CHAPTER 4

SUDDEN IMPACT: THE SEVERE WEATHER EVENTS OF 2017
CHAPTER 4: SUDDEN IMPACT: THE SEVERE WEATHER EVENTS OF 2017

# Contents

List of Figures ................................................................................................................................. iii  
List of Tables .................................................................................................................................. iv  
Introduction ....................................................................................................................................... 124  
1. Conceptual framework for analysis of health impact and response ........................................... 124  
2. Methodology for data collection ................................................................................................... 127  
3. Description of the severe weather events of 2017 .................................................................. 128  
   3.1 Hurricanes Irma and Maria .................................................................................................... 128  
   3.2 The vulnerability of Dominica ................................................................................................. 133  
4. Health outcomes .......................................................................................................................... 134  
   4.1 Mortality, injury and displacement .......................................................................................... 134  
   4.2 Safety and security .................................................................................................................... 136  
   4.3 Mental health .......................................................................................................................... 137  
   4.4 Gastro-intestinal disease ........................................................................................................ 138  
   4.5 Malnutrition: under- and over-nutrition .................................................................................. 141  
   4.6 Fever ....................................................................................................................................... 141  
   4.7 Respiratory conditions ............................................................................................................. 143  
   4.8 Mosquito-borne disease ........................................................................................................... 144  
   4.9 Leptospirosis ............................................................................................................................ 148  
5. Environmental determinants of health ......................................................................................... 150  
   5.1 Buildings and infrastructure .................................................................................................... 150  
      Impact ....................................................................................................................................... 150  
      Response ................................................................................................................................. 161  
   5.2 Safe drinking water and sanitation ........................................................................................ 167  
      Impact ....................................................................................................................................... 167  
      Response ................................................................................................................................. 168  
   5.3 Food security, safety and nutrition ............................................................................................ 170  
      Impact ....................................................................................................................................... 170  
      Response ................................................................................................................................. 171  
   5.4 Disease vectors ....................................................................................................................... 174  
      Impact ....................................................................................................................................... 174  
      Response ................................................................................................................................. 175  
   5.5 Air quality and pollution .......................................................................................................... 176  
      Impact ....................................................................................................................................... 176  
      Response ................................................................................................................................. 177  
6. Building blocks of health systems............................................................................................... 177  
   6.1 Leadership and governance ..................................................................................................... 177  
      Impact ....................................................................................................................................... 177  
      Response ................................................................................................................................. 177  
   6.2 Health workforce ..................................................................................................................... 181  
      Impact ....................................................................................................................................... 181  
      Response ................................................................................................................................. 183  
   6.3 Health information systems ...................................................................................................... 185  
      Impact ....................................................................................................................................... 185  
      Response ................................................................................................................................. 186  
6.4 Medical products and technologies .......................................................................................... 188  
      Impact ....................................................................................................................................... 188
LIST OF FIGURES

