



Research for Action on Climate Change and Health in the Caribbean: **A Public, Private, People's and Planetary Agenda**

Caroline F. Allen¹, Renée M. West¹, Georgiana Gordon-Strachan², Saria Hassan³,
Shelly McFarlane², Karen Polson-Edwards⁴, Audreyanna Thomas⁴, C. James
Hospedales^{5*}, Robert Dubrow^{6*}



¹Blue Sky Development Consulting

²Caribbean Institute for Health Research, The University of the West Indies

³Rollins School of Public Health, Emory University

⁴Pan American Health Organization

⁵EarthMedic and EarthNurse Foundation for Planetary Health

⁶Yale Center on Climate Change and Health, Yale School of Public Health

*Co-chair

Suggested citation: Allen CF, West RM, Gordon-Strachan G, Hassan S, McFarlane S, Polson-Edwards K, Thomas A, Hospedales CJ, Dubrow R. Research for Action on Climate Change and Health in the Caribbean: A Public, Private, People's and Planetary Agenda. Research for Action on Climate Change and Health in the Caribbean Project, 2024.



DOMAIN 1: CLIMATE CHANGE HEALTH IMPACTS, EXPOSURES AND VULNERABILITY

4. NONCOMMUNICABLE DISEASES AND RISK FACTORS

4.1. WHAT IS HAPPENING?

Since the beginning of the twenty-first century, noncommunicable diseases (NCDs) have accounted for approximately 75% of all deaths in the English- and Dutch-speaking Caribbean. The three leading causes of death are cerebrovascular disease, diabetes and ischaemic heart disease (CARPHA, 2017, 2020).

Higher temperatures associated with climate change can cause a number of NCD-related health difficulties. The human cardiopulmonary system is sensitive to changes in temperature. Viscosity of blood increases when temperatures are higher, which can lead to high blood pressure and heart rate – known risk factors for cardiovascular disease events such as heart attacks, strokes and other vascular events. Concurrent acute and chronic respiratory conditions can be aggravated by temperature changes, which can cause constriction of the bronchial tubes (Ebi et al., 2006; Kjellstrom et al., 2010; McMichael et al., 2003). Dehydration caused by exposure to high temperatures can cause kidney stones or acute kidney failure.

Higher temperatures can result in less outdoor physical activity, contributing to increased NCD incidence. Increasing minimum temperatures, which interfere with overnight recovery from heat stress in vulnerable people living with NCDs, may exacerbate NCDs. Adults who suffer from preexisting cardiovascular and pulmonary disease, the elderly, children and outdoor workers are particularly vulnerable to increased air temperatures. People living in cities are subject to the “urban heat island effect”, which further multiplies the effects of hotter weather (Campbell-Lendrum and Corvalán, 2007). Older people, among whom there is a higher prevalence of NCDs, are particularly vulnerable to higher ambient air temperatures, which can result in cognitive impairments (Yi et al., 2021).

Extreme weather events and increased ambient air temperatures have been found to increase mortality and morbidity among people with underlying heart disease or diabetes (Evans et al., 1993; Martinez-Lozano et al., 2021; R4ACCHC, 2023a; Zilbermint, 2020). It has been demonstrated that vasodilation, which allows people to adapt to high or low temperatures, is severely compromised in older populations and people with diabetes. Some medication taken by people with NCDs affect their thermoregulation capacity, thus preventing the ability to transfer heat from the body to the environment (Xu et al., 2019).

Longer term degradation of local fisheries and the agriculture sector due to climate change may result in increased dependence on imported high-calorie, high-sodium, high-sugar, low-micronutrient processed foods, contributing to increased NCD incidence and the exacerbation of existing cases. Extreme weather events can also reduce access to nutritious foods for months or even years, thus perpetuating dependence on unhealthy imported foods. For example, in 2017 Hurricane Maria caused the loss of 100% of crops in Dominica (Buenfil, 2021; CARPHA, 2018; Dubrow, 2021; Gordon-Strachan, 2021).

Increased episodes of asthma and chronic respiratory disease can be caused by degradation of air quality associated with climate change. For instance, fires and smoke are associated with hotter weather and drought, and the toxicity of emissions from vehicles is exacerbated in hot weather. Dust from damaged infrastructure and trees, the burning of debris following a hurricane and the Saharan dust that blows across the Atlantic Ocean can lead to further air pollution (Allen et al., 2019; Akpinar-Elci et al., 2015; Cadelis et al., 2014; Hambleton, 2008). See Chapter 5, “Air quality”.

