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EXECUTIVE SUMMARY

This Report, from the Caribbean Public Health Agency (CARPHA), examines the State of Public Health in 2017 across a small and diverse region of the world. The countries of the Caribbean are small in population and geographical size, and highly vulnerable to external man-made and environmental shocks. The Report describes a major threat to the health of Caribbean people and the communities where they live, learn, work and play; that of climate change. The examination of climate change is framed within a more general description of links between climate and health. Actions that have been taken to address the links are presented, along with examples of good practice and suggestions for the future. We examine connections between climate and environmental determinants of health such as food and water security and quality, wastewater, air quality, heat stress and storm damage. We examine impacts on infectious disease, vector-borne disease, non-communicable diseases and mental health. We identify evidence for these connections in the Caribbean and suggest strategies to strengthen the evidence base. The challenges for Caribbean health systems are explored and analysed, looking at building blocks of health systems: leadership and governance; the health workforce; health information systems; medical products and technology; service delivery, and financing (Shumake-Guillemot, Villalobos-Prats, & Campbell-Lendrum, 2015).

Climate and health in global context

Chapter 1 reviews connections between climate and health. The terms “climate change” and “climate variability” are defined. Seasonal cycles of weather patterns such as El Niño-Southern Oscillation are also described. The chapter reviews scientific evidence for climate change, including the extent of increases in Greenhouse Gases (GHGs), temperatures in the atmosphere and the ocean, changes in global precipitation cycles, reductions in global snow and ice, a rise in global mean sea level, and changes in weather extremes. Also featured are comparisons between the global and the Caribbean situation in indicators of climate change such as the extent of warming and heavy precipitation.

General impacts of climate change and variability on health are described by use of a conceptual framework that shows relationships between direct effects of climate change on variables such as droughts and floods, indirect effects on environmental variables such as air pollution and water quality, and social factors such as public health infrastructure and age. Health outcomes result from complex interrelationships and dynamics between these variables, which may occur simultaneously, making prediction of health outcomes difficult. Taking specific environmental variables one at a time, it is possible to predict effects on specific health conditions and diseases, though impact will be mediated by social factors including social determinants of health such as poverty and gender inequality. Health conditions often associated with climate change and variability include vector-borne diseases, other infectious diseases, respiratory diseases, allergies, poisoning, injury, undernutrition, mental illness and cardiovascular diseases (Watts et al., 2015).

Chapter 1 ends with a short history of global climate meetings and agreements and climate and health initiatives since the first World Climate Conference in 1979. Also included are descriptions of the International Health Regulations that pertain to climate issues; the Global Framework for Climate Services; the work of the Lancet Commission on Health and Climate Change and the Lancet Countdown, and the United Nations Sustainable Development Goals relating to climate and health.

Caribbean vulnerabilities to climate change and climate variabilities

Chapter 2 focuses on the vulnerabilities of health in Caribbean Small Island Developing States (SIDS) to climate change and climate variability, and vulnerabilities of specific populations. The United Nations Department of Economic and Social Affairs has listed 16 Caribbean SIDS, including small islands and the mainland territories of Belize, Guyana and Suriname. Common characteristics of SIDS include low-lying coastlines, concentration of populations on or near coastlines, relatively small geographical area and thus lack of economies of scale, small populations with significant levels of external migration, heavy dependence for resources and income on imports and exports, high energy costs, high relative poverty, and high indebtedness. SIDS' contribution to GHG emissions is extremely small, but they are affected by climate change far more than most of the larger contributors to GHG emissions. Caribbean countries have sought to highlight this inequity during participation in global meetings on climate and GHG emissions.

Sea level rise (SLR) is an especially important challenge for Caribbean SIDS, because of the concentration of populations and key economic resources such as tourist facilities on coastlines. Since 1993, global sea level has risen more than twice as rapidly than in the remainder of the 20th century. Impacts on individual countries depend on their topography and the geographical distribution of key resources. For instance, countries with coastal plains below 10m such as Belize, Guyana and Suriname already have considerable experience of flooding from storms, coastal storm surges and sea level rise, saltwater intrusion of ground water and erosion with loss of mangroves. An example is massive flooding in Guyana in 2004-5 (Singh, 2017). Volcanic island coasts are vulnerable to beach erosion from SLR and storms, landslides and flooding from precipitation inland flowing towards the coast (Simpson et al., 2010). Under these conditions, storms and hurricanes can cause massive damage, as was seen for example in Dominica following Tropical Storm Erika in 2015 and Hurricane Maria in 2017.

Having safe, reliable and sustainable source of **drinking water** is a challenge for SIDS, with typical sources of freshwater being groundwater and surface (rivers, springs and ponds) water from rainfall. Alternatives have been rainfall harvesting and desalination plants. Climate change threats to freshwater quality and availability in SIDS include increasing frequency of floods and droughts and saline intrusion due to increasing sea level rise. Some SIDS are already experiencing challenges. In the Bahamas, water is brought mainly from the main island, Andros, to the predominately tourist destination of New Providence. Effective water management systems are a critical aspect of climate change adaptation.

Coral reefs are important for the prevention of coastal erosion through the supply of sediment to the shores and the dissipating of wave energy. Reefs also supply certain marine species for the fishing industry and form an integral part of the Caribbean beach and dive tourism industry. Coral bleaching, due to rising sea temperature (i.e. thermal stress), and reduced coral growth due to increased ocean acidification, is affecting the ability of coral reef systems to survive. In the Belize Barrier Reef System, it was found that coral bleaching doubled in the 3 years 2014-'17 during which an El Niño event occurred (Christ, 2018). **Changes in the ecosystem** of plants and animal species on land and in the sea affect food security through the destruction of crops and entire animal species, and reduce export earnings otherwise gained through fishing, agriculture and tourism industries. These changes especially affect fishing communities, subsistence farmers and some indigenous people who rely on sale of specific fish and agricultural produce.

Caribbean SIDS are economically vulnerable as sectors on which they rely heavily for subsistence or revenue, such as fishing, agriculture and tourism, are highly sensitive to climate change. The fishing industry, for instance, is a major foreign exchange earner and is responsible for approximately 10% of the region's protein intake. Some marine species are moving away from

the equatorial waters into cooler seas, reducing availability. The marine ecosystem balance is changing, causing shortages and threatening extinction of some species, while invasive predatory species such as lionfish flourish and further threaten the ecosystem. Threats to links in a food chain negatively affect species all along the chain.

Caribbean countries are highly dependent on food imports and exports, and therefore the risks of under-nutrition and malnutrition increase when import prices rise because of climate change influences on the agricultural sector around the world. Impacts from the regional drought of 2009-2010 resulted in reduced agricultural crops in several countries including Guyana (rice), Dominica (bananas), and Antigua and Barbuda (onions and tomatoes). In St Vincent and the Grenadines, the price of tomatoes more than doubled (Trotman et al., 2017).

Some populations are especially vulnerable. People who live in poor neighbourhoods and unregulated housing are vulnerable because of lack of sanitation services and drainage, which enable the proliferation of disease vectors such as mosquitoes and of disease-carrying micro-organisms that multiply faster in hot weather. Single parents, most of whom are women, their children and the elderly are especially vulnerable as they spend the most time at home in such neighbourhoods. After disasters, it has been found that there are usually increases of domestic violence towards women.

Young children's rapid metabolisms, immature organs and nervous systems that are still developing and their bodies mean that they are ill-equipped to deal with issues of food and water shortages and mental and physical stress. During warm spells and heat waves young children are vulnerable to potential increases in respiratory diseases and vector-borne diseases. The elderly, the disabled, people with NCDs and mental health problems are especially vulnerable, especially following disasters such as hurricanes. Persons suffering from chronic diseases are vulnerable to interruptions of medical supplies. Some, such as kidney patients, are dependent on machinery that relies on a consistent electricity supply.

Indigenous people generally live in remote and resource-scarce areas of Caribbean countries and can easily be further deprived of necessities such as water and food by climate change. Subsistence farming, on which they rely to a large extent, is threatened, as are distribution systems for other sources of food and medicine.

It is imperative that Caribbean SIDS build adaptive capacity and resilience to climate changes to sustain national development and protect health, especially among vulnerable segments of the region's population. An ethical requirement is financial and technical support from countries who are the greatest GHG emitters.

Health impact of climate in the Caribbean

Chapter 3 examines evidence specifically for the Caribbean of climate variability and change and health outcomes. The analyses are guided by a conceptual framework, developed by the US Global Change Research Programme, which shows primary exposure pathways by which climate change affects health (United States Global Change Research Program, 2016). We examine evidence for the Caribbean on climate drivers, exposure pathways and health outcomes. Climate drivers focussed on in this chapter are increasing temperature and precipitation extremes; SLR is considered in chapter 3 while severe events are the subject of chapter 4. Exposure pathways examined include extreme heat, poor air quality, food availability and quality, water availability and quality, changes in infectious agents and population displacement. Health outcomes

described include heat-related illness, cardio-pulmonary illness, food- and water-borne disease, vector-borne disease, mental health consequences and stress.

Climate drivers may occur simultaneously, interactions between exposure pathways are multiple, and contextual factors condition eventual health outcomes. The analyses of this chapter consider drivers, pathways and health outcomes one by one, but it is important to note interactions (of which examples are given in the chapter) and the consequent need for multi-sectoral action in adaptation and mitigation.

Evidence of climate change and variability in the Caribbean is presented. Global Climate Models (GCMs) predict that the population of the Caribbean will increasingly be exposed to precipitation extremes leading to drought and flooding, to increased temperatures, and to extreme weather events such as hurricanes. Sea levels are expected to rise between 0.21 and 0.48 m by the year 2100. Caribbean Regional Climate Models (RCMs) have been developed since 2003 by a consortium of researchers at the University of the West Indies, the INSMET (Institute of Meteorology) in Cuba, the Caribbean Community Climate Change Centre (CCCCC) in Belize and, more recently, the Anton de Kom University of Suriname. The RCMs have produced finer-scale projections than the GCMs, enabling differences to be discerned in projected climatic conditions between the northern and central/ southern Caribbean and between the larger islands and surrounding sea.

Heat-related illness, including sunstroke, sunburn, heat stress, heat exhaustion, and dehydration, affects some populations more than others. Most of the evidence for the impact of gradual warming and heatwaves comes from outside the Caribbean. This suggests that women are less heat-tolerant than men. There is need for further research on the impacts of menstrual cycle phase, use of contraceptive pills, physical fitness, cardiovascular function, and anthropometric measurements on the susceptibility of women. Elderly people, people using psychotropic drugs for medicinal or recreational purposes, and people with pre-existing cardio-respiratory illnesses, are also relatively susceptible. People without access to air-conditioning – generally those on lower incomes – and people living in urban areas, where infrastructure retains heat, have increased risk. A study in Grenada and Trinidad and Tobago used focus group discussions to explore perceptions of health impacts of climate change among Caribbean health-care providers. Participants perceived air temperatures as hotter than usual and gave examples of heat-related illness and hospital admissions alongside clinical experience mosquito-borne, flood-related, respiratory and mental illnesses that they attributed to local impacts of climate change (Macpherson & Akpınar-Elci, 2015).