Figure 1: Conceptual framework for the analysis of health impacts of severe weather events .......................... 126
Figure 2: Hurricane Irma over the North-Eastern Leeward Islands ......................................................................... 130
Figure 3: Hurricane Maria track history .............................................................................................................. 131
Figure 4: Wind gusts of Hurricane Maria as it passed over Dominica ................................................................... 132
Figure 5: Rainfall totals at Canefield Airport, Dominica (10-minute intervals), on 18 and 19 September 2017 ........................................................................................................................................ 132
Figure 6: Percentage of survey respondents experiencing disruption to medical services in Puerto Rico following Hurricane Maria ........................................................................................................................................ 136
Figure 7: Number of gastroenteritis cases per week in Dominica in 2015 (Tropical Storm Erika) and 2017 (Hurricane Maria), compared with six-year average 2012-17 ........................................................................... 139
Figure 8: Impact of Hurricanes Irma and Maria at Category 4 or 5 strength on numbers of gastroenteritis cases by week in CMS in 2017 ........................................................................................................................................ 140
Figure 9: Impact of Hurricanes Irma and Maria at Category 4 or 5 strength on numbers of fever cases by week in CMS in 2017 ........................................................................................................................................ 142
Figure 10: Number of fever with respiratory symptoms cases per week in Dominica in 2015 (Tropical Storm Erika) and 2017 (Hurricane Maria), compared with six-year average 2012-17 .......... 143
Figure 11: Laboratory confirmed cases of dengue in the English- and Dutch-speaking Caribbean, 2004 - 2017 .............................................................................................................................................. 145
Figure 12: Number of confirmed cases of leptospirosis by CMS, 2013-2017 ........................................................ 149
Figure 13: Poster depicting climate change and health links, by the Environmental Health Department, Dominica .............................................................................................................................................. 150
Figure 14: Damage from Hurricane Maria to buildings in Dominica, September 2017 ........................................ 151
Figure 15: Damage to Princess Margaret Hospital Laboratory, Dominica, September 2017 ......................... 155
Figure 16: Damage by Hurricane Irma to the health facility at Capoons Bay, Tortola, British Virgin Islands .............................................................................................................................................. 157
Figure 17: Impact of Hurricane Maria flood waters on a house in Dominica, September 2017 ...... 158
Figure 18: Damaged house, with debris arranged for solid waste collection. Roseau, May 2018 .... 159
Figure 19: Overflowing garbage collection facilities in the British Virgin Islands following Hurricane Irma .............................................................................................................................................. 160
Figure 20: Picture showing aid agency tarpaulin amidst damage to buildings and a vehicle in Roseau .............................................................................................................................................. 161
Figure 21: Solar panels among damaged roofs, Roseau, May 2018 ................................................................. 163
Figure 22: Debris left by Hurricane Irma in the British Virgin Islands ................................................................... 165
Figure 23: The British Virgin Islands’ plan for debris management following Hurricane Irma .................... 166
Figure 24: Waste and sanitation hazards in Dominica, September 2017 ........................................................... 167
List of Tables

Table 1: Caribbean countries and territories impacted by Hurricanes Irma and Maria at Category 4 or 5 strength, September 2017 ................................................................. 128
Table 2: Hurricane strength categories: the Saffir Simpson scale ................................................................. 129
Table 3: Mortality, displacement and impact on GDP of Tropical Storm Erika and Hurricane Maria in Dominica ........................................................................................................ 134
Table 4: Confirmed Cases of Dengue in the English and Dutch-speaking Caribbean, 2014 - 2017 .. 146
Table 5: Confirmed Cases of Chikungunya in the English and Dutch-speaking Caribbean, 2014 – 2017 .................................................................................................................. 147
Table 6: Confirmed Cases of Zika in the English and Dutch-speaking Caribbean, 2014 – 2017 .... 148
Table 7: Damage to health facilities in Dominica, as at 27 October 2017 ......................................................... 152
Table 8: Damage to buildings of the Princess Margaret Hospital, as at 15 October 2017 .................. 156
Table 9: Dominica: distribution of damages, losses and needs by sector inflicted by Hurricane Maria, November 2017 ........................................................................................................ 190
INTRODUCTION

There is evidence that the increase in greenhouse gases (GHGs) has led to increases in tropical sea surface temperatures which are correlated with increased intensity of tropical cyclones, including hurricanes (Emanuel, 2005; Webster, Holland, Curry, & Chang, 2005). 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). In this chapter we assemble available evidence of the health impact of and response to these hurricanes in the Caribbean and include a case study of Hurricane Maria in the Commonwealth of Dominica.¹

1. CONCEPTUAL FRAMEWORK FOR ANALYSIS OF HEALTH IMPACT AND RESPONSE

Hurricanes have an obvious direct impact on health through injury, but also, and crucially, on environmental determinants of health and the health system. In this chapter we look at how health outcomes, environmental determinants and health system building blocks were affected by Hurricanes Irma and Maria. We also look at the responses of the government and people of Caribbean countries in terms of public health action to rebuild and adapt environmental determinants and the health system to reduce ill-health and produce better health outcomes in the immediate aftermath of a severe weather event: in this case, action following Hurricanes Irma and Maria up to the end of 2017. Chapter 5 will look at strategies, organisations and finances to address climate and health issues in the Caribbean. The bulk of the evidence comes from a case study of the impact of Hurricane Maria on Dominica, but sources of evidence on the effects of the two hurricanes on other Caribbean countries have also been reviewed and included.