Extreme weather events also put a strain on the running of, and access to, health facilities and healthcare services. High winds associated with hurricanes may lead to power outages affecting essential services, including refrigeration for the storage of medication. Other technologies, such as dialysis machines and radiotherapy

treatment for cancer patients, may also be compromised. Roads are often blocked by fallen trees, landslides or flooding, thus preventing patients from reaching health facilities (CARPHA, 2018; Martinez-Lozano et al., 2021; Ryan et al., 2015). Other challenges include problems accessing remote medical advice due to telephone and internet outages, and reliance on ad hoc volunteers and external assistance (Cruz-Cano and Mead, 2019; Hassan et al., 2020; Joshipura, 2021).

Surveillance data on select health conditions, including some NCDs, are collected at the national level by health ministries. These include mortality data on diabetes, cerebrovascular disease, ischaemic heart disease, other cardiovascular diseases, hypertensive heart disease and malignant neoplasms. The Caribbean Public Health Agency (CARPHA), the Pan American Health Organization (PAHO) and the Caribbean Institute for Meteorology and Hydrology (CIMH) produce a quarterly Caribbean Health Climatic Bulletin, which includes advice for people with specific conditions. The Caribbean Institute for Health Research (CAIHR) at the University of the West Indies (UWI) in Jamaica has established a climate and health observatory to examine the linkages between weather and health. This will include examining retrospective data on hospital admissions of patients with cardiovascular diseases and other chronic diseases. Projections will also be made to provide early warnings. Chronic disease registries are currently being set up in several Caribbean countries. CAIHR is also working with the George Alleyne Chronic Disease Research Centre (GA-CDRC) to analyse associations between climate change and strokes by using data from the Barbados National Stroke Registry (Allen et al., 2021).

Limited studies of climate and health relating to NCDs have been conducted in the Caribbean. One area of study has been the relationship between asthma incidence and increased dust, including Saharan dust (Akpinar-Elci et al., 2015; Cadelis et al., 2014; Hambleton, 2008; Prospero et al., 2008). These studies are detailed in Chapter 5, “Air quality”.

The incidence of diabetes may have increased in Puerto Rico following Hurricanes Irma and Maria. People with diabetes also experienced difficulties in obtaining their medication and accessing health care after these hurricanes, but one study showed that this did not result in a significant increase in average blood glucose levels or uncontrolled diabetes (Martinez-Lozano et al., 2021). In the United States Virgin Islands, it was found that surges in the incidence of childhood type 1 diabetes occurred in 1984 and 2005, when there was unusually high rainfall with lower than normal temperatures (Tull and Yarandi, 2017). Other climatic changes such as extreme weather events and rising temperatures were also demonstrated to be risk factors for mortality and morbidity among people living with diabetes, especially those with cardiovascular complications (Zilbermint, 2020).

Institutional capacity for NCD research is strong in the Caribbean, but climate change has not been firmly integrated into NCD research programmes and projects. CAIHR at UWI has conducted substantial research on NCDs and has a dedicated research centre, the GA-CDRC. This centre has conducted research on food systems and security and the prevention of NCDs in the political and economic contexts. The Windward Islands Research and Education Foundation (WINDREF) has conducted research on the management of NCDs (Allen et al., 2021), but only a very small portion of this research has looked specifically at climatic factors affecting NCD risk.

4.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Increase knowledge of risks and their management pre- and post-disaster among people living with noncommunicable diseases

In the immediate aftermath of an extreme event such as a hurricane, access to health services, transport and refrigeration for medical supplies, and the availability of clean water and nutritious food can be substantially reduced. Therefore, it is vital that people living with NCDs, vulnerable populations such as the elderly and people with disabilities, and people at risk of developing NCDs know how to manage their condition and mitigate the risk of developing NCDs in the future. They should also be provided with information on emergency measures that are in place locally (as per the recommendations below) to enable them to access medication, medical care and nutritious food (Hassan et al., 2020; Kim and Hassan, 2021; R4ACCHC, 2023b). Tailored communication strategies should be developed, including strategies employing sign language and braille materials.

Develop climate and health information tailored to reducing risks related to noncommunicable diseases in the context of climate change

Information and health communication products on the climate-related risks specific to each NCD should be developed. For example, fact sheets can be developed for people with congestive heart failure on the risks associated with heat, air quality and extreme weather events, and how to reduce these risks.

Civil society organisations can play a critical role in developing communication products based on the lived experience of people living with NCDs and communicating the information directly to vulnerable communities such as indigenous people and people with disabilities. For instance, fact sheets on diabetes and climate change can be created, with information on the specific climate-related risks facing people living with diabetes and how to reduce them. Levels of education, age and cultural issues such as religion and language need to be taken into consideration when developing knowledge products. Dissemination can be sector specific. For example, the Caribbean Hotel and Tourism Association could disseminate NCD-specific climate and health information to its members through webinars. Different working groups could be created for different communities/sectors to lead on the development of such information. The media and other communication specialists should be involved (R4ACCHC, 2022a,b, 2023c).