Weather and climate conditions can influence the transportation and concentration of air-borne pollutants including dust, pollen, fossil fuel pollutants and smoke. The influx to the Caribbean of Sahara dust has increased dramatically since 1970 due to ongoing drought in North Africa caused by fluctuations in the North Atlantic Oscillation, in a possible manifestation of anthropogenic climate change. The potential association between Sahara dust and asthma has been the subject of research projects in Barbados, Grenada and Guadeloupe (Akpinar-Elci, Martin, Behr, & Diaz, 2015; Cadelis, Tourres, & Molinie, 2014; Hambleton, 2008; Prospero et al., 2008). Associations have been found between days of hospitalisation with asthma symptoms and days of Sahara dust. However, the inclusion of other climate variables in examining Sahara dust and asthma associations led to the conclusion that other variables, such as atmospheric humidity and grass pollen, may have greater explanatory power than Sahara dust (Hambleton, 2008). This highlights the complexity of links between climate and health, and the difficulties of isolating specific risk factors. Pulmonary diseases other than asthma and potential climate risk factors other than Sahara dust have received little attention in the Caribbean climate and health research.

Studies in Jamaica have shown perceptions by farmers, corroborated by climate data, that conditions are drying, seasonal patterns are changing, and these phenomena are reducing agricultural productivity (Allen, Curtis, & Gamble, 2010; Gamble et al., 2010). As noted in Chapter 2, fisheries are also negatively affected by ocean temperature rise, acidification and coral bleaching. Droughts in several Caribbean countries in 2009-10 and 2014-16 led to water and food shortages. Climate change is reducing the region's food security, increasing vulnerability not only to under-nutrition, but to NCDs associated with over-consumption of processed food, most of which is imported, when local food production is reduced. In the context of climate change, there is need for increased attention to Integrated Water Resources Management planning and policy.

Susceptibility to food- and water-borne diseases is also likely to increase. This may be associated with damage to food- and water-distribution infrastructure by severe weather events, and pollution accelerated by changes in precipitation and heat. The development of harmful algal blooms is associated with (among other things) increases in the nutrients the algae consume, which can result from upwelling of the ocean floor during storms, and warming seas and other bodies of water. Ciguatera is a toxin that is produced by a harmful alga that can lead to poisoning of people who eat fish that have been exposed to it. The ciguatera toxin may be found in large tropical reef fish, such as barracuda, grouper, red snapper, eel, amberjack, sea bass, and Spanish mackerel. An increase in ciguatera fish poisoning in the Caribbean is one of the possible outcomes of climate change. Projections suggest that the habitat of most species of harmful algae will shift further north and south within and beyond the tropical belt as a consequence of global warming.

Human behaviour and cultural practices can aggravate climate impacts. Large numbers of Caribbean people are not serviced by sewage-collection systems, but rather depend on individual systems such as septic tanks, soakaways, and pit latrines. In times of high rainfall and flooding, storm-water runoff and floodwaters may become contaminated with faecal waste from these systems and can pose serious health risks. One of the reasons often advanced, by laypersons and experts alike, for repeated flooding in several Caribbean countries, is the clogging of waterways with solid waste.

As people migrate to improve their health and other conditions from the impacts of climate change, Caribbean policy-makers will need to develop strategies to address the potential influx of migrants from within and outside the region, while enabling adaptations to climate change and thus attracting citizens, notably health workers, to remain in their countries. Internal displacement is a further likely impact. As agricultural systems are put under strain, urbanisation may increase, compounding climate-related challenges in urban spaces.

Disease vectors, and the infectious micro-organisms they carry, are susceptible to climate influences such as temperature, precipitation, humidity, surface water and wind, and biotic factors such as vegetation, host species, predators, competitors, parasites and human interventions. The life cycle of dengue virus, and of mosquitoes and their biting rates, are speeded up by increasing heat. Addressing the major threats of several vector-borne diseases (VBDs), such as chikungunya, dengue, Zika, leptospirosis and schistosomiasis, requires attention to reducing the number and extent of water bodies where vectors breed or live and pathogens proliferate. Poorer and disadvantaged communities tend to live in low lying marginalized areas with poor drainage and prone to flooding. Water and sanitation management, and involvement of communities in reducing breeding sites, are critical. CARPHA has produced guidelines for community mobilisation to reduce mosquito breeding sites (CARPHA, 2017).

An important set of studies by the University of the West Indies and CARPHA looked at the impact of climate on the threat of dengue fever (Chen, Chadee, & Rawlins, 2006). One of these studies combined climate data from meteorological offices and data on dengue from CAREC, showing clear seasonal patterns and associations with El Niño. This study assisted in the development of a temperature index to gauge the potential for the onset of dengue. A further study showed that dengue cases rose rapidly about a month after an increase in the number of containers positive for larvae and pupae of the *Aedes aegypti* mosquito per 100 premises (the Breteau Index). The lead investigators recommended a system of early warning of VBD using the temperature and Breteau indices. More recently, a study combined geographic with climate and Breteau Index information to map ‘hot spots’ of likely dengue infection, using Global Positioning technology to help provide early warning. An online GIS platform was set up that would allow for data sharing and the generation of seasonal epidemic forecasts. The study found that drought conditions positively influence dengue relative risk at long lead-times of up to five months, while excess rainfall increased the risk at shorter lead times between 1-2 months. The research also involved local public health, environmental specialists and meteorologists in a series of consultations to improve mechanisms for cooperation and joint working (Stewart Ibarra et al., 2017).

Psychological impacts of climate variability and change, ranging from mild stress responses to chronic stress or other mental health disorders, have received little consideration in the literature on climate and health in the Caribbean, or in policy initiatives to address climate change in the region. Weather can affect mood and disposition to other stresses encountered by people. Extreme heat can decrease psychological resilience. Vulnerability to negative mental health consequences of climate variability and change is related to various forms of social inequality and power imbalances. The development of human resources to assist in the psychological recovery of people affected by disaster is important. There are efforts in various Caribbean countries to train citizens in the provision of psychological first aid and more long-term counselling and support skills.

The literature review for this chapter found much discussion of logical consequences for health of certain climate drivers or exposure pathways, but little primary research evidence specific to the Caribbean. Studies of impact of climate on dengue, and of Sahara dust on respiratory disease, are good examples of the combination of climatic and health information to guide action. They relied heavily on weather monitoring and health surveillance systems in the countries studied, to generate the required data. There is scope for a great deal more Caribbean research and use of surveillance and monitoring data to enable appropriate adaptation measures to be taken. While high-tech surveillance methodologies, involving for instance the use of GPS, are available internationally, the development of robust surveillance in the Caribbean should pay attention to what is sustainable given resource limitations which themselves are aggravated by climate change.

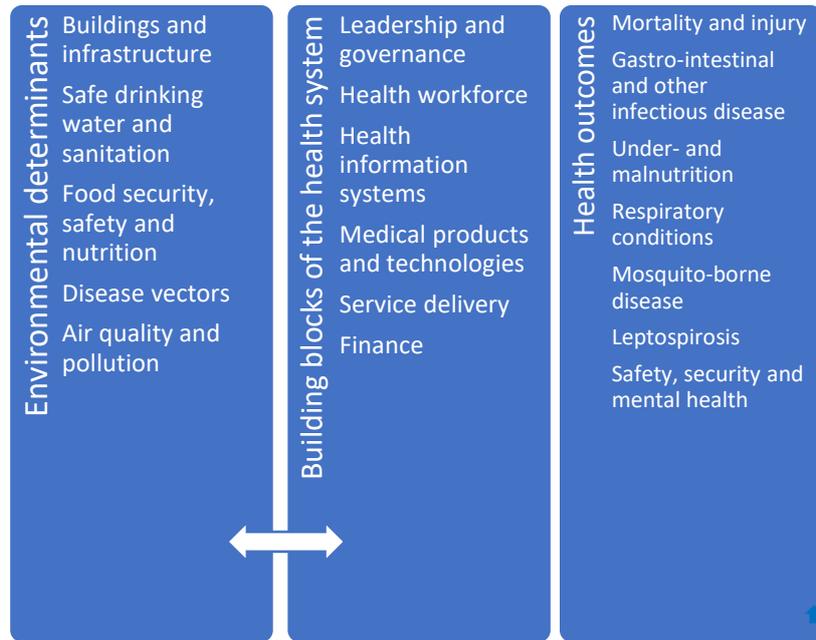
Sudden impact: the severe weather events of 2017

2017 saw two of the most devastating hurricanes to have afflicted the Caribbean. The strongest storm on record to exist in the open Atlantic region was Hurricane Irma. It was the first Category 5 hurricane ever to strike the Leeward Islands (NASA Earth Observatory, 2017) and was followed only two weeks later by Hurricane Maria, which struck the Windward Island of Dominica at Category 5 intensity (Government of Dominica, 2017). Hurricane Irma was at Category 5 – the maximum hurricane strength – discontinuously¹ from September 5-9, 2017, with sustained wind speeds of approximately 180 mph/ 285 kmh. Hurricane Maria was at category 5 discontinuously from September 18-20, 2017, with sustained wind speeds of 175 mph/ 280 kmh. Chapter 4 assembles available evidence of the health impact of and response to these hurricanes in the Caribbean and includes a case study of Hurricane Maria in Dominica.

Hurricanes have an obvious direct impact on health through injury, but also, and crucially, on environmental determinants of health and the health system. Chapter 4 uses the conceptual framework below, examining each environmental determinant, building block of the health system and health outcome in turn. Evidence of impact of the hurricanes on each is examined, along with the responses of government and other agencies.

¹ Discontinuous duration means that the hurricane weakened below Category 5 then re-strengthened to that classification at least once.

Figure 1: Conceptual framework for the analysis of health impacts of severe weather events



Sources: Authors, drawing on (Shumake-Guillemot et al., 2015; Watts et al., 2015; WHO, 2015, 2018)

Key informant interviews were conducted in Dominica, May 21st-25th 2018, to gather information in addition to what was available via literature and statistical review. The qualitative data collected in Dominica provides examples of scenarios that have been and are likely to be faced by Caribbean people as a result of severe weather events that may be associated with climate change.

Dominica is a volcanic island with steep hills and mountains, and population settlements mostly on the coast. These geographic features, common to SIDS, render the island highly vulnerable to floods and landslides. Of the total estimated population of 72,025 in 2017, 66,920 were estimated to have been affected by Hurricane Maria (92.9%), and 65,000 were said to require material support (90.2%). 1,862 people were homeless or displaced. Health outcomes of Hurricane Maria in Dominica may be summarised as follows.

Mortality

At the end of 2017, 27 deaths were recorded in Dominica as a consequence of Hurricane Maria. In Puerto Rico, a study of mortality following Hurricane Maria (which struck that island on 20 September) found many more deaths had occurred than the official death toll of 64. The researchers interviewed 3,299 individuals, seeking information on deaths in their household, and on disruptions to medical care and utilities such as water and electricity. It was found that the mortality rate had increased by 62% over the same period the previous year, yielding a total of 4,645 excess deaths - more than 70 times the official estimate. One-third of the deaths were attributed by respondents to delayed or interrupted health care (Kishore et al., 2018). On this basis, and the reports from Dominica of disrupted access to health care, it is likely that the death toll was higher than 27.