The environmental determinants of health considered in this Chapter are heavily affected by severe weather events:

- Buildings and infrastructure
- Safe drinking water and sanitation
- Food security, safety and nutrition
- Disease vectors
- Air quality and pollution (WHO, 2015)

¹ The official name of the Commonwealth of Dominica will be shortened to Dominica in the rest of this chapter.
The impact of severe weather events on these determinants can be reduced by effective health system responses. Thus, the health system effectively *socially mediates* the environmental impact. However, "building blocks" of the health system (Shumake-Guillemot, Villalobos-Prats, & Campbell-Lendrum, 2015) can also be negatively affected:

- Leadership and governance
- Health workforce
- Health information systems
- Availability of medical products and technologies
- Service delivery
- Finance

Leadership and governance can themselves be affected and play a central role in addressing the impact on the other building blocks and the environmental determinants.

It is difficult to separate out the likely impact of each of these factors on any specific health condition. For instance, the prevalence of a vector-borne disease such as dengue may be associated with a combination of damage to infrastructure, lack of sanitation services and lack of environmental health service delivery in the aftermath of a hurricane, so that mosquito-breeding sites proliferate. It is also inherently difficult to impose experimental conditions to find out the relative contributions of factors, because these factors are mostly difficult to control and are interdependent. In this chapter we examine the following health conditions, weaving in the story of the environmental and health system impacts on these as recounted by informants in Dominica and from the statistics, research and technical literature:

- Mortality and injury
- Gastro-intestinal disease
- Malnutrition (under- and over-nutrition)
- Fevers
- Respiratory conditions
- Mosquito-borne disease
- Leptospirosis
- Safety, security and mental health
Severe weather events have impacts on social determinants of health such as employment, sources of livelihood, income inequality, poverty and gender equality.\(^2\) The impacts on social determinants of health generally take place over the medium to long term, while the current analysis is of information about immediate post-hurricane effects. Chapter 2 presents information on economic and social vulnerabilities and populations at risk. The Dominica Post-Disaster Needs Assessment (PDNA) for Hurricane Maria has estimates of effects on employment and livelihood but some of these effects are not immediately felt and were difficult to predict. A lack of recent poverty data to use as a baseline for the measurement of effects on poverty was also noted (Government of Dominica, 2017). In the current analysis we concentrate on environmental determinants and health system building blocks and discuss social and economic factors that were indicated by interviewees or in the literature as

interacting with these to produce health outcomes. The vulnerabilities of different populations are considered as a cross-cutting theme throughout the chapter.

The remainder of this chapter is organised as follows. First, we describe the methodology for data collection. We then describe the hurricanes in 2017. Third, we present health outcomes of Hurricanes Maria and Irma in the region. Fourth, we examine the impact of the hurricanes on environmental determinants of health, and the responses of the government and people of Caribbean countries in 2016 to address these determinants. Fifth, we look at the impact on and responses of the health system in 2017. The longer-term and broader Caribbean institutional and policy responses to address disasters and climate change will be addressed in Chapter 5.

2. METHODOLOGY FOR DATA COLLECTION

This chapter is based on review of available documentary and statistical evidence relating to the categories listed in the figure above. Epidemiological data was received from the Health Information Unit of the Commonwealth of Dominica and from CARPHA’s Surveillance, Disease Prevention and Control Division. Documentary evidence on the health impact and response to Hurricanes Irma and Maria in countries other than Dominica was sought via literature search and consultation with experts.

A case study was conducted of the experiences of the Commonwealth of Dominica following the passage of Hurricane Maria on September 18th, 2017. The inclusion of the case study was important to provide real-life scenarios experienced by Caribbean people during the 2017 hurricanes. The qualitative data collected from informants in Dominica provides context, understanding and depth to the analysis provided by review of technical and policy documents and statistics. The story of what happened during and after Hurricane Maria in Dominica in 2017 provides valuable examples of scenarios that have been and are likely to be faced by Caribbean people as the frequency of severe weather events accelerates.

The choice of Dominica was approved by the Oversight Committee (see Appendix 1), along with the research protocol for the Dominica fieldwork, which includes data collection instruments. A visit to Dominica was carried out by a Consultant, 21-26 May 2018. The Consultant met with key informants from agencies and offices listed in Appendix 2 and interviewed them regarding the health impact and response to severe weather events and climate issues in Dominica. Two focus groups were conducted with informants from the health sector and other sectors (public works and emergency response). Following return from Dominica, the Consultant also carried out phone interviews with representatives of the Community Mental Health Team and the Nursing Department. Information on reconstruction of hospital facilities was received by email from the Facilities Manager of the Princess Margaret Hospital. Informants were asked for their professional opinions and not sensitive, personal information. To protect confidentiality, names of persons interviewed and included in focus group discussions have not been included in this report.