These information products can be further adapted to take account of gender- and age-specific risks. The WHO STEPwise approach to NCD risk factor surveillance surveys in 14 Caribbean countries and territories¹ found major differences between genders in terms of NCD risk: men were more physically active and more likely to have high blood pressure and/or smoke, whereas women were more likely to be overweight or obese (although there were high rates of overweight and obesity among both sexes). The different physiology of men, women and older people affects their physical reactions to climate-related factors, such as extreme heat and changes in the supply of nutritious food. It is important to develop tailored health-promotion programmes based on knowledge of the susceptibilities of both sexes and older people to climate stressors, taking account of both lifestyle factors (e.g. exercise types and levels) and physiological differences (CARPHA, 2020).

¹Countries that have conducted the WHO STEPwise survey or equivalent: Anguilla, Aruba, the Bahamas, Barbados, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

Structural/governmental and private sector actions

Train healthcare professionals on the links between climate change and noncommunicable diseases, and the management of health care following extreme events

Medical professionals need to be trained on the health impacts of environmental factors affected by climate change, such as air pollution and water quality, on NCDs as part of their regular learning curriculum. During training, special attention should be given to delivering medical response to people living with NCDs following extreme events and integrating NCDs into disaster preparedness. This training can be carried out in collaboration with national and regional academic institutions (R4ACCHC, 2023c).

Include management of noncommunicable diseases in national disaster preparedness and recovery plans

An island-wide survey in Puerto Rico following Hurricane Maria in 2017 found that many people had disrupted access to health care due to factors such as inability to obtain medicines, inability to use respiration equipment, damaged roads and other barriers to transportation, closed facilities and unavailability of doctors. This helped to explain why the number of deaths in Puerto Rico during the three and one-half months following the hurricane was 62% higher than during the same period in the previous year (Kishore et al., 2018). It is believed that 37% of excess deaths in the two months after Maria were due to complications from heart disease and diabetes (Cruz-Cano and Mead, 2019).

Strategies to address these challenges include the following:

- Ensure access to adequate supplies of commonly used medications through a centralised pharmacy registry; raise awareness of locations where medication will be available; increase the use of pharmacies as medication and supply distribution centres, and the availability of pharmacists to distribute them; and provide a list of alternative medications that patients could use if they are unable to get their usual prescriptions.
- Communicate with people living with NCDs before and after an extreme event to ensure that they have information on how to obtain medical care and supplies. People living with NCDs should be provided with access to and/or advice on forms of communication able to withstand extreme events, so that they are able to obtain information after an extreme event even if the electricity supply and/or internet connection have been disrupted. For instance, they can obtain radios and batteries and be advised on which channels to tune into; public health personnel may need to visit people living with NCDs in person or communicate with communities via loudhailer/loudspeaker (R4ACCHC, 2023b,c).
- Include guidance on the management of people living with NCDs and their access to medication and food in protocols for hurricane shelters (CARPHA, 2018; Hassan et al., 2020; R4ACCHC, 2022c).

It is important to use an inclusive and “all-of-society” approach when developing these plans and to include people from the government ministries responsible for the environment, local government, works and transport, communications, finance and, of course, health. People on the ground can contribute to the design of approaches that are appropriate and effective in their circumstances. Therefore, it is important to include community leaders, workers and local businesses, and also young people, older people, indigenous people, religious communities and migrants. In addition, people living with NCDs and the civil society organisations that represent them must be involved in developing those parts of plans relating to the health and well-being of people living with NCDs, pre- and post-extreme events. It is necessary to build capacity to develop such plans, particularly at the community level (R4ACCHC, 2023c). The World Diabetes Foundation has supported the Organisation of Eastern Caribbean States (OECS) to develop a project that will address and mitigate risks from natural disasters and the subsequent disruption of health care for people with diabetes and other NCDs (see Box 1).