Mental health

Following Tropical Storm Erika in 2015, interviews with survivors and Ministry of Health officials revealed a need for additional mental health services in response to the trauma of displacement and destruction of homes and workplaces and loss of social support networks from their home communities (Ravaliere & Murphy, 2017). The Community Mental Health Team (CMHT) noted following Hurricane Maria that the initial period among many survivors may be termed a psychological “honeymoon” as people bonded with others in joint efforts to recover and share stories that are full of hope. This was encouraged by seeing the extent of international and local agency response to the emergency. After about a month, people realised multiple demands on their lives and that the resources to respond physically and emotionally were being depleted. This period of disillusionment was said to be marked by sentiments of abandonment, resentment, disorientation, disharmony and discontent. Stressors continued to erode people’s sense of confidence and mastery. The CMHT recommended providing training to increase the number of people in communities with psychological first aid and longer-term psychosocial support skills. An objective of this was to help people come to terms with what had happened and move towards reconstruction.

Gastroenteritis

The Dominica Health Vulnerability and Adaptation Assessment concluded in 2016 that gastroenteritis was an important risk from climate change, noting the special vulnerability of the Kalinago community, people on low incomes, the elderly and children (Dominica Ministry of Health and the Environment, 2016). Analyses of data from Dominica reported to CARPHA reveal that the years 2015 and 2017 had unusually high numbers of reports of gastroenteritis symptoms as compared with the average for Dominica for the six years 2012-'17. Of note was the increase in numbers of cases in the weeks after Tropical Storm Erika in 2015 and after Hurricane Maria in 2017.

Further analysis of syndromic data reported to CARPHA show that the countries struck by Hurricanes Irma and Maria followed a similar pattern of gastroenteritis cases in 2017 to other countries prior to the hurricanes. Following Hurricanes Irma and Maria, pattern of cases of gastroenteritis increased more rapidly in the countries that were struck by the hurricanes at Category 4 or 5 than in those that were not.

Food security

The Dominica Post-Maria Disaster Needs Assessment (PDNA) estimated that approximately 24,000 people would be made severe or borderline food insecure as a result of the hurricane (Government of Dominica, 2017). Damage to agriculture and supply routes and loss of income led to a restricted and unbalanced diet, with less fresh food and more canned and processed food. There was a shortage of some nutrients and thus some under-nutrition. At the same time, there may have been overconsumption of processed food, containing large amounts of salt, sugar and fat, thus increased risk of NCD, and difficulties for people with specific dietary requirements such as those with diabetes.

Fever

Hurricanes prevented many people from maintaining their usual hygiene standards, leading to generalised risk of infection. One of the major symptoms of infection is fever. Analysis of syndromic data reported to CARPHA showed that countries affected by Hurricanes Irma and Maria at Category 4 or 5 experienced increases in fever cases following the Hurricanes and lasting about 10 weeks in countries affected by Irma. However, there was little apparent difference

between these countries and other Caribbean countries in fluctuations in reported fever cases from the dates of the hurricanes until the end of the year. This may reflect a general increase in fevers influenced by wet season conditions throughout the Caribbean.

Mosquito-borne disease

According to the Health Information Unit in Dominica, there were no confirmed cases of mosquito-borne diseases – dengue, chikungunya or Zika - in that country in 2017. Given the high levels of inland flooding that occurred during Hurricane Maria that may have led to additional standing water sources where mosquitos can breed, the absence of VBDs appears to be as a direct result of quick mobilisation of the Environmental Health Department (EHD) and the Dominica Solid Waste Management Corporation (DSWMC). The hurricane was immediately followed by mobilisation by the EHD and its partners to eliminate potential breeding sites caused by flood- and rain-water. Action by the DSWMC to clean up debris also assisted in reducing breeding sites. This achievement should be put in the context of the general VBD situation in the Caribbean in 2017, where there were low numbers of cases of dengue, chikungunya and Zika as compared with the years 2014 to 2016. CMS affected by Hurricanes Irma and Maria at Category 4 or 5 strength – Anguilla, Antigua and Barbuda, The Bahamas, British Virgin Islands, Dominica, St. Maarten and Turks and Caicos Islands - experienced fewer cases of VBD in 2017 than in the years 2014 to 2016, suggesting that Hurricanes Irma and Maria did not increase the number of cases of mosquito-borne disease.

Leptospirosis

Dominica did not experience an increase in confirmed leptospirosis cases in 2017 – the number fell from 14 in 2016 to 7 in 2017. There has been an increase in numbers of confirmed cases in most Caribbean countries, including Dominica, since 2015. This may be associated with trends in rainfall rather than specific storms.

Environmental Determinants of Health

Health infrastructure

Hurricane Maria devastated the health infrastructure, along with residential and business buildings, the road and transport system and utilities providing essential goods and services such as water, sanitation services, electricity and communications.

In every parish of Dominica, health care facilities were rendered partially or non-functional, and less than half of health care facilities were functional. One health facility was entirely destroyed by a landslide. Many people experienced difficulties in access to health care facilities because of damage to roads. The Post-Disaster Needs Assessment (PDNA) drew attention to building features of some facilities that were not resilient. For instance, two health centres were located in the mouths of rivers and had been covered in river debris.

The main tertiary health institution, the Princess Margaret Hospital in Roseau, experienced varying levels of damage to its facilities. Six of 24 of the rooms/ wards/ facilities of the hospital were not operational or were destroyed, and a further 9 were partially operational. The damage was accompanied by a 42.8% reduction in the number of beds available at the hospital.

To avoid breaks in access to essential medicines, the Ministry of Health and the Environment (MOHE) began to work on a plan for lists of people with chronic conditions to be developed by their local health centres, and supplies of medicines covering at least a month to be stored at these

centres in accordance with the profile of people on the list. Technical support was provided, notably by CARPHA and PAHO, to the Ministry of Health and the Environment's efforts to rebuild and recover health care facilities. Guidance from PAHO's Safe Health Care Facilities initiative was used. These agencies also assisted in environmental assessments and support of health care workers' efforts to return to work as normal and to build their professional skills to respond to disasters.

Utilities and sanitation

Electrical power outages were experienced by the whole population for 2-3 days, followed by sporadic supply during reconstruction. People in houses that had lost roofs mostly remained without electricity by the end of 2018 because re-connecting electricity was not safe. Hazards included threats to security, food spoilage and loss of economic productivity.

By the end of 2017, it was estimated by the Dominica Solid Waste Management Corporation (DSWMC) that 1.5 million cubic metres of debris had been created by Hurricane Maria. The DSWMC experienced challenges because of the centralisation of its services. Most of its trucks and equipment were in Roseau and were submerged by mud, water or debris, damaged or unable to leave the city because of damage to roads. This had a cascading health impact since there were delays in removal of hurricane debris and solid waste. The DSWMC has since developed a plan for de-centralisation of equipment and waste management and greater involvement of communities.

In the British Virgin Islands, a *Debris and Waste Management Plan* was produced within 10 days of having been struck by Hurricane Irma. The speed was necessary because of the imminent danger of also being struck by Hurricane Maria. The debris stream was categorized into 13 types and was prioritized for collection based on risk level, starting with animal carcasses (which can cause infection) and galvanize (which can easily be transported by wind and cause injury).

Because the water and electricity supply to many areas of Dominica was channelled via pipes and wires over bridges and other infrastructure above the ground, Hurricane Maria's destruction and damage to bridges and infrastructure cut off supply to many areas for periods ranging from days to months. Many water storage tanks providing back-up supply were blown down. Damage to the Roseau wastewater treatment plant affected 5,190 households and included lift stations, fore mains, manholes, interceptor pipes, sewer lines, three major bridge crossings, gravity mains and about 3,000 service connections. The Canefield and Jimmit sewerage systems were blocked by flood debris (Government of Dominica, 2017). These sanitation challenges were managed by a massive mobilisation of international aid, with agencies distributing potable water and educating on the use of other sources during visits to communities with the Environmental Health Department. The Water, Sanitation and Hygiene (WASH) programme also distributed equipment and supplies and provided advice for domestic and environmental clean-up.

Ecosystem disruption

It is estimated that 80 to 90% of Dominica's trees were defoliated by Hurricane Maria (Government of Dominica, 2017). This led to increased evaporation of water and risk of contamination. In some water sources, new colourful blooms of algae and traces of sulphur and iron were identified by Environmental Health Officers. Analysis of the risks to human health were hampered by damage to the national laboratory at the Princess Margaret Hospital. An environmental health specialist from CARPHA visited to conduct tests of water quality.

To re-establish food safety, the Environmental Health Department staff rapidly embarked on inspections in a variety of settings where food was sold (e.g. restaurants and shops) or served (e.g. canteens). Street vending of food was suspended for two months as a precautionary measure. Establishments which had failed the inspection were provided with advice and assistance to re-establish their services to public health standards. Each dining establishment that passed the inspection was provided with a sticker which was prominently displayed so that members of the public could determine safe places to eat. This process facilitated confidence of the public in the establishments, increasing custom, boosting local businesses and assisting economic recovery.

Building Blocks of the Health System

Leadership and governance

There was damage to the workplaces and electronic equipment of many public servants, and to transport infrastructure to enable them to get to their workplaces. Some public records and registration documents that were in paper form were destroyed, while damage to computers meant that much work was lost.

Nevertheless, the Government's Emergency Operation Centre (EOC) held weekly meetings with national response committees and international organizations, coordinating the response, with the support of the Caribbean Disaster and Emergency Management Authority and the United Nations Office for Coordination of Humanitarian Affairs. The Health Emergency subcommittee of the National Emergency Planning Organisation (NEPO) met almost daily for at least six weeks to coordinate the health response. NEPO was established in the 1980s and was partly a response to the devastation caused by Hurricane David in 1979. Communities had Disaster Plans coordinated by Village Councils, which generally helped in rolling out the response.

Health workforce

Hurricane Maria exposed existing shortages in health personnel. It took place at a time when the nursing contingent was below capacity by around 25%, with some posts having not been filled for several years. Foreign recruitment agencies for nurses reportedly continued to advertise and attract local health personnel after the hurricane. Caribbean governments and aid agencies supplemented the numbers of health care workers, but generally for a limited period of up to two months. Nurses and other health care workers had to deal with damage to their properties and possessions and to transportation systems while trying to maintain their attendance at work and their professional standards. PAHO assisted by providing buses to transport nurses, especially at night time, in part to ensure their security. PAHO and other agencies also provided extra skills training to health personnel, focussing on emergency management and psychosocial support skills. The government conducted Community Health Aide training to increase the pool of people with nursing skills in the community.

Health information systems

A programme of digitization of health information, which was due for completion by December 2017, was interrupted by Maria and was not completed. When Maria struck, some health records, and registration documents were destroyed. Internet and cellphone communication were re-established unevenly across the island and service was sporadic. This posed challenges to communication between parts of the health system and between health care workers and the public. Following Tropical Storm Erika, the Health Information Unit and CARPHA worked together to establish reporting on health events for surveillance using a popular phone messaging

app (Ahmed, Francis, Russell, Ricketts, & Hospedales, 2016). Following Maria, the use of mobile phone technology for surveillance was impractical. This highlights the importance of flexibility of response according to the utilities affected by a disastrous event. Communication via more time-honoured forms such as word-of-mouth, radio and loud-hailers from vehicles assumed more importance

The WHO *Operational Framework for Building Climate Resilient Health Systems* highlights different types of information that should be provided for resilience, such as: vulnerability, capacity and adaptation assessments; integrated risk monitoring and early warning, and health and climate research (Shumake-Guillemot et al., 2015). Dominica has been involved in all three. The Assessment of Climate Change and Health Vulnerability and Adaptation in Dominica was completed in 2016 (Dominica Ministry of Health and the Environment, 2016). The EHD of the MOHE is involved in the Caribbean Climate Outlook Forum (CariCOF – see Chapter 5) which promotes the development and effectiveness of early warning systems based on meteorological information. It has also been involved in an international research project to develop early warning systems for dengue outbreaks using geographic as well as weather information. These commendable initiatives built important skills to address climate threats but limited protection from the overall impact of Hurricane Maria. This extreme event highlighted the need to focus on health information infrastructure that is resilient to severe weather events (Stewart-Ibarra et al., 2018; Stewart Ibarra et al., 2017). The *Post-Disaster Needs Assessment* was an important piece of research that enabled lessons to be learned (Government of Dominica, 2017).