The research presented in this chapter is based on one week of fieldwork along with literature review and statistical data analyses by a Consultant within a limited timeframe. Readers are referred to post-disaster assessments conducted by teams of multiple agencies and professionals for a more comprehensive account of health consequences of severe weather events. This chapter recounts the
experiences of one hurricane-affected country in depth and puts this in the context of further information from other Caribbean countries on health impact and responses to severe weather events.

3. DESCRIPTION OF THE SEVERE WEATHER EVENTS OF 2017

3.1 Hurricanes Irma and Maria

The most severe weather events for the Caribbean in 2017 were Hurricanes Irma and Maria, which affected numerous Caribbean islands. Hurricane Irma was at Category 5 – the maximum hurricane strength – discontinuously3 from September 5-9, 2017, with sustained wind speeds of approximately 180 mph/ 285 kmh (Cangialosi, Latto, & Berg, 2018). Hurricane Maria was at category 5 discontinuously from September 18-20, 2017, with sustained wind speeds of 175 mph/ 280 kmh. The following table shows the Caribbean countries and territories most heavily affected, since these hurricanes hit them while at Category 4- or 5- strength. It is followed by a table that defines the hurricane strength categories according to the Saffir-Simpson hurricane scale, with the predicted types of damage according to each category on the scale. It is important to note that countries neighbouring those listed in the following table were also affected, though the eye of the hurricane4 did not pass over their land. The outer bands of the hurricanes led to some level of destruction in neighbouring states, such as Guadeloupe and Montserrat in the case of Hurricane Maria. The focus of this chapter is mainly on those countries that took a direct hit from one of these two hurricanes, because they demonstrate the full consequences of severe weather events and the extreme actions necessary to recover, adapt and mitigate against events of this severity.

Table 1: Caribbean countries and territories impacted by Hurricanes Irma and Maria at Category 4 or 5 strength, September 2017

<table>
<thead>
<tr>
<th>Irma</th>
<th>Maria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguilla</td>
<td>Dominica</td>
</tr>
<tr>
<td>Antigua and Barbuda</td>
<td>Puerto Rico</td>
</tr>
<tr>
<td>The Bahamas</td>
<td></td>
</tr>
<tr>
<td>British Virgin Islands</td>
<td></td>
</tr>
<tr>
<td>Cuba</td>
<td></td>
</tr>
<tr>
<td>St. Barts</td>
<td></td>
</tr>
<tr>
<td>St. Maarten</td>
<td></td>
</tr>
<tr>
<td>Turks and Caicos Islands</td>
<td></td>
</tr>
<tr>
<td>US Virgin Islands</td>
<td></td>
</tr>
</tbody>
</table>

Key: Red italics = Affected by winds of Category 5 strength  
Purple = Affected by winds of Category 4 strength  
Sources: (Cangialosi et al., 2018; US National Hurricane Center, 2018)

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

4 The US National Oceanic and Atmospheric Administration provides definitions of the different parts of hurricanes, including the eye, eyewall and spiral bands, at http://www.aoml.noaa.gov/hrd/tcfaq/A11.html
Table 2: Hurricane strength categories: the Saffir Simpson scale

<table>
<thead>
<tr>
<th>Category</th>
<th>Sustained Winds</th>
<th>Types of Damage Due to Hurricane Winds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>74-95 mph 119-153 km/h</td>
<td><strong>Very dangerous winds will produce some damage:</strong> Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles are likely to result in power outages that could last a few to several days.</td>
</tr>
<tr>
<td>2</td>
<td>96-110 mph 154-177 km/h</td>
<td><strong>Extremely dangerous winds will cause extensive damage:</strong> Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.</td>
</tr>
<tr>
<td>3 (major)</td>
<td>111-129 mph 178-208 km/h</td>
<td><strong>Devastating damage will occur:</strong> Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.</td>
</tr>
<tr>
<td>4 (major)</td>
<td>130-156 mph 209-251 km/h</td>
<td><strong>Catastrophic damage will occur:</strong> Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.</td>
</tr>
<tr>
<td>5 (major)</td>
<td>157 mph or higher 252 km/h or higher</td>
<td><strong>Catastrophic damage will occur:</strong> A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.</td>
</tr>
</tbody>
</table>