Box 1: Mitigating the risks from natural disasters and the subsequent disruption of health care for people living with noncommunicable diseases

In 2019, the OECS, through its health unit and the health ministries of its Member States, received funding to implement the “Diabetes in Disasters in Eastern Caribbean Island States” project. Its partners include CARPHA and WINDREF. This project aims to address and mitigate the risks from natural disasters and the post-disaster disruption of health care for people with diabetes and other NCDs. The project is ongoing. Activities have included (World Diabetes Foundation, n.d.):

- Establishing a project steering committee consisting of health authorities and other key local/regional stakeholders from all participating Member States;
- Assessing health outcomes for people with diabetes/NCDs for the two years following the 2017 Hurricanes Irma and Maria using existing records with clinical indicators;
- Using video documentation of the initial health system response and lessons learned as a regional advocacy tool;
- Training healthcare professionals in disaster preparedness and response for vulnerable people with diabetes/NCDs;
- Updating national and regional response plans and shelter management tools to include response to vulnerable people with diabetes/NCDs;
- Establishing patient registers (integrated with existing health management information systems) with clinical indicators for improved disaster preparation and response;
- Developing and piloting a new OECS electronic patient record in two selected island states to improve continuity of care for patients moving within or outside the region following a natural disaster.

Source: World Diabetes Foundation (n.d.).

Use World Health Organization noncommunicable disease kits in the aftermath of a natural disaster

The World Health Organization (WHO) has developed NCD kits (NCDKs) to be used in the aftermath of natural disasters. Each kit has sufficient supplies to support the care of up to 10 000 people living with NCDs for three months. The kit includes oral medicines, basic diagnostic equipment, restocking supplies for single use items, products requiring refrigerated transport and storage (i.e., “cold chain”) such as insulin and accompanying treatment guidelines. Only medicines in the WHO Model List of Essential Medicines are included. There are five different modules within each kit. The modules can be ordered separately depending on need, available resources and logistics in the field. The modules are as follows (WHO, 2017):

- Module 1 – medicines only, not including cold-chain insulin (for 10 000 people lasting three months);
- Module 2 – cold-chain medicines only, including insulin (for 10 000 people lasting three months; requires availability of an adequate cold chain);
- Module 3 – items including plasters, gloves, cotton wool, urinary test strips, disinfectant swabs (for 10 000 people lasting three months);
- Module 4 – supplies, e.g. blood lancets, needles, blood test strips, valve mouth pieces, batteries (for the equipment in Module 5);
- Module 5 – equipment, e.g. blood glucose monitors, stethoscope, sphygmomanometer, otoscope and ophthalmoscope set, batteries, thermometer (can last longer than three months).

In 2020, key Caribbean stakeholders were interviewed about the NCDKs and indicated that they were acceptable and that it was feasible to use them to assist people with NCDs following extreme events. Stakeholders

underlined the need for integrated work between disaster response agencies and agencies caring for people with NCDs, and the need to consider the logistics of training, storage, distribution, cost-sharing and redistribution of unused medication (Hassan et al., 2021).

Develop and implement communication and other tools for disaster preparedness for people living with noncommunicable diseases

Tools to facilitate disaster preparedness among people living with NCDs should be developed and implemented in the Caribbean (R4ACCHC, 2023b). The approach and checklist of the Juvenile Diabetes Research Foundation and the Diabetes Disaster Response Coalition of the United States of America can be adapted by individual countries or regionally for various NCDs. The Juvenile Diabetes Research Foundation and the Diabetes Disaster Response Coalition collaborated to form the Diabetes Disaster Relief Coalition, which ensures that people with diabetes have support, sufficient insulin and sufficient supplies before a major storm or hurricane. This coalition created a “patients’ preparedness plan”, which includes a disaster preparation emergency checklist, and also created information resources on how to locate a shelter, discard sharps, request diabetes care in an emergency or disaster and store insulin safely (JDRF, n.d.; Zilbermint, 2020). While this information improves individual-level preparedness, its dissemination in an organised and effective way requires national and regional reach. This approach can be either a civil-led initiative as in the United States of America or government-led as in the case of the Diabetes in Disasters in Eastern Caribbean Island States project coordinated by ministries of health in OECS Member States (World Diabetes Foundation, n.d.).

Address the main risk factors for noncommunicable diseases

Addressing the main risk factors for NCDs can reduce the burden of poorly managed NCDs and the prevalence of NCDs. This will, in turn, reduce the impact of climate change on health. Since the 2007 Declaration of Port of Spain, “Uniting to Stop the Epidemic of Chronic NCDs” (CARICOM, 2007), Caribbean governments have been involved in setting up mechanisms such as national NCD commissions and implementing strategies for prevention and control of NCDs, including addressing the main risk factors.