Medical products and technologies

The availability of medical products and technologies was severely reduced by the storm by damage to infrastructure, including roads, health centres, electrical power and refrigerators within health care facilities. “Building back better” involved not only designing more sturdy physical structures but operational procedures regarding storage and delivery of medicines.

Finance

The World Bank estimated damages and losses to Dominica from Hurricane Maria of about 226% of 2016 GDP. This was in addition to the estimated losses of 90% of GDP from Tropical Storm Erika in 2015. The health sector accounted for 1.8% of the total damages. Housing sustained the most damage: 38.5% of the total. Massive aid resources poured into Dominica immediately after Hurricane Maria, but many ceased soon afterwards. Longer-term financial support from bilateral and multilateral agencies for building climate resilience has had to contend with the assessment of need based on limited indicators, such as income per capita. There is a need for international agencies to broaden the measurement of need to include climate indicators.

Responses to climate change and health in the Caribbean: strategies, organisations and finances

Chapter 5 provides information on regional strategies and frameworks that aim to address climate and health issues (separately or jointly) in the Caribbean. Caribbean and international organisations implementing strategies and initiatives to build resilience to climate variability and change and its impact on health in the Caribbean are then described. Finally, some of the more established funding mechanisms for climate are presented.

Regional Strategies and Frameworks

Regional strategies and frameworks include the Liliendaal Declaration, the Caribbean Regional Framework for Achieving Development Resilient to Climate Change, the Caribbean Cooperation in Health IV (CCH IV), and the CARICOM One Health Policy. The first two of these concentrate on climate change, while CCH IV and One Health consider climate change alongside other determinants of health.

The Liliendaal Declaration (2009) defined roles in climate action for CARICOM and its partners, while noting that the global response to climate change should be undertaken on the basis of common but differentiated and historical responsibility and that it should not compromise the ability of SIDS to pursue sustainable development, nor perpetuate poverty. The parties resolved to strengthen educational institutions to provide training, education, research and development programmes in climate change and disaster risk management, notably in health.

The Caribbean Regional Framework for Achieving Development Resilient to Climate Change was prepared by the Caribbean Community Climate Change Centre (CCCCC) on behalf of the CARICOM Heads of State in 2007. The CCCCC has primary responsibility for coordinating the implementation of the Framework. Strategy 5 of the framework commits CARICOM governments to promote the dissemination of successful adaptation experiences to address the impacts of climate change on: (a) water supply; (b) coastal and marine ecosystems; (c) tourism; (d) coastal infrastructure; and (e) health, which are stated to represent the largest threats to the well-being of the CARICOM countries.

In 2012 an Implementation Plan was developed for this Framework: *“Delivering Transformational Change 2011-2021”*. The plan involves establishing how regional and national bodies will work together; securing investment to support the action plan; proposing a monitoring and evaluation system; and obtaining buy-in from governments and funders across the region.

The CCH IV provides a framework for CARICOM members states to address common regional health and development issues. Strategic Priority Area 2 focuses on safe, resilient, health promoting environments and has as its strategic outcome, “Regional health security improved through reduction of environmental and occupational threats and through building a disaster-resilient health sector, with emphasis on vulnerable populations.” Under Strategic Priority Area 2, areas of common concern identified include vector-borne disease, water resource management, liquid and solid waste management, capacity to detect and respond to outbreaks, food security and safety, healthy built environments that mitigate climate change, and disaster mitigation and management.

A CARICOM One Health policy was ratified by Ministers of Agriculture at the Council for Trade and Economic Development in 2013. Over the next two years this was also endorsed by the Caribbean Animal Health Network, the CARICOM Chief Veterinary Officers, Chief Medical Officers,

Ministers responsible for Human and Social Development at the Council for Health and Social Development and the Ministers responsible for the Environment. The One Health approach recognises the benefits of working across sectors to address challenges of climate change, food and nutritional security, non-communicable diseases, infectious diseases and limited opportunities for economic growth. The One Health, One Caribbean, One Love project is implemented by University of the West Indies, St Augustine and its partners and has a major focus on capacity-building.

Organisations Working on Climate and Health in the Caribbean

Caribbean Public Health Agency (CARPHA)

CARPHA's Environmental Health and Sustainable Development (EHSD) Department (formerly the Caribbean Environmental Health Institute) conducts a range of activities: environment monitoring services via its ISO 17025 accredited laboratory; indoor environmental quality assessment; environmental assessment; developing healthy work and schools' environments; technical assistance for waste management, and improving environments during emergency response (such as assessing shelters to ensure quality water supplies).

CARPHA is involved in a Global Environment Facility (GEF)-funded project, *Integrating Water, Land and Ecosystems (IWEco) Management in Caribbean SIDS*. CARPHA is responsible for two components: to strengthen Sustainable Land Management (SLM) and Integrated Water Resources Management (IWRM) and the associated indicators framework; and policy, legislative and institutional reforms and capacity building for SLM, IWRM and ecosystem services management taking into account climate change resilience building.

The Caribbean Aqua-Terrestrial Solutions (CATS) Programme is a joint CARICOM and German government initiative being implemented by CARPHA and the German Development Cooperation Agency. The programme focusses on improving resilience and adaptation to climate change of marine and adjacent coastal spaces and communities.

CARPHA is implementing a major mosquito-borne disease prevention project with European Union funding, stimulated by the regional Zika epidemic of 2015-'16. Activities include human resource capacity building through training and an Integrated Vector Management Toolkit.

CARPHA is also a partner in the Organisation of Eastern Caribbean State's (OECS) project, due to start in 2019, *Addressing Diabetes in Disaster in the Organisation for Eastern Caribbean States*. CARPHA has lead responsibility for assessment of the health outcomes, including deaths, due to diabetes and hypertension for one year following hurricanes Irma and Maria in the affected OECS states compared to baseline levels, and development and implementation of training on risks, preparation and responses for vulnerable communities with diabetes or other NCDs

An Expert Panel² on Climate Change and Health was formed in 2017, initiated by CARPHA. The role of this Panel is, *"to coordinate the development of a climate change strategic roadmap to analyse, control and where possible prevent the impact on human health and the environment."* In 2018 the Panel established six strategic imperatives to reduce the impact of climate change on health in the Caribbean. Strategic imperatives identified in the roadmap focus on awareness-

² Representatives from the following are represented on the Expert Panel: CARPHA, CCCCC, CIMH, American Public Health Association, Tulane University, and ministries responsible for health in Antigua and Barbuda, Bahamas, Bermuda, Dominica, Montserrat, St Kitts and Nevis and St Vincent and the Grenadines.

raising, strengthening community resilience, evidence-based decision-making, resilience of infrastructure and health care facilities, and resource coordination.

Pan American Health Organization (PAHO)

PAHO's Plan of Action on Climate Change and Health 2012-2017 identifies four strategic areas: evidence; awareness raising and education; partnerships, and adaptation. Objectives, indicators and recommended actions are defined for each.

PAHO's *Smart Health Care Facilities Initiative* aims to increase the resilience of health care facilities to damages caused by changes in weather patterns and reduce their environmental footprint. Emphasis on improving structural safety is accompanied by efforts at energy and water conservation, emission reduction, strengthened surveillance and use of environmentally friendly appliances and fixtures. A Smart Hospitals Toolkit shows how to establish smart health care facilities.

The Caribbean Disaster Risk Management Programme (CDRMP) 2016-'22 aims to build health sector capacity to manage and reduce deaths, injuries and illness after a disaster. Strategies include: training in disaster risk reduction and management for emergency workers; the establishment of a virtual emergency coordination platform for the health sector; technical support to improve the safety and environmental performance of health care facilities; installation of essential emergency equipment, and provision of gender-sensitive technical information and publications.

Climate Studies Group, (CSG) University of the West Indies (UWI), Mona, Jamaica

The CSG was formed in 1994 within the Physics Department of UWI, Mona. A pioneering piece of work was the generation of future scenarios of precipitation and temperature change over the Caribbean. Another major research project examined the impact of climate variability on dengue in the Caribbean. Both these projects were described in Chapter 3. Other projects concern generation of climate change scenarios with application to health and water resources; understanding climate change impacts on biodiversity and development of projects that study these impacts; and investigating hurricanes using regional climate models.

Caribbean Meteorological Organization (CMO)

The CMO is a specialized agency within CARICOM, which coordinates scientific and technical activities in weather, climate and water for 16 English-speaking Caribbean countries. In 2017 an implementation plan was established for a Severe Weather Forecasting Demonstration Project (SWFDP) for the Eastern Caribbean. The SWFDP provides forecasts of extreme weather in order rapidly to implement disaster risk reduction procedures and activities to protect lives and properties while supporting economic sectors such as tourism and fishing.

Caribbean Institute of Meteorology and Hydrology (CIMH)

CIMH is the technical arm of the CMO and acts as the CMO's education, training and research unit. Its primary functions, relating to the sciences of meteorology and hydrology, are to provide facilities for training, act as a centre of research, offer consultancy services, and collect, analyse and publish data. Its capacity/training programmes have trained most of the meteorologists in the Meteorological Services in the English-speaking Caribbean. From as far back as 1970, the CIMH has collected and archived hourly and daily climatic data from member CMO countries.

The Caribbean Regional Climate Change Centre (Caribbean RCC) has been based at the CIMH since 2013. The Building Regional Climate Capacity in the Caribbean (BRCCC) programme arose from

previous work of the CIMH and developed the Caribbean RCC. The BRCCC programme focuses on infrastructure development, extension of climate services, and capacity-building. Among the activities of the Caribbean RCC, it: archives and disseminates the climate data of Member States of the CMO; develops and publishes Caribbean climate outlooks on rainfall, drought and dry spells, wet days and extreme wet spells, temperature and heat wave days, coral reef conditions and liaises with regional stakeholders in the areas of health; disaster risk reduction; agriculture and food security, and water resources.

Caribbean Climate Outlook Forums (CariCOF) meet bi-annually, just prior to the beginning of the wet and dry seasons, to discuss weather and climate information beneficial to many sectors, including disaster risk reduction, water, health, energy, and agricultural sectors. The Forums usually consist of a technical training workshop for meteorologists and climatologists on seasonal forecasting, followed by a General Assembly.

The Caribbean RCC also initiated the *Early Warning Information Systems Across Climate Timescales (EWISACT) Consortium*, which consists of an alliance of seven sector partners, each committed to the development and integration of climate services in sectoral decision-making in the areas of health, tourism, disaster risk management, climate, water and agriculture. The EWISACT's Consortium has developed sector-specific climate bulletins (for agriculture, health and tourism) which include key climate messages from CIMH's technical climate products. The Caribbean Health-Climatic Bulletin is published quarterly and is developed and disseminated by CARPHA, PAHO and CIMH to help the sector manage risk.