*Source: (US National Hurricane Center, 2018)*

Hurricane Irma reached its maximum intensity on 5 September 2017 and continued with this intensity – with windspeed of 155 knots (178mph / 287 km/h) – when it made landfall on Barbuda on 6 September. The level of destruction made that island uninhabitable, with the entire population being evacuated in the days following the passage of Irma. Several Caribbean countries – including Dominica – immediately sent equipment and supplies to assist the people of Barbuda. This gesture of solidarity resulted in the unfortunate weakening of the capacity of Dominica to address the damage caused when Hurricane Maria hit Dominica on 18 September.
During its journey through the Leeward Islands, Irma’s gusts reached 185 mph/295 (295 kilometres) per hour, making it the strongest storm ever to hit the islands and one of the strongest storms ever measured in the Atlantic basin (NASA Earth Observatory, 2017). On 6 September, Irma continued with Category 5 strength when it hit St. Maarten, followed by Anguilla, then proceeded to the British Virgin Islands, making landfall on Virgin Gorda while still at maximum intensity. The eye of Irma passed just south of the Turks and Caicos Islands on 7 September, then made landfall on Little Inagua Island in the Bahamas on 8 September at category 4 intensity. This slight weakening ended Irma’s 60-hour period of sustained category 5 intensity, which is the second longest such period on record (behind the hurricane that hit Santa Cruz del Sur, Cuba, in 1932). Irma then intensified and made landfall near Cayo Romano, Cuba, on 9 September, with estimated maximum winds of 145 knots (167 mph/268 kmh). This marked the first category 5 hurricane landfall in Cuba since 1932. Irma’s interaction with land caused it to weaken significantly, first to a category 4 storm a few hours after landfall in the Cuban Keys and then down to a category 2 hurricane later that day when the eye was near Isabela de Sagua. Irma then made a turn towards the north west and moved to the Florida Straits on 10 September (Cangialosi et al., 2018).

Hurricane Maria was an extremely rapidly-intensifying storm (Pasch, Penny, & Berg, 2018). It was first reported as a category 1 hurricane at 17:00 Atlantic Standard Time (AST) on 17 September 2017. Some 18 hours later, the storm was upgraded from category 1 to category 3. The storm remained a category 3 for just 3 hours and was then upgraded to a category 5. Notification that it had reached Category 5 strength was issued only 1 hour 15 minutes prior to the storm’s landfall in Dominica. The hurricane made landfall at approximately 21:00 AST and the storm progressed over Dominica with the eye exiting the island at approximately 22:45 AST. The following diagram shows that it moved...
from Category 3 to Category 5 strength just before landfall in Dominica (Government of Dominica, 2017). On leaving Dominica its intensity fell to Category 4, and it made no further landfall in the Eastern Caribbean, but the effects of its outer bands of wind and rain continued to be felt in neighbouring islands such as Guadeloupe and Montserrat. When it next made landfall in Puerto Rico on 20 September it was at high Category 4 strength, just below the threshold for a category 5 storm. The hurricane’s centre crossed the island, roughly diagonally from southeast to northwest, for approximately 7 hours and 45 minutes before it emerged into the Atlantic (Pasch et al., 2018).

Figure 3: Hurricane Maria track history

Source: (Government of Dominica, 2017)

In Dominica, the effect of the hurricane began to be felt around 11:00 AST on 18 September, with rainfall and light winds which intensified throughout the afternoon and into the evening until Hurricane Maria made landfall as a Category 5 storm, packing gusts exceeding 170 mph (277km/h) (Government of Dominica, 2017) and maximum sustained winds (continuing for at least 10 minutes and measured at Douglas Charles airport) of 150 mph (Pasch et al., 2018). After landfall, the island was exposed to extraordinary winds for more than 3 hours as the storm passed over the centre of the island. This was accompanied by intense rainfall, which provoked flash floods and landslides. Data acquired from the Caribbean Institute of Meteorology and Hydrology (CIMH) indicates that the heaviest rainfall began the evening of 18 September and lasted into the morning of 19 September. In addition to winds and rainfall, the coastline was pummelled by high waves, causing major damage in the south-west. Storm surge from the event was recorded at the tide gauge in Marigot, on the east coast, as being about one metre above predicted tide levels (Government of Dominica, 2017).
Figure 4: Wind gusts of Hurricane Maria as it passed over Dominica