The main risk factors for NCDs include alcohol consumption; smoking tobacco; physical inactivity; poor nutritional habits, including diets high in salt, sugar and fat and low in fresh fruits and vegetables; and being overweight or obese. Dependency on food imports, many of which are high in sugar and fat, is one of the factors that place people in SIDS at risk of NCDs in the context of climate change (see Chapter 12, “Agriculture and food safety and security”, for more information) (R4ACCHC, 2022d). Several Caribbean countries have sought to reduce diet-related risks by implementing taxes on sugar-sweetened beverages (e.g. Antigua and Barbuda, and Barbados) (R4ACCHC, 2022b), and efforts are under way to provide front-of-packaging warning labels on processed food products to notify consumers of dietary ingredients that can increase the risk of NCDs, with the Healthy Caribbean Coalition providing assistance to several Caribbean countries (HCC, 2021; R4ACCHC, 2023c). All Caribbean countries should sign up to the WHO Framework Convention on Tobacco Control, one of the world’s most adopted international treaties (WHO, 2003). In the context of climate change, it is particularly important to implement these types of measures to address risk factors.

It is important to recognise that some actions to promote healthier lifestyles have co-benefits for climate change mitigation and adaptation, such as the provision of additional green spaces, more shaded pathways to promote physical activity (R4ACCHC, 2022b) and the promotion of less meat consumption. Chapters 15, “Climate-friendly health-promoting infrastructure”, and 5, “Air quality”, include further details of climate change mitigation measures with health co-benefits relating to NCDs.

Research gaps and how to address them

Evaluate the impact of disaster preparedness on noncommunicable disease outcomes and develop evidence-based strategies to reduce the impact of disasters on noncommunicable diseases

There are associations between hurricane preparedness and the impact of hurricanes on health. In a study in Puerto Rico following Hurricane Maria that involved people who were obese, overweight and/or had diabetes, those who were prepared to a low to medium level were twice as likely to suffer harmful health impacts than people who were highly prepared. Furthermore, people whose diet changed as a result of power outages, financial challenges and/or disruption to their drinking water supply were significantly more likely to experience detrimental health impacts (Joshipura, 2021). Similar studies with people living with NCDs could be conducted in the wake of other extreme events. Such studies should compare the cost of the health impacts in cases when there is no preparedness with cases of different levels of preparedness (Zilbermint, 2020). Results from these evaluations should be used to inform the development of evidence-based strategies at the individual, community, health system and policy levels to reduce the impact of disasters on NCDs.

Conduct studies to develop evidence-based strategies to reduce disruptions to healthcare service access in the event of a climate-induced disaster

- Document the effect of disasters on access to healthcare systems. Example research questions:
 - To what extent do people living on dialysis miss their scheduled days for dialysis?
 - What proportion of people living with diabetes or cardiovascular disease have had their medication interrupted, for how long and why (e.g. displaced from their homes without taking their medication with them; pharmacies closed; no access to physicians to get their prescriptions)?
- Understand the effectiveness of existing emergency preparedness planning and smart health facilities in improving access to healthcare services in the event of a climate-induced disaster. Example research question:
 - How does lack of emergency power and water at healthcare facilities affect access to care?
- Develop evidence-based strategies that improve access to healthcare services in the event of a disaster.
- Use outputs from the studies suggested above to inform future strategies that improve the resilience of the healthcare system.

Identify the impact of environmental determinants on people living with noncommunicable diseases

The ways we manage (or mismanage) natural resources and the built environment, and social/economic exclusion, are largely responsible for the health outcomes of climate change and how they are distributed. Further studies are needed on the impact of various environmental practices on the risk of developing NCDs and morbidity among people living with NCDs. Studies should examine exposure to NCD risks linked to practices in key sectors, including agriculture, forestry, fisheries, construction, sanitation, transport, and land ownership and use. Monitoring data on practices in these sectors is needed, including levels of organic and inorganic pollutants they release into the air, soil and water (Allen, 2021; R4ACCHC, 2023c).

After extreme events, it is particularly important to monitor the impact of disruption to essential services, including health, sanitation, water, communication, transport and electricity, on the health of people living with NCDs. Service disruption tends to coincide with further environmental stressors following extreme events, such as a subsequent extreme event (e.g. extreme heat following a hurricane), mould exposure and air pollution (CARPHA, 2018). After Hurricanes Irma and Maria struck Puerto Rico, environmental factors such as wind, water, heat, air pollution, noise pollution and mosquitoes were found to be highly challenging for women with

gynaecological cancers (Méndez-Lázaro et al., 2021). Being aware of these stressors can assist with pre- and post-disaster plans, to mitigate morbidity and assist with supporting well-being, including mental recovery.