Caribbean Community Climate Change Centre (CCCCC)

The mission of the CCCCC is to support Caribbean people to address the impact of climate variability and change on economic development, via timely forecasts of the impacts of climate variability and change on the environment and development of special programmes on sustainable development. The CCCCC provides analyses of the impacts on the environment and develops special programmes for sustainable development. It serves as an information hub to facilitate decision-making, hosting knowledge products and portals such as the Caribbean Climate Online Risk and Adaptation Tool (CCORAL), Tourism Carbon Calculator, the Coral Reef Early Warning System, the Caribbean Regional Environmental and Atmospheric Database Management System (CREAD) and the Caribbean Assessment of Regional Drought (CariDRO) online tool for drought assessment.

The CCCCC has been involved in many projects over the years. A notable project was the *1.5 to Stay Alive* campaign, launched ahead of the UNFCCC COP-15 Climate Change Conference in Copenhagen in 2009. The campaign focussed on the dangers to SIDS of a global temperature rise beyond 1.5 degrees above pre-industrial levels. It included curriculum units for children and videos on topics including water consumption and health.

Caribbean Disaster Emergency Management Agency (CDEMA)

CDEMA is the regional inter-governmental agency for natural disaster management in CARICOM. CDEMA's functions include mobilising, coordinating and providing disaster relief; mitigating or eliminating the immediate impacts of disasters; collecting and disseminating reliable information on disasters affecting Caribbean PSs; encouraging the adoption of disaster loss reduction and mitigation policies and practices, and coordinating the establishment of adequate disaster response capabilities. Rapid Needs Assessments are conducted to make recommendations for improved disaster response capabilities. The Regional Response Mechanism (RRM) for disasters is coordinated through the Regional Coordinating Centre (RCC) housed at the CDEMA Coordinating Unit in Barbados. CDEMA hosts the Caribbean Risk Information System (CRIS), a

virtual platform with risk management data available to stakeholder to facilitate analysis, research, greater awareness of risk management and climate change adaptation in the Caribbean.

Regional Coordinating Mechanism on Health Security

After the 2014 epidemic of Ebola in West Africa, a Regional Coordinating Mechanism on Ebola was formed to counteract any threats of an outbreak in the Caribbean. In 2015 it was decided that this Regional Coordinating Mechanism should be extended to include all public health threats. The entity was renamed Regional Coordinating Mechanism on Health Security (RCMHS). The RCMHS complements and promotes work to conform with the International Health Regulations 2005, including improving core capacities of disease surveillance and early detection, multi-hazard public health emergency preparedness and response, and the necessary human resource capacity to perform these public health functions.

In 2016 the region's Council for Human and Social Development (COHSOD) supported the planning of a 5-year Roadmap for the Caribbean Region Global Health Security Agenda. The Roadmap, which was approved by COHSOD in September 2017, seeks to support the Caribbean region to develop the capacities necessary to prevent, detect, report and respond to infectious disease outbreaks. The Roadmap seeks to achieve coordination between countries and regional agencies; communicate with, and advocate to, development partners and countries about support and priority issues; and monitor and track regional progress towards achievement of IHR 2005 capacities at the regional level. Chaired by CARPHA, the RCMHS has oversight for the Roadmap, its promotion and implementation.

CARICOM Implementation Agency for Crime and Security (IMPACS)

IMPACS was established in 2006 as part of the Regional Framework for Crime and Security and is the implementation arm for CARICOM's agenda on crime and security. In 2017 CARPHA and CARICOM IMPACS signed a memorandum of understanding. CARPHA works closely with IMPACS in the prevention and potential tracking of patients with who may be infectious during outbreaks of highly contagious epidemics. Risks of such outbreaks are increasing as a result of climate change, migration and travel.

Climate change, pandemics and migratory pressure are defined in the framework as future risks that can impact on threats such as transnational organised crime, human trafficking and smuggling, public disorder and terrorism.

Centre for Resource Management and Environmental Studies

CERMES is a Department of the Faculty of Science and Technology at the UWI. It runs Master of Science programmes in Environmental Management and Renewable Energy Management. The focus of research and projects is on tropical island environmental management, including the impact of climate change. Research and publications have examined fisheries, coastal zone management and water resource policy development.

Caribbean Agricultural Research and Development Institute (CARDI)

CARDI was established in 1974 by CARICOM, and is dedicated to research and development in order to improve competitiveness and sustainability in the Caribbean agricultural sector. CARDI is concerned with food security, including the nutritional balance resulting from the combination of imports and local food availability. In collaboration with CIMH, CARDI produces the Caribbean Agro-Climatic Bulletin (ACB), an operational tool which assists the agricultural sector with climatic forecasts and provides recommendations for mitigation and adaptive measures.

Climate Funding

The challenges faced by the Caribbean in relation to climate and health are profound and require funding from a variety of sources at national, regional and international levels from private and public sectors. Under Article 9 of the 2015 UNFCCC Paris Agreement, it was stated that developed countries would provide financial resources to assist developing countries with respect to mitigation and adaptation.

Climate Investment Funds (CIF)

CIF was set up in 2008, since when 14 donor countries have contributed over US\$8 billion dollars to developing and emerging economies in shifting to climate resilient and low carbon development. The CIF consists of two main funds: the Strategic Climate Fund (SCF) and the Clean Technology Fund (CTF). The SCF finances new approaches or scales up activities through the Pilot Programme for Climate Resilience (PPCR), the Scaling Up Renewable Energies Programme in Low Income Countries (SREP) and the Forest Investment Programme. CTF supports renewable energy, low carbon technologies, energy efficiency and clean transport. The resources are held in trust by the World Bank and disbursed as grants, highly concessional loans and risk mitigation instruments to recipient countries through Multilateral Development Banks (MDBs): the Inter-American Development Bank (IDB) in the case of the Caribbean.

The PPCR is supporting six Caribbean SIDS – Dominica, Grenada, Haiti, Jamaica, St. Lucia and St. Vincent and the Grenadines – through a regional programme comprised of individual country plans and a regional track. The project runs from 2015-'20 and US\$10.39 million have been granted to improve regional processes to acquire, store, analyse, access and disseminate climate relevant data, and pilot and scale up innovative climate resilient initiatives in the region. The main implementing agency is the UWI and the Project Steering Committee comprises participating country governments, the CIMH, CCCCC, the Climate Studies Group at UWI, the PPCR Regional Track Project Management Unit at UWI Mona, Jamaica and UWI Moni Office of Research and Innovation. Component 4 of the Caribbean Regional Track includes support for applied adaptation initiatives in several key sectors, including health, where the focus is on mosquito-borne diseases.

The Green Climate Fund

Advanced economies have formally agreed to jointly mobilize US\$100 billion per year by 2020, from a variety of sources, to address the pressing mitigation and adaptation needs of developing countries. Governments also agreed that a share of new multilateral funding should be channelled through the Green Climate Fund, set up by the 194 countries who are parties to the UNFCCC in 2010, as part of the Convention's financial mechanism.

The Fund aims for a floor of 50% of the adaptation allocation for particularly vulnerable countries, including SIDS. 2016 was the GCF's first full year of operations.

The Caribbean Development Bank (CDB)

The CDB's Climate Resilient Strategy 2012-2017 aimed to implement of a transformative climate resilient policy and investment financing strategy. The CDB has two major climate change resilience programmes, which are co-financed by metropolitan country aid agencies:

1. The Community Disaster Risk Reduction Fund (CDRRF) focusses on community needs to reduce their vulnerability to climate change risks. It is a trust fund, managed by the CDB with funding from Canada's Department of Foreign Affairs, Trade and Development and the UK's Department for International Development and CDB.

2. The National Disaster Risk Management (NDRM) Programme is an initiative of the African, Caribbean and Pacific (ACP) states and is funded by the EU. It works to improve disaster risk reduction and climate change adaptation in the CARIFORUM countries.

Caribbean Catastrophe Risk Insurance Facility

CCRIF was established in 2007 as the first multi-country risk pool in the world. In 2014 it was restricted into a Segregated Portfolio Company (SPC) to allow for new products and expand the geographical area. CCRIF SPC is a not-for-profit pooling facility which offers insurance in times of catastrophic tropical cyclones, earthquakes and excess rainfall events providing quick short-term finances in times of disaster. The company is owned, operated and registered in the Caribbean and offers policies to Caribbean and Central American governments. Participating Caribbean countries pay membership fees and there is additional funding from CDB and the World Bank and governments of several countries outside the region through a Multi-Donor Trust Fund.

To date, CCRIF has paid out just under US\$139 million in 38 pay-outs to 13 member countries. Of this, approximately US\$95 million was for tropical cyclones; US\$9million for earthquakes and US\$35million for excess rainfall.

Conclusion: Elements of health systems needed to address climate challenges

In analysing the achievements and suggesting ways forward it is helpful to make use of the WHO's *Operational Framework for Building Climate Resilient Health Systems*. This identifies ten components of climate resilient health systems, which are analysed one by one in the conclusion of this report (Shumake-Guillemot et al., 2015).

Leadership and governance

Caribbean leaders have presented a united front to the international community in highlighting the vulnerability of Caribbean SIDS and historical responsibility of developed countries for the bulk of GHG emissions leading to climate change. At home, regional agencies have reached agreements with Caribbean governments on frameworks and have provided the governance structure for projects using international and regional funding. Specific regional agencies identified in chapter 5 address specific dimensions of the climate and health nexus.

There is nevertheless the potential to increase focus on health amidst the extensive work on climate change. The *Strategic Roadmap for Climate Change and Health in the Caribbean* being developed by the Expert Panel on Climate and Health could be drafted to specify specific roles and responsibilities for Caribbean agencies. A specific governance mechanism for climate and health is lacking. At country level, multi-sectoral approaches and moving beyond institutional silos should be a priority.

Health workforce

All the agencies listed in Chapter 5 are involved in various ways and to various degrees in human resource capacity building, conducting training workshops and degree programmes, and providing technical assistance. At the same time, it is useful to note a recommendation of the Lancet Countdown, that health professionals must be incorporated in the decision-making processes in order to advance progress on climate change (Watts et al., 2017). This will empower and help engage them in initiatives and advocacy.

There is also a need to recognise and respond to the enormous human resource capacity challenges of the region. Initiatives to decrease health worker migration and mobilise the

Caribbean diaspora on climate and health issues are necessary. Extending skills beyond the traditional medical workforce should receive increased attention. Online modes of skill development should be developed. Important initiatives also include the development of climate services through knowledge products disseminated through bulletins, tools and online portals so that both specialists and citizens can prevent negative consequences of climate events.

Vulnerability, capacity and adaptation assessment

Several countries have conducted vulnerability, capacity and adaptation assessments in collaboration with regional and international partners. To be effective, these assessments must be followed by action to build institutions and have effective governance mechanisms for action, including monitoring and evaluation capacity. There is also need for integration between efforts to address climate variability health issues (such as seasonal variation in dengue prevalence), slow onset impacts of climate change (such as gradual increase in dengue cases over the years) and sudden impacts from severe weather events (such as disease outbreaks).

Integrated risk monitoring and early warning

Risk monitoring depends on the establishment of effective surveillance systems. Thus, strengthening health and climate surveillance and integrating the two are necessary to address climate and health challenges. Collaborative mechanisms between agencies responsible for each are necessary.