Source: (United Nations, 2017)

Figure 5: Rainfall totals at Canefield Airport, Dominica (10-minute intervals), on 18 and 19 September 2017
Hurricane Maria was followed by extended periods of rain as the wet season wore on. This compounded the difficulties in Dominica, with outcomes including:

- The proliferation of potential mosquito-breeding sites on altered landscapes and in pieces of debris from the storm.
- Increased risk of leptospirosis and infectious diseases resulting from contact with flood waters and standing bodies of rainwater.
- Decomposition of organic matter into puddles and water sources, increasing risk of infectious diseases and harmful algae blooms.
- The development of mould in buildings, leading to risk of infection by fungal organisms. This especially affected buildings with damaged roofs.
- Delays in repairs to buildings, especially to electricity fittings, as they were insufficiently dry for the work to be carried out.

The health outcomes of these situations will be detailed in later sections.

### 3.2 The vulnerability of Dominica

Hurricane Maria was the fifth time on record that Dominica has taken a direct hit from a hurricane, but never had it faced a storm of such ferocity and strength (United Nations, 2017). Dominica is vulnerable to natural disasters arising from meteorological events (high wind, excess rainfall and hurricanes) and geophysical events (earthquake, volcano and tsunami). These have had negative long-term effects on socioeconomic well-being and general economic and fiscal stability. Hurricanes have repeatedly set back economic development, notably Hurricane David in 1979, in which around 75% of the population was rendered homeless (Lawrence, 1979). Particularly damaging are events associated with excessive or prolonged rainfall, which provokes flooding and landslide activity. The island's mountainous, rugged landscape with 9 peaks, each with its own radial drainage system, poses a challenge for the construction of a safe build environment, particularly for road construction.

The steep topographic conditions and rugged interior have led to human settlements and physical development being highly concentrated along narrow coastal areas (particularly in the south and west) (Government of Dominica, 2017). These features render the population especially vulnerable to both inland flooding from run-off from the hills and mountains, and from storm surge and coastal flooding. Dominica thus exhibits several features of vulnerability associated with SIDS, as detailed in Chapter 2.

Gross national income per capita is estimated at around US$6,990 per year, placing Dominica in the upper middle income bracket (World Bank, 2017). Dominica is classified as having high human development, ranking 96th out of 188 countries in the Human Development Index in 2016 (United Nations Development Programme, 2016). The Human Development Index amalgamates data on education, life expectancy and income per capita. The high classification results largely from achievements in life expectancy and education. Life expectancy is estimated at 78.2 for women and 73.8 for men (United Nations, 2008) and 75 overall (Government of Dominica, 2017). These statistics
belie the considerable vulnerability of the country and its economy to climate change and natural disasters.

The discrepancy between the generally high performance on standard measures of development used by international agencies and governments to determine eligibility for financial assistance, and the high level of vulnerability to climate change and natural disasters, is a feature of Caribbean SIDS in general. See section 6.6 for a summary of economic losses in Dominica from Hurricane Maria.

One of the challenges faced is migration, especially of skilled human resources (see section 6.2). The Dominica Census of 2011 gave a non-institutional population of 70,739, with the population having fallen in each census since 1981, when the non-institutional population stood at 73,795 (Commonwealth of Dominica, 2011). Higher life expectancy among women than men belies lower economic security among women, with labour force participation of 70.6% for men and 59.5% for women (Allen & Christophe, 2018; International Labour Organisation, 2017). Among men in 2011, the average number of hours per week spent on unpaid domestic work was 7 hours, while for women it was 16.1 hours; a 2.3-fold difference (Commonwealth of Dominica Central Statistical Office, 2016).

The different roles of men and women in the economy lead to different vulnerabilities, with men more vulnerable to changes in employment status and the unpaid work and family care burden falling more heavily on women.

4. Health Outcomes

4.1 Mortality, injury and displacement

In the immediate aftermath of Tropical Storm Erika (August 27, 2015), 11 persons were confirmed dead, 574 persons homeless, 7,229 affected in disaster-declared areas, while losses amounted to 90% of Dominica’s Gross Domestic Product (Government of Dominica, 2015). While still recovering from this storm, Hurricane Maria struck, with even more devastating results, as shown in the following table.