Determine the effectiveness of actions at the individual, community, structural/government and private sector levels

Actions need to be evaluated to ensure that they are effective. Evaluations may be of process, impact and/or cost-effectiveness. Determining the barriers to and the facilitators of implementing suggested actions would also be helpful in making recommendations for the way forward. Research questions could include the following:

- As a result of increased public awareness through communication strategies prior to an extreme weather event, were people living with NCDs able to access medication, medical care and nutritious food after the event?
- Are there sufficient numbers of healthcare professionals trained in emergency response and preparing people living with NCDs for disasters? Are there sufficient first responders trained in the emergency management of people living with NCDs? What are the barriers to and facilitators of responding to the needs of people living with NCDs in the disaster setting?
- Was an all-of-society approach used when including pre- and post-disaster management of NCDs in national disaster preparedness and recovery plans?
- Were the NCDKs distributed efficiently and available to the population in need, pre and post disaster?
 - Were sufficient numbers of personnel trained to assist with use of the NCDKs pre and post disaster?
 - What were the barriers to and facilitators of implementing the NCDKs?
- After a national weather event, was the shelter management tool for people living with NCDs cost-effective?

Surveillance gaps and how to address them

Create national and local noncommunicable disease registries

To provide assistance after an extreme weather event, it is necessary to be able to locate people living with NCDs. Information of the type of NCD, its burden and the distribution of the disease also needs to be captured. Known people living with NCDs and those at high risk of developing an NCD should also be documented at the local level (Hassan et al., 2020). Registries should be updated annually, especially prior to hurricane season.

Monitor the association between climate and severe weather and noncommunicable disease events

Incidence figures on new cases of NCDs (especially those that show acute manifestations such as stroke and acute myocardial infarction) and exacerbation of NCDs (e.g. emergency department visits among asthma and chronic kidney disease patients) can be monitored alongside climate and weather and air pollution data showing, for instance, precipitation, temperature and fine particulate matter levels. Tests of association between these data can help identify important climate-related risk factors for NCDs and for exacerbation of NCDs and assist in the development of early warning systems (EWSs) and other prevention and treatment interventions. EWSs assist in risk prediction and generation of disease vulnerability maps, which in turn enables more efficient allocation of public health resources (Hassan, 2021).

Research and surveillance capacity-strengthening needs

Capacity needs to be strengthened in the realm of climate and NCDs, as does NCD surveillance, to successfully address the aforementioned research questions and gaps. This includes strengthening capacity in implementation science, qualitative and mixed methods research, and advanced statistical methodologies.

Capacity needs to be strengthened to form new, and strengthen existing, collaborations and partnerships across disciplines invested in climate and health (R4ACCHC, 2023c). Health information systems, and capacity to house such systems, are key to research and surveillance. CAIHR at UWI in Jamaica has initiated a climate and health observatory to examine the linkages between weather and health, including NCDs. To create such an observatory, tailored information technology systems within CAIHR and partner institutions such as the University Hospital of the West Indies and Bustamante Hospital for Children should be designed and implemented. Since this observatory is expected to operate at the regional level, such collaborations must be formalised between regional agencies that collect both health data, such as CARPHA and GA-CDRC, and meteorological data, such as CIMH. Even though there are some national partnerships that feed into regional entities (e.g. national ministries of health that report certain diseases and syndromes to CARPHA), further collaborations to report climate-related health conditions, such as heat-related illnesses and conditions caused by air pollution, must be strengthened.

A surveillance system that captures climate- and health-related injuries, conditions and diseases at the level of national health facilities would provide useful information for forecasting and planning the health workforce, medication and other health system needs in general, and for people living with NCDs specifically. Again, there must be strong collaboration between national hospitals and clinics and meteorological agencies. Strengthening of electronic record systems will be crucial in this regard.

