have deleterious effects on their health and worsen their chronic diseases.

Finally, recommendations and solutions for addressing this serious issue generally fall into two major categories: (1) actions toward limiting climate change, and (2) building more resilient healthcare systems. Climate change is a global concern and action such as shifting toward clean and renewable energy is one of the most important solutions for reducing climate change.

Building climate-resilient health systems includes investing in resources to prepare for climate change and implementing actions to direct health care's role to climate change and better preparedness for worst-case possibilities like heat stroke waves or communicable diseases epidemics. Moreover, as a result of power outages during extreme heat which can lead to dangerous scenarios, hospitals must rely on backup generators and many alternative safe sources. Furthermore, investing in renewable power sources for healthcare facilities and moving toward decarbonizing healthcare systems since the healthcare industry alone is responsible for 4.4% of the world's total emissions (Karliner et al. 2020). Investing in prevention strategies and promotional healthcare interventions will also benefit the most vulnerable communities by improving health, lowering morbidity and disease vulnerabilities, and significantly minimizing the burden on health systems. Healthier people are more resistant to threats. Healthcare workers should be provided with the appropriate and updated training and resources to execute adaptation and mitigation programs, particularly in areas that have already suffered significant environmental damage.

Conclusions

The effects of climate change represent a considerable risk to patients' health and care in several aspects. Losing access to healthcare facilities, shortage in drugs due to disruption of supply chains resulting from climate extreme events, infections spread, increasing occurrence of medical errors, the emergence of new diseases, raising many problems with the safety of drug use, increasing patients vulnerability, delay in cancer detection and management, and worsening prognosis of cancer cases, are examples of the catastrophic effects that climate change poses on the health and patients care. Therefore, this issue must be given more attention, and actions need to be taken to limit climate change and its disastrous consequences.

Abbreviation

HPV Human papilloma virus

Acknowledgments

Not applicable.

Author contributions

SA conceptualized the idea, performed the literature review, wrote drafts, and prepared the final manuscript. The authors read and approved the final manuscript.

Funding

This research did not receive any type of funding.

Availability of data and materials

Not applicable.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Received: 28 February 2023 Accepted: 4 April 2023

Published online: 11 April 2023

References

- Bari A, Khan RA, Rathore AW (2016) Medical errors causes, consequences, emotional response, and resulting behavioral change. *Pak J Med Sci* 32:523. <https://doi.org/10.12669/pjms.323.9701>
- Bar-Or O, Lundegren H, Buskirk E (1969) Heat tolerance of exercising obese and lean women. *J Appl Physiol* 26:403–409. <https://doi.org/10.1152/jappl.1969.26.4.403>
- Bein T, Karagiannidis C, Quintel M (2020) Climate change, global warming, and intensive care. *Intensive Care Med* 46:485–487. <https://doi.org/10.1007/s00134-019-05888-4>
- Brubakk K, Svendsen MV, Deilkås ET, Hofoss D, Barach P, Tjomsland O (2021) Hospital work environments affect the patient safety climate: a longitudinal follow-up using a logistic regression analysis model. *PLoS ONE* 16:e0258471. <https://doi.org/10.1371/journal.pone.0258471>