<table>
<thead>
<tr>
<th></th>
<th>Dead</th>
<th>Homeless/ displaced</th>
<th>Losses as percentage of GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical Storm Erika</td>
<td>11</td>
<td>574</td>
<td>90%</td>
</tr>
<tr>
<td>Hurricane Maria</td>
<td>27</td>
<td>1,862</td>
<td>226%</td>
</tr>
</tbody>
</table>

Sources: (Government of Dominica, 2017; Government of the Commonwealth of Dominica, 2015)

On 27 September 2017, the Police declared that 27 people had lost their lives and a further 31 people were missing as a result of Hurricane Maria.

Numbers injured during Tropical Storm Erika and Hurricane Maria in Dominica have not been calculated. Interviewees for the current assessment noted that many of the injuries occurred shortly
after the hurricane, as people tried to move debris. An attempt was made to calculate injuries arising from the hurricane during the 2017 PDNA. The indicator of injuries could not be computed, as much of the pre-disaster data sets of the sector were destroyed by Hurricane Maria, making it challenging for health sector experts to provide the necessary information. At the time, the Ministry of Health was moving towards an integrated electronic information system; the Dominica Integrated Information Systems for Health (DIISH). All 52 primary health care centres were to be linked to this network, which would allow them to back up information locally and use it off-line (HIU Information and Communications Systems, 2017; PAHO, 2017). The hurricane put the development of DIISH on hold.

The 1,862 displaced represents people who were still in 63 collective centres by the end of September 2017. Most of the displaced people were in collective centres at schools (53%). This was a source of disruption in the education of children in those schools, which added to the education disruption caused by damages to school and road infrastructure. The UN reported that 32% the people still in collective centres were among the most vulnerable. The most common vulnerabilities reported were: elderly persons (25 per cent), single female headed households (13 per cent) and persons with chronic illnesses (12 per cent).

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%) (Government of Dominica, 2017).

A further aspect of displacement was the need to evacuate critical patients because they were unable to receive the care they needed locally because of damage to health infrastructure (see section 5.1).

The immediate death toll of 27 was much less than the 56 people who lost their lives in Dominica after Hurricane David, another Category 5 storm, in 1979 (Lawrence, 1979). The lower toll may be attributed to greater disaster preparedness, as detailed in Section 6 of this Chapter.

However, immediate deaths do not include all deaths that are attributable to a hurricane. According to the Centers for Disease Control and Prevention, deaths can be directly attributed to a tropical cyclone if they are caused by forces related to the event, such as flying debris, or if they are caused by unsafe or unhealthy conditions resulting in injury, illness, or loss of necessary medical services. Official death tolls tend to be limited mostly to those caused by forces related to the event and confirmed as such by a medical examiner or forensic scientist. Deaths from infectious diseases that occur after the event, or from chronic diseases left untreated because of breaks in access to treatment, do not tend to appear in official death tolls.

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 used a representative, stratified sample of 3,299 randomly chosen households to produce an independent estimate of all-cause mortality after the hurricane. One person per household reported on deaths in their household, as well as on disruptions to medical care and to utilities such as water and electricity. It was found that the mortality rate had increased by 62% over the same period the previous year – 20 September - 31 December 2016 - yielding a total of 4,645 excess deaths (95% Confidence Interval, 793 to 8,498).
The study suggested that the number of excess deaths was more than 70 times the official estimate. One-third of the deaths were attributed by respondents to delayed or interrupted health care. The following diagram shows the percentage of all households in the survey reporting at least one day of disrupted medical services according to factors causing the disruption. These factors were not necessarily related to reported deaths, but the diagram shows some of the types of disruption that may have contributed to the excess death toll over the previous year (Kishore et al., 2018).

**Figure 6: Percentage of survey respondents experiencing disruption to medical services in Puerto Rico following Hurricane Maria**

![Diagram showing percentage of survey respondents experiencing disruption to medical services](source)

Source: (Kishore et al., 2018), page 7

The Puerto Rico study highlights that the period following a hurricane is one of extreme disruption to health-sustaining environmental factors, including health care and access to basic utilities. This disruption can have fatal consequences. Section 5 of this chapter examines various forms of disruption to environmental determinants of health in Dominica, and how the people of that country responded to them.

### 4.2 Safety and security

Interviews conducted for the current assessment showed that a wide variety of displacement situations were experienced in