Risk monitoring and early warning also need to focus at different levels, on climate variability health issues, slow onset impacts of climate change and sudden impacts from severe weather events. Types of information to be included and modes of communication with different stakeholders need to be considered for each.

Climate and health research

The literature review conducted for this report revealed many sources of information on climate and health links, but few of them were based on primary research from the Caribbean. Regional research has covered a limited range of topics, focusing particularly on mosquito-borne diseases and Sahara dust. There is scope for much more research to identify links between other elements of climate and health, and for greater use of surveillance data in analysis of climate and health links.

Climate and health research is challenging because of the complex interactions and dynamics between climate, health and intervening social behaviours and factors. There is need for capacity-building and increase in numbers of people qualified to conduct modelling and advanced statistics to measure links between climate and health variables and build models that can be used in early warning and policy development. There is also need for more translational communication to make research findings accessible for use by policy-makers and the general public. Operational and behavioural research and the development of guidelines for behavioural interventions are also needed.

Climate resilient and sustainable technologies infrastructure

PAHO's Smart Health Care Facilities initiative and the work of CARPHA EHSD have helped adaptation and mitigation considerations to be integrated into health systems. The huge damage to infrastructure inflicted by severe weather events highlights the need for a broad combination of technical guidance, human resource development, raw materials and finance to address the challenges and "build back better." Surveillance and information infrastructure should also be

strengthened, including data storage and management practices, computer hardware and software. New communications technologies and media should be fully utilised.

Management of environmental determinants of health

The capacity of regional and international initiatives to achieve change in environmental determinants depends on the capacities of environmental health staff and departments in countries, which are often under-resourced. There is also a need for increased government-level support to address issues such as industrial pollution and GHG emissions, which are subject to considerations of economic growth and the influence of business owners on policy-makers.

Climate-informed health programmes

There is a need for increased awareness and use of climate information and available technological solutions to climate threats in the health sector. Conversely, decision-makers on climate issues should increase the use of health information and form alliances with health sector partners. There is a need for multi-agency collaboration and to move beyond institutional silos to address climate-related health hazards.

Emergency preparedness and management

Emergency preparedness mechanisms have been established in Caribbean countries, including mechanisms to prepare for and manage the health response. CDEMA and the Regional Response Mechanism have assisted hugely in coordination and implementation of emergency response. The RCMHS and CARICOM IMPACS are important initiatives to address security issues, which focus on health emergencies. There is a need to increase attention to the security and mental health issues that arise in post-disaster situations. Other areas for attention include the development of water, solid waste and debris management plans; food security and medical supplies for people with NCDs; and protection of communications, information, data and surveillance infrastructures.

Climate and health financing

To date, funds from international financing mechanisms such as the CIF and GCF have reached a limited number of Caribbean countries, and do not address the full range of challenges brought by climate change. The underlying cause remains predominantly the contributions to GHG emissions of major and large industrialised countries. Greater mitigation efforts by the major emitters is necessary to reduce the risks to health of climate change for Caribbean people, whose part in climate emissions is extremely small.

Policy-makers have established critical finance institutions for Caribbean development and to assure resilience in the face of disaster: the CDB and CCRIF. Regional institutions have played a critical role in mobilising and channelling resources to areas of need.

Unfortunately, the evidence of this report suggests that even greater efforts are needed in resource mobilisation. Central to this will be the greater involvement of the health sector and professionals in climate initiatives, and public engagement and communication. It is hoped that the findings of this report will be widely communicated so that it can help mobilise and gather Caribbean people and their energies for the road ahead.

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INTRODUCTION

In 2008 on World Health Day, the World Health Organisation (WHO) Director General declared that “climate change endangers health in fundamental ways.” She noted that “developing countries and small island nations will be the first and hardest hit” (Chan, 2008). In 2015, the WHO went on to state, “Climate change is the greatest threat to global health in the 21st century” (World Health Organisation, 2015). These words hit home in the light of the floods, storms and hurricanes that have affected the small islands and low-lying coastal countries of the Caribbean, with some of the most powerful and devastating on record affecting several countries in 2017. The dramatic effects of hurricanes on health are in the public eye: other connections between the climate and health are also the subject of this report.

This Report, from the Caribbean Public Health Agency (CARPHA), examines the State of Public Health in 2017 across a small and very diverse region of the world. The countries of the Caribbean are small in population and geographical size, and highly vulnerable to external man-made and environmental shocks. The Report describes a major threat to the health of Caribbean people and the communities where they live, learn, work and play; that of climate change. The examination of climate change is framed within a more general description of links between climate and health. Actions that have been taken to address the links are presented, along with examples of good practice and suggestions for the future. We examine connections between climate and environmental determinants of health such as food and water security and quality, waste water, air quality, heat stress and storm damage. We examine impacts on infectious disease, vector-borne disease, non-communicable diseases and mental health. We identify evidence for these connections in the Caribbean and suggest strategies to strengthen the evidence-base.³ The challenges for Caribbean health systems are explored and analysed. The challenges for Caribbean health systems are explored and analysed, looking at building blocks of health systems: leadership and governance; the health workforce; health information systems; medical products and technology; service delivery, and financing (Shumake-Guillemot, Villalobos-Prats, & Campbell-Lendrum, 2015).

State of Public Health Reports (SPHRs) are designed to help guide policy-makers and institutional partners in decisions on issues of public health importance for the region. Climate change was identified in a poll of Caribbean Ministry of Health stakeholders in 2016 as one of the priority topics for SCPHRs⁴, which are to be produced annually by CARPHA according to the Inter-Governmental Agreement establishing CARPHA.

³ It is not necessary to accept that climate change is attributable to human action in order to accept that unusual climatic variations shift the conditions for health. In this report we examine links between climate and health, which are important regardless of whether they result from human actions such as those increasing greenhouse gases (GHGs) in the atmosphere.

⁴ Participants in the 2016 poll of CARPHA Member States (CMS) comprised participants representing Ministries of Health from CMS. They were asked to allocate points to eight subject areas based on: relevance to CMS and regional development, Caribbean Cooperation in Health Priority Areas, economic impact, and alignment to events, partners and funding. The eight subject areas were: childhood obesity/non-communicable diseases, mosquito borne viral diseases, climate change and health, healthy ageing, violence and injury prevention, anti-microbial resistance, universal health coverage, tourism and health, Caribbean regional development through functional cooperation in health, and the Caribbean region’s regulatory capacity. Representatives from 22 of CARPHA’s 24 Member States responded. The two subject areas that attracted the most points were: childhood obesity/ non-communicable diseases and mosquito-borne viral diseases (Hunte, 2017). The two thematic areas for the SPHR 2014-2016 were determined to be childhood obesity and vector-borne diseases, while the 2017 report focuses on climate and health, which attracted the third greatest number of points at that time.

This Report is based on collation and review of evidence of links between climate and health globally and with specific focus on the Caribbean. The main methodology was review of documents, statistics and scientific studies. Sources included (but were not restricted to) expert agencies such as CARPHA, the Caribbean Institute of Meteorology and Hydrology (CIMH), the Caribbean Community Climate Change Centre (CCCCC), the University of the West Indies, the Caribbean Disaster and Emergency Management Agency (CDEMA), the Pan American Health Organization/ World Health Organization, other United Nations agencies and the Intergovernmental Panel on Climate Change (IPCC). Peer-reviewed journal articles were also included in the review. Data collection was also carried out in Dominica, as a case study of impact and responses to severe weather events following the passage of Hurricane Maria on September 18th, 2017. The methodology for the case study is provided in Chapter 4. An Oversight Committee of international and regional climate and health experts guided the content and methodology of this Report. (see Appendix 1 for members of the Oversight Committee).

Studies of climate relevant to health tend to include a number of technical and commonly used, but sometimes misunderstood, terms. To assist in understanding, this report includes a Glossary of such terms.

Structure of the Report

We introduce this report by first giving a brief profile of the Caribbean and its people. Major health issues affecting the region are summarised, drawing on the detailed description in the *State of Caribbean Public Health Report 2014-'16: Building Resilience to Immediate and Increasing Threats: Vector-Borne Diseases and Childhood Obesity*, with updates using 2017 data where available.

Chapter 1 places climate and health in global context. It examines the scientific basis for concerns about links between climate and health, including climate change and climate variability. The strength of the 2017 hurricanes that affected the Caribbean, and the increasing frequency of extreme weather events in the region, have been attributed to climate change. Chapter 1 outlines the causes and major consequences of climate change for health. It is noted that hurricanes are examples of sudden, highly visible impact of climate change. However, there are also longer-term, slow onset impacts, such as water shortages, increasing morbidity due to heat stress and changing epidemiology of infectious and vector-borne diseases. The chapter defines and examines the differences between sudden and slow-onset impacts. It also examines climate variability and general impacts on health when climate variables move outside their usual ranges. The chapter goes on to discuss policy approaches to climate and health, including the frameworks and agreements of the international community in response to climate change.

Caribbean countries and territories are SIDS and low-lying coastal States. Chapter 2 examines the vulnerabilities of these States to change and variability in climate. The differential impacts of climate change and variability on specific populations are outlined.

Chapter 3 presents Caribbean evidence of climate and health links. It is noted that the body of evidence is strongest for vector-borne diseases in terms of health outcomes. There is also evidence of impacts on environmental determinants of health such as air and water quality.

Chapter 4 presents evidence from Caribbean countries of sudden, highly visible impact, especially Hurricanes Irma and Maria of 2017. Scientific documentation of the impacts of these storms is still at an early stage. Therefore, the chapter draws on evidence of vulnerability and impact assessments of previous storms and includes results of a data-gathering exercise in Dominica, looking at the impacts on health conditions, health infrastructure, human resources and

environmental and social determinants of health. The responses of the health sector and health-determining entities such as water and sanitation services in Dominica are examined.

Chapter 5 looks at strategies, organisations and finances to address climate and health challenges in the Caribbean. Several mechanisms and institutions have been established in the Caribbean to address climate and health links: these will be described and reviewed.

The report concludes by analysing achievements and gaps in key areas linking climate and health, using the WHO's *Operational framework for building climate resilient health systems* (Shumake-Guillemot et al., 2015) as the guide for analysis.

The Caribbean Region

The Caribbean comprises multiple islands and low-lying mainland territories and countries. The Region is remarkably diverse, with a mix of languages and ethnicities. Countries have varying sizes, geographic landscapes and political systems.

Population sizes vary from extremely small (approximately 1,900 in Saba) to relatively large (approximately 11.4 million in Cuba). Many of the states comprise small islands, which have been identified as facing development challenges resulting from small size, internal and external transport costs, coastal weather patterns, vulnerability to climate change, dependence on income from a small range of exports, and high dependence on imports to meet basic nutritional and other needs (International Labour Organization, 2014; UNEP, 2014). The Central America mainland country of Belize and the South American mainland countries of Guyana and Suriname are also considered part of the Caribbean, given a similar political history to the Caribbean islands. These mainland countries are in low-lying coastal zones, making them especially vulnerable to climate impacts on coastal regions, such as sea level rise, coastal erosion and floods.

The Caribbean is in the tropical zone and has little temperature variation throughout the year. There are two seasons; a rainy or wet season that runs roughly from June to November, and a dry season from December to May. The region is prone to tropical storms and hurricanes during the rainy season, with the hurricane season starting on June 1st and ending on November 30th. It is also prone to earthquakes resulting from movement of the Caribbean tectonic plate, and volcanic activity since several territories include volcanoes. Major natural disasters have afflicted many of the Caribbean countries, and these have set back development, sometimes for years or decades, and brought grave public health consequences.