- Correa-Rotter R, Wesseling C, Johnson RJ (2014) CKD of unknown origin in Central America: the case for a Mesoamerican nephropathy. *Am J Kidney Dis* 63:506–520. <https://doi.org/10.1053/j.ajkd.2013.10.062>
- Fouillet A, Rey G, Laurent F, Pavillon G, Bellec S, Guihenneuc-Jouyaux C, Clavel J, Jouglu E, Hémon D (2006) Excess mortality related to the August 2003 heat wave in France. *Int Arch Occup Environ Health* 80:16–24. <https://doi.org/10.1007/s00420-006-0089-4>
- Gerwig K (2022) Climate change and healthcare: a complicated relationship. *Front Health Serv Manage* 39:4–10. <https://doi.org/10.1097/HAP.0000000000000148>
- Hiatt RA, Beyeler N (2020) Cancer and climate change. *Lancet Oncol* 21:e519–e527. [https://doi.org/10.1016/S1470-2045\(20\)30448-4](https://doi.org/10.1016/S1470-2045(20)30448-4)
- Hopp S, Dominici F, Bobb JF (2018) Medical diagnoses of heat wave-related hospital admissions in older adults. *Prev Med* 110:81–85. <https://doi.org/10.1016/j.jypmed.2018.02.001>
- Ishigami A, Hajat S, Kovats RS, Bisanti L, Rognoni M, Russo A, Paldy A (2008) An ecological time-series study of heat-related mortality in three European cities. *Environ Health* 7:1–7. <https://doi.org/10.1186/1476-069X-7-5>
- Karliner J, Slotterback S, Boyd R, Ashby B, Steele K, Wang J (2020) Health care's climate footprint: the health sector contribution and opportunities for action. *Eur J Pub Health* 30(ckaa165):843
- Kumar A, Mohammadnezhad M, May W (2021) Patients' perception of factors influencing noncompliance with medication among cardiac patients in Fiji: a qualitative study. *Patient Preference Adherence*. <https://doi.org/10.2147/PPA.S322731>
- Layton JB, Li W, Yuan J, Gilman JP, Horton DB, Setoguchi S (2020) Heatwaves, medications, and heat-related hospitalization in older Medicare beneficiaries with chronic conditions. *PLoS ONE* 15:e0243665. <https://doi.org/10.1371/journal.pone.0243665>
- MacFadden DR, McGough SF, Fisman D, Santillana M, Brownstein JS (2018) Antibiotic resistance increases with local temperature. *Nat Clim Change* 8:510–514. <https://doi.org/10.1038/s41558-018-0161-6>
- Mazer-Amirshahi M, Fox ER (2018) Saline shortages—many causes, no simple solution. *N Engl J Med* 378:1472–1474. <https://doi.org/10.1056/NEJMp1800347>
- Monteiro A, Carvalho V, Oliveira T, Sousa C (2013) Excess mortality and morbidity during the July 2006 heat wave in Porto, Portugal. *Int J Biometeorol* 57:155–167. <https://doi.org/10.1007/s00484-012-0543-9>
- Nogueira LM, Sahar L, Efsthathiou JA, Jemal A, Yabroff KR (2019) Association between declared hurricane disasters and survival of patients with lung cancer undergoing radiation treatment. *JAMA* 322:269–271. <https://doi.org/10.1001/jama.2019.7657>
- Nogueira LM, Yabroff KR, Bernstein A (2020) Climate change and cancer. *CA Cancer J Clin* 70:239–244
- Rifkin DI, Long MW, Perry MJ (2018) Climate change and sleep: a systematic review of the literature and conceptual framework. *Sleep Med Rev* 42:3–9. <https://doi.org/10.1016/j.smrv.2018.07.007>
- Ryan BJ, Franklin RC, Burkle FM, Watt K, Aitken P, Smith EC, Leggat P (2016) Defining, describing, and categorizing public health infrastructure priorities for a tropical cyclone, flood, storm, tornado, and tsunami-related disasters. *Disaster Med Public Health Prep* 10:598–610. <https://doi.org/10.1017/dmp.2016.3>
- Salas RN (2020) The climate crisis and clinical practice. *N Engl J Med* 382:589–591. <https://doi.org/10.1056/NEJMp2000331>
- Salas RN, Friend TH, Bernstein A, Jha AK (2020) Adding a climate lens to health policy in the United States: commentary explores how healthcare policymakers can integrate a climate lens as they develop health system interventions. *Health Aff* 39:2063–2070
- Southerland VA, Brauer M, Moheg A, Hammer MS, Van Donkelaar A, Martin RV, Apte JS, Anenberg SC (2022) Global urban temporal trends in fine particulate matter (PM_{2.5}) and attributable health burdens: estimates from global datasets. *Lancet Planet Health* 6:e139–e146. [https://doi.org/10.1016/S2542-5196\(21\)00350-8](https://doi.org/10.1016/S2542-5196(21)00350-8)
- United Nations (2022) Climate action. <https://www.un.org/en/climatechange/what-is-climate-change>. Accessed 2 January 2023
- WHO (2022) Why mental health is a priority for action on climate change. <https://www.who.int/news/item/03-06-2022-why-mental-health-is-a-priority-for-action-on-climatechange#:~:text=The%20IPCC%20revealed%20that%20rapidly,%2C%20grief%2C%20and%20suicidal%20behaviors>. Accessed 5 January 2023
- Wondmagegn BY, Xiang J, Dear K, Williams S, Hansen A, Pisaniello D, Nitschke M, Nairn J, Scalley B, Xiao A (2021) Increasing impacts of temperature on hospital admissions, length of stay, and related healthcare costs in the context of climate change in Adelaide South Australia. *Sci Total Environ* 773:145656. <https://doi.org/10.1016/j.scitotenv.2021.145656>
- Zhao Q, Guo Y, Ye T, Gasparrini A, Tong S, Overcenco A, Urban A, Schneider A, Entezari A, Vicedo-Cabrera AM (2021) Global, regional, and national burden of mortality associated with non-optimal ambient temperatures from 2000 to 2019: a three-stage modeling study. *Lancet Planetary Health* 5:e415–e425. [https://doi.org/10.1016/S2542-5196\(21\)00081-4](https://doi.org/10.1016/S2542-5196(21)00081-4)

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Submit your manuscript to a SpringerOpen® journal and benefit from:

- Convenient online submission
- Rigorous peer review
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

Submit your next manuscript at ► [springeropen.com](https://www.springeropen.com)