4.3. REFERENCES

- Akpinar-Elci, M., Martin, F. E., Behr, J. G., Diaz, R. (2015). Saharan dust, climate variability, and asthma in Grenada, the Caribbean. *Int J Biometeorol.* 59(11):1667–1671. Available from: <https://doi.org/10.1007/s00484-015-0973-2>.
- Allen, C. F., West, R. M., Johnson, D., St Ville, S., Cox, I., Hospedales, C. J. (2019b). Impact of Hurricane Maria on environmental determinants of health in Dominica (O-52). *West Indian Med J.* 68 (Supplement 1):37.
- Allen, C. F. (2021). Management of environmental determinants of health: research and implementation agenda preparatory document. Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (A Virtual Conference); 5–8 October.
- Allen, C. F., West, R. M., Beagley, J., McGushin, A. (2021). Climate change and health in small island developing states. London: The *Lancet* Countdown on Health and Climate Change, University College London. Available from: <https://www.lancetcountdown.org/resources>.
- Buenfil, J. (2021). Impacts of climate change on agriculture: health implications. Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (A Virtual Conference); 5–8 October.
- Cadelis, G., Tourres, R., Molinie, J. (2014). Short-term effects of the particulate pollutants contained in Saharan dust on the visits of children to the emergency department due to asthmatic conditions in Guadeloupe (French Archipelago of the Caribbean). *PLOS One.* 9(3):e91136. Available from: <https://doi.org/10.1371/journal.pone.0091136>.
- Campbell-Lendrum, D., Corvalán, C. (2007). Climate change and developing-country cities: implications for environmental health and equity. *J Urban Health.* 84(Supplement 1):109–117. Available from: <https://doi.org/10.1007/s11524-007-9170-x>.
- CARICOM (Caribbean Community) (2007). Declaration of Port of Spain: Uniting to Stop the Epidemic of Chronic NCDs. Georgetown, Guyana: CARICOM. Available from: <https://caricom.org/declaration-of-port-of-spain-uniting-to-stop-the-epidemic-of-chronic-ncds/>.
- CARPHA (Caribbean Public Health Agency) (2017). State of public health in the Caribbean region 2014–2016: building resilience to immediate and increasing threats – vector-borne diseases and childhood obesity. Port of Spain: CARPHA.
- CARPHA (Caribbean Public Health Agency) (2018). State of public health in the Caribbean 2017–2018 – climate and health: averting and responding to an unfolding health crisis. Port of Spain: CARPHA. Available from: <https://carpha.org/What-We-Do/Health-Information/State-of-Public-Health>.
- CARPHA (Caribbean Public Health Agency) (2020). State of public health report 2019: healthy ageing in the Caribbean. Port of Spain: CARPHA.
- Cruz-Cano, R., Mead, E. L. (2019). Causes of excess deaths in Puerto Rico after Hurricane Maria: a time-series estimation. *Am J Public Health.* 109(7):1050–1052. Available from: <https://doi.org/10.2105/ajph.2019.305015>.
- Dubrow, R. (2021). Research on impact of climate on health: preparatory document. Paper presented at the Climate Change and Health in Small Island Developing States: Focus on the Caribbean (A Virtual Conference); 5–8 October.
- Ebi, K. L., Lewis, N. D., Corvalan, C. (2006). Climate variability and change and their potential health effects in small island states: information for adaptation planning in the health sector. Durham, NC: National Institute of Environmental Health Sciences, National Institutes of Health.
- Evans, E., Rendell, M., Bartek, J., Connor, S., Bamisedun, O., Dovgan, D., Giitter, M. (1993). Thermally-induced cutaneous vasodilatation in aging. *J Gerontol.* 48(2):M53–57. Available from: <https://doi.org/10.1093/geronj/48.2.m53>.
- Gordon-Strachan, G. (2021). Health co-benefits of mitigation and adaptation: preparatory document. Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (A Virtual Conference); 5–8 October.
- Hambleton, I. (2008). Constituents of African dust and paediatric asthma in Barbados (1996–2005). Cave Hill, Barbados: Chronic Disease Research Centre, University of the West Indies.
- Hassan, S. (2021). Climate resilient health systems: research and implementation agenda preparatory document. Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (A Virtual Conference); 5–8 October.