This Report provides details of storms and hurricanes (in chapter 4), but other natural events have also been disastrous. For example, the 2010 earthquake in Haiti killed 230,000 and displaced 1.5 million people, and was followed by the largest cholera epidemic ever reported in a single country (Devioux, 2011; Domercant et al., 2015; Ghose, Boucicaut, King, Doyle, & Shubert, 2013; Pape et al., 2010; Rahill, Joshi, & Hernandez, 2016; Rouzier, 2011; Walldorf et al., 2012).

Caribbean countries have highly open economies, meaning that they are highly dependent on imports for consumption and inputs for production, and on exports for income. For instance, 70% of foods consumed are imported from outside the Region. This affects susceptibility to Food-Borne Diseases (FBDs), and to Non-Communicable Diseases (NCDs) associated with the consumption of processed foods high in fat, sugar, artificial flavourings and preservatives. Additionally, the major export of most countries is tourism, which accounts for 25-65% of Gross Domestic Product (GDP) in most countries. While contributing to prosperity and cultural diversity, this also affects the range of goods available to local people and susceptibility to a wide range of pathogens from around the world.

Factors affecting Caribbean health at population level include (but are not limited to) population ageing, import dependency, sedentary lifestyles, climate and natural disasters. Between censuses conducted around 1990 and those around 2010, the proportion of the Caribbean population aged 14 and under fell by 9 percentage points, while the population 65 and over increased by 2 percentage points.⁵ The change in the age profile is among contributors to increased prevalence of NCDs. The transition towards a services economy, led by sectors such as finance, and away

⁵ These population data refer to CARPHA Member States (CMS), as listed in Table 2 of Chapter 1. There are 26 CMS, including CARICOM Member States, CARICOM Associate Members and Dutch Caribbean States.

from agriculture and manufacturing, and the advent of social media and hand-held digital devices, have tended to decrease physical activity levels (Caribbean Public Health Agency, Allen, & West, 2017).

The Caribbean has a rich mix of people of varying backgrounds. These include indigenous people, Africans, Asian Indians, Europeans, Chinese, Indonesian Javanese and many of mixed ancestry. The population of most countries comprises a mostly people of African descent, but in Guyana, and Trinidad and Tobago, people of Indian descent outnumber them. There are four primary languages in the Caribbean: English, Spanish, French and Dutch, and several dialects including Patois, Creole and Papiamentu.

Politically, the countries can be grouped into the Caribbean Community (CARICOM) Member States, the United Kingdom Overseas Territories (UKOTs), the Dutch Caribbean (both municipalities in the Netherlands and countries), the French Departments and the Hispanic Countries. CARICOM consists of fifteen Member States, inclusive of the Organisation of Eastern Caribbean States (OECS), which is made up of nine member countries that share a common currency and a common market and economy. The UK Overseas Territories (UKOTs) are associate Member States of CARICOM.

Countries vary widely in economic development, and in levels of health expenditure. There are wide variations in health expenditure as a percentage of government expenditure, bearing little relationship to the national income levels of each country (World Bank Databank, 2017).

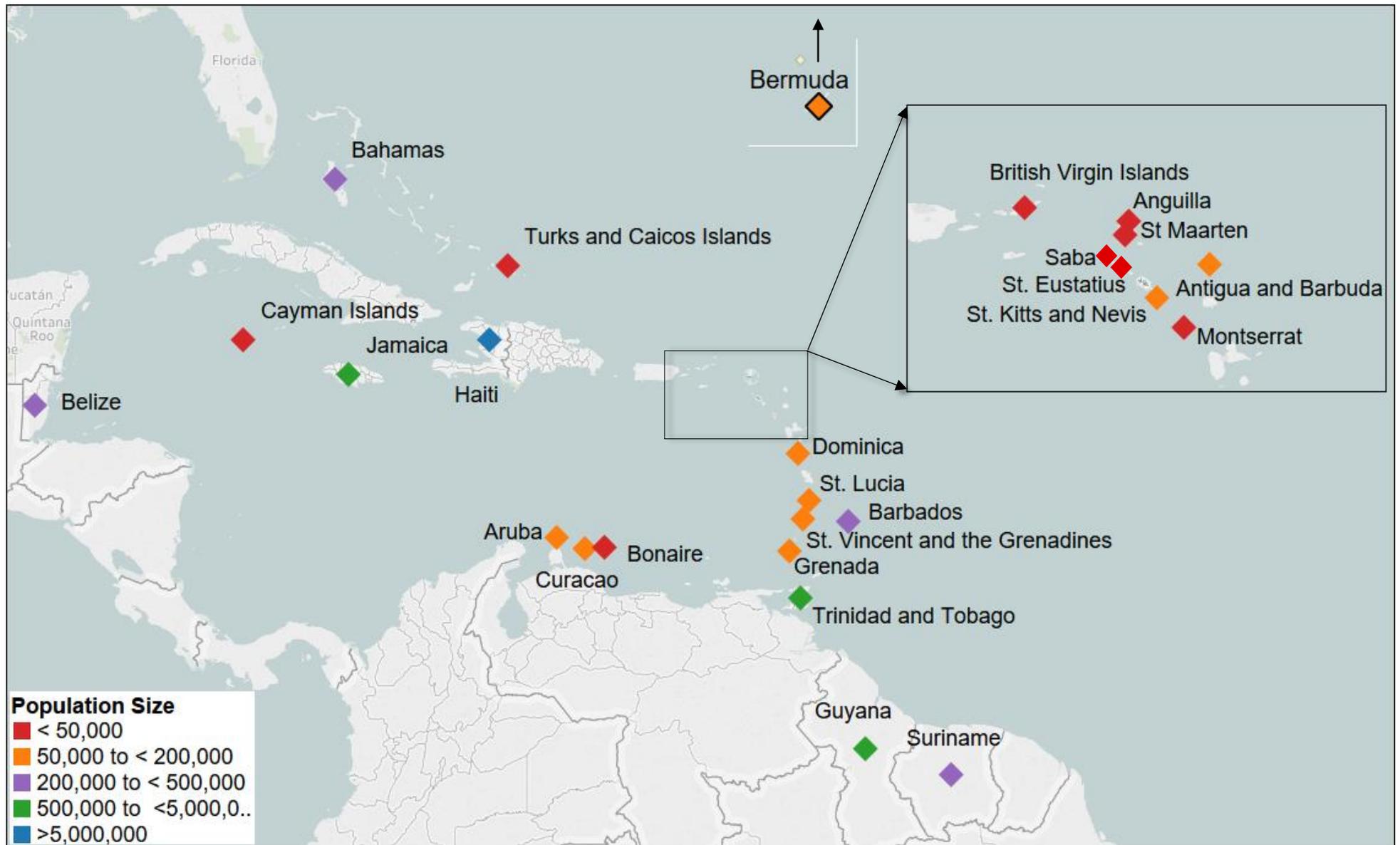
This report focuses mostly on Caribbean Public Health Agency (CARPHA) Member States (CMS). CARPHA, established in 2013, merges pre-existing specialist Caribbean public health agencies, each with a history of cooperation and achievements in health. The issues highlighted in this report are likely to be similar in Caribbean countries and territories that are not part of this grouping. CARPHA membership currently includes all CARICOM Member States and associate Member States as well as the Dutch Caribbean (Table 1).

Table 1: CARPHA Member States (CMS)

CARICOM Member States	CARICOM Associate Members	Dutch Caribbean
Antigua and Barbuda*	Anguilla*	Aruba
Bahamas	Bermuda	Bonaire
Barbados	British Virgin Islands*	Curacao
Belize	Cayman Islands	Saba
Dominica*	Turks and Caicos Islands	St. Eustatius
Grenada*		Sint Maarten
Guyana		
Haiti		
Jamaica		
Montserrat*		
Saint Lucia*		
St. Kitts and Nevis*		
St. Vincent and the Grenadines*		
Suriname		
Trinidad and Tobago		

* OECS Member States

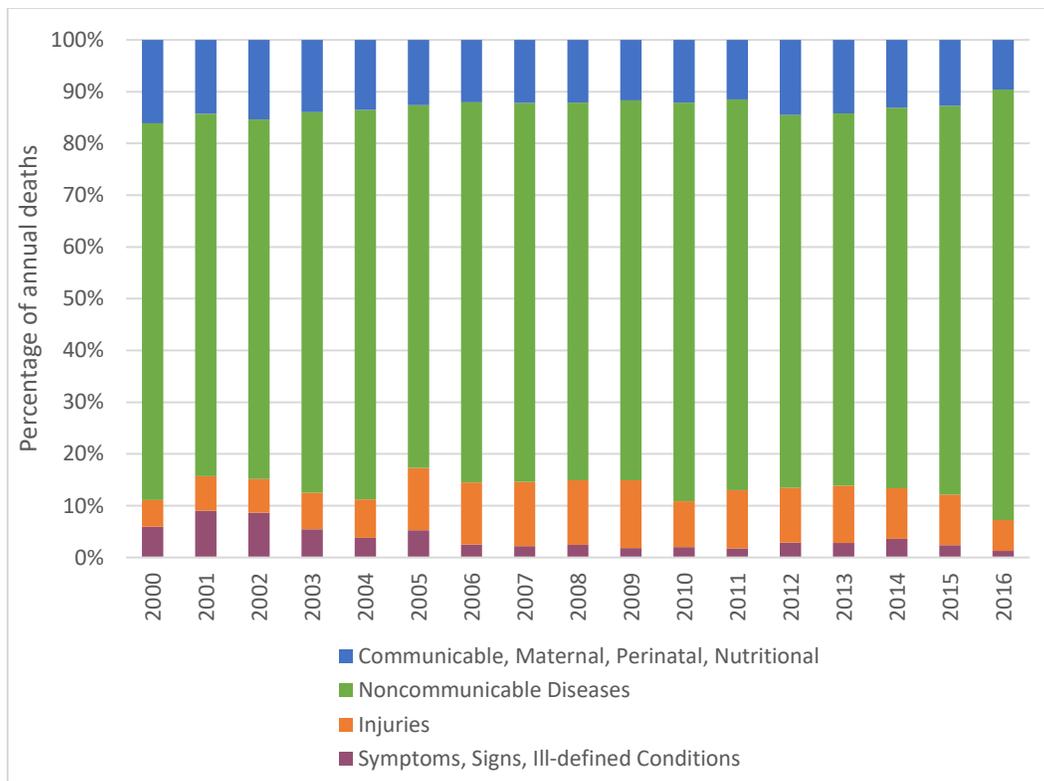
Figure 2: Map showing population sizes among CARPHA Member States



Epidemiology

The following diagram shows that the major causes of death in Caribbean countries are from NCDs, followed by: communicable, maternal, perinatal and nutritional conditions; and injuries. NCDs accounted for three-quarters (73%) of deaths in the 2000 to 2016 period, maternal, perinatal and nutritional conditions accounted for 13.2%, injuries for 9.7%, and symptoms, signs and ill-defined conditions for 4.1%. A striking finding is the increase in injuries as a cause of death. These accounted for 5% of deaths in 2000 and 10% in 2015 (Caribbean Public Health Agency et al., 2017). The association of climate with each of these broad categories will be explored in later chapters.

Figure 3: Percentage contribution to total deaths of broad groupings of conditions in the English- and Dutch-Speaking Caribbean, 2000-2016



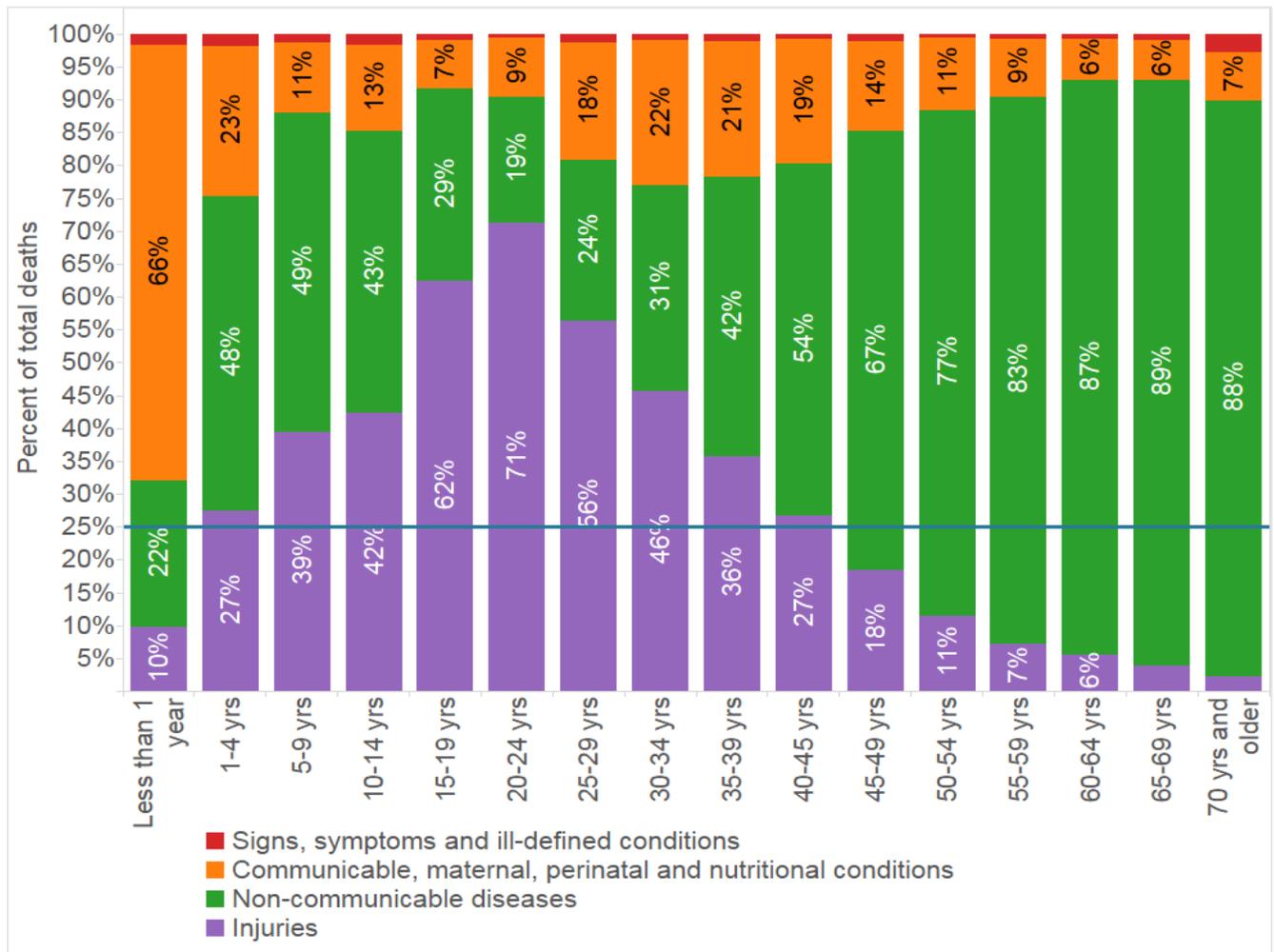
Note: Underlying causes of deaths grouped using the Global Burden of Diseases (World Health Organization, 2008)

Source: Data reported to CARPHA

The three leading causes of death from 2000 to 2016 are cerebrovascular disease, diabetes and ischemic heart disease, which, collectively, accounted for 29.6% of all deaths over the period. HIV started the 21st century as the fourth leading cause of death, but its rank has declined and hypertensive diseases are now the fourth leading cause.

When cause of death data is presented by age group, it becomes clear that NCDs account for the majority of deaths for persons from the age of 40 upwards. Communicable, maternal, perinatal and nutritional conditions account for the majority of deaths among infants, and between 10% and 25% among children up to the age of 14 and in adults 20-54 year olds. Injuries are an important cause of death among children and young adults, accounting for more than a quarter of deaths from age 1 to 45, and exceeding half of deaths among youth aged 15-29 (Caribbean Public Health Agency et al, 2017).

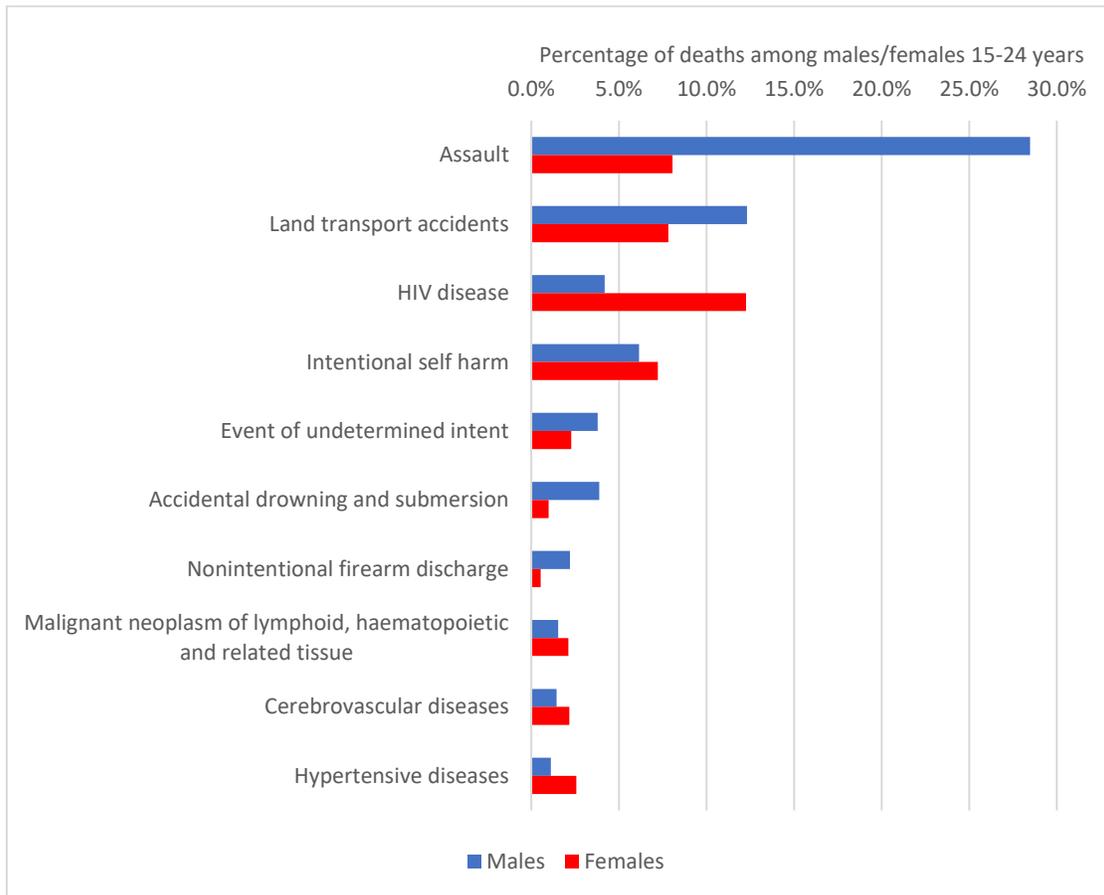
Figure 4: Annual regional deaths by age in CARPHA Member States



Source: Data reported to CARPHA (Hospedales, 2017)

Analysis of the patterns of death from injury by sex shows that the majority are among boys and men. Assault is the leading cause of death among males aged less than 65 years old, indicating a need for alliances between health, security and law enforcement agencies to reduce assaults to men and boys, which may be linked the drug trade, excessive alcohol consumption and gang activity. It is also important to note that girls and women are also subject to increasing violence, though it is less frequently fatal (Caribbean Public Health Agency. 2017).

Figure 5: Top 10 underlying causes of death by sex among youth 15 to 24 years old (2000-2016)



Source: Data reported to CARPHA

Vaccination has made an important contribution to the reduction in prevalence of some other communicable diseases. In 2015, on average, Caribbean countries had achieved at least 95% vaccination coverage against polio; diphtheria, tetanus and pertussis; and measles, mumps and rubella. The average coverage for the anti-tuberculosis vaccine, BCG, was 91% (PAHO, 2016). The increasing availability of anti-retroviral therapy has contributed to a decrease in the age of death from AIDS from, on average, 30 years old in 1996 to 50 years old in 2015 (Caribbean Public Health Agency et al., 2017).

Viruses for which no effective vaccine exists continue to affect public health. Since 2009, when it was declared a Public Health Emergency of International Concern (PHEIC), H1N1 virus (also known as “swine flu”) has caused considerable illness in CMS, accounting for 17% of respiratory virus illness cases in 2014, 31% in 2015 and 20% in 2016. The three respiratory viruses with the most cases reported were (in descending order of numbers): RSV, H1N1 and H3 in 2014; H1N1, rhinovirus and RSV in 2015, and RSV, H1N1 and rhinovirus in 2016 (Caribbean Public Health Agency et al., 2017).

The 2014-’16 period saw the arrival in the Caribbean of two mosquito-borne diseases that had not previously existed in the region: chikungunya and Zika. The Caribbean chikungunya epidemic of

2014-'15 was followed by the Zika epidemic of 2015-'16, exposing the high vulnerability of the region to mosquito-borne disease (PAHO, 2017a, 2017b). This is confirmed by the fact that since the 1980s, cases of dengue have risen in the region, with several major outbreaks and a transition from an endemic-epidemic state to a highly endemic state with annual outbreaks in multiple locations (Brathwaite Dick et al., 2012). The associations of vector-borne disease with climate variability will be explored in later chapters.

Increasing numbers of cases and outbreaks of acute gastroenteritis and food-borne disease pathogens have been reported by CMS. Since 2005, salmonella has accounted for the largest number of reported cases of laboratory-confirmed food-borne disease, followed (in descending order of numbers) by ciguatera, camphylobacter, shigella, norovirus and vibrio.

Anti-microbial pathogens, resistant to medical drugs, have been reported in the Caribbean by hospitals and in community settings. Cases of resistance by the following pathogens have been identified: pneumococci, *Haemophilus influenzae*, multi-drug resistant *Mycobacterium tuberculosis*, Enterobacteriaceae and carbapenemase-producing bacteria (Caribbean Public Health Agency et al., 2017).

Conclusion

This overview of the Caribbean and features of its health conditions highlights the vulnerabilities of the region to environmental and external influences, as a function of size, tropical island and coastal zone geography and history as a peripheral area of the global economy. Climate change and variability are critical manifestations of environmental and largely external influences on Caribbean health. These influences will be examined in the remainder of this report.

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