- Hassan, S., Nguyen, M., Buchanan, M., Grimshaw, A., Adams, O. P., Hassell, T., et al. (2020). Management of chronic noncommunicable diseases after natural disasters in the Caribbean: a scoping review. *Health Aff.* 39(12):2136.
- Hassan, S., Harewood, H., Cox, R., Luciani, S., Lawrence-Williams, P., Hassell, T., et al. (2021). Feasibility and acceptability of using emergency NCD kits after natural disasters in the Caribbean. The 65th Annual CARPHA Health Research Conference: Pandemic, NCDs and Climate Change: The Caribbean's Triple Threat; 16–19 June. Online, Port of Spain: Caribbean Public Health Agency.
- HCC (Healthy Caribbean Coalition) (2021). Growing support for front of package warning labels on packaged foods. Saint Michael, Barbados: HCC. Available from: <https://www.healthycaribbean.org/growing-support-for-front-of-package-warning-labels-on-packaged-foods/>.
- JDRF (Juvenile Diabetes Research Foundation) (n.d.). Disaster relief: resources and tools. New York: JDRF. Available from: <https://www.jdrf.org/disasterrelief/>.
- Joshipura, K. (2021). Hurricanes Irma and Maria, preparedness, resilience and health. Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (A Virtual Conference); 5–8 October.
- Kim, E., Hassan, S. (2021). Understanding challenges to managing non-communicable diseases after natural disasters in the Caribbean: a qualitative study. Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (A Virtual Conference); 5–8 October.
- Kishore, N., Marqués, D., Mahmud, A., Kiang, M. V., Rodriguez, I., Fuller, A., et al. (2018). Mortality in Puerto Rico after Hurricane Maria. *New Eng J Med.* 379:162–170. Available from: <https://doi.org/10.1056/NEJMs1803972>.
- Kjellstrom, T., Butler, A. J., Lucas, R. M., Bonita, R. (2010). Public health impact of global heating due to climate change: potential effects on chronic non-communicable diseases. *I J Pub Health.* 55(2):97–103. Available from: <https://doi.org/10.1007/s00038-009-0090-2>.
- Martinez-Lozano, M., Noboa-Ramos, C., Alverado-Gonzalez, G., Joshipura, K. (2021). Impact of Hurricanes Irma and Maria on diabetes incidence and management. Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (A Virtual Conference); 5–8 October.
- McMichael, A. J., Campbell-Lendrum, D. H., Corvalán, C. F., Ebi, K. L., Githeko, A. K., Scheraga, J. D., Woodward, A. (2003). Climate change and human health: risks and responses. Geneva: World Health Organization.
- Prospero, J. M., Blades, E., Naidu, R., Mathison, G., Thani, H., Lavoie, M. C. (2008). Relationship between African dust carried in the Atlantic trade winds and surges in pediatric asthma attendances in the Caribbean. *Int J Biometeorol.* 52(8):823–832. Available from: <https://doi.org/10.1007/s00484-008-0176-1>.
- R4ACCHC (Research for Action on Climate Change and Health in the Caribbean) (2022a). R4ACCHC dialogue with the Caribbean Hotel and Tourism Association.
- R4ACCHC (Research for Action on Climate Change and Health in the Caribbean) (2022b). R4ACCHC dialogue with the Healthy Caribbean Coalition.
- R4ACCHC (Research for Action on Climate Change and Health in the Caribbean) (2022c). R4ACCHC dialogue with the University of the West Indies, School of Clinical Medicine and Research, the Bahamas.
- R4ACCHC (Research for Action on Climate Change and Health in the Caribbean) (2022d). R4ACCHC dialogue with key stakeholders from Saint Lucia.
- R4ACCHC (Research for Action on Climate Change and Health in the Caribbean) (2023a). Breakout room session on non-communicable diseases. Stakeholder Dialogue: Caribbean Research for Action Agenda on Climate & Health, 9–10 May.
- R4ACCHC (Research for Action on Climate Change and Health in the Caribbean) (2023b). Feedback from breakout room session on health impacts of extreme weather events. Stakeholder Dialogue: Caribbean Research for Action Agenda on Climate & Health, 9–10 May.
- R4ACCHC (Research for Action on Climate Change and Health in the Caribbean) (2023c). Feedback from breakout room session on non-communicable diseases. Stakeholder Dialogue: Caribbean Research for Action Agenda on Climate & Health, 9–10 May.

- Ryan, B., Franklin, R. C., Burkle, F. M., Jr., Aitken, P., Smith, E., Watt, K., Leggat, P. (2015). Identifying and describing the impact of cyclone, storm and flood related disasters on treatment management, care and exacerbations of non-communicable diseases and the implications for public health. *PLOS Curr.* 7:eurrents.dis.62e9286d9152de04799644dcca04799647d04799288. Available from: <https://doi.org/10.1371/currents.dis.62e9286d152de04799644dcca47d9288>.
- Tull, E., Yarandi, H. (2017). The association of rainfall and temperature anomalies with childhood Type 1 Diabetes. *West Indian Med J.* 66(Supplement 1):15.
- WHO (World Health Organization) (2003). WHO Framework Convention on Tobacco Control. Geneva: WHO.
- WHO (World Health Organization) (2017). Noncommunicable disease kit. Geneva: WHO.
- World Diabetes Foundation (n.d.). To address and mitigate risks due to natural disasters and subsequent disruption of healthcare for people with diabetes and other NCDs – WDF18-1586. Bagsværd: World Diabetes Foundation. Available from: <https://www.worlddiabetesfoundation.org/projects/saint-lucia-wdf18-1586>.
- Xu, Z., Tong, S., Cheng, J., Crooks, J. L., Xiang, H., Li, X., et al. (2019). Heatwaves and diabetes in Brisbane, Australia: a population-based retrospective cohort study. *Int J Epidemiol.* 48(4):1091–1100. Available from: <https://doi.org/10.1093/ije/dyz048>.
- Yi, F., Zhou, T., Yu, L., McCarl, B., Wang, Y., Jiang, F., Wang, Y. (2021). Outdoor heat stress and cognition: effects on those over 40 years old in China. *Weather and Climate Extremes.* 32:100308. Available from: <https://doi.org/10.1016/j.wace.2021.100308>.
- Zilbermint, M. (2020). Diabetes and climate change. *J Comm Hosp Intern Med Perspect.* 10(5):409–412. Available from: <https://doi.org/10.1080/20009666.2020.1791027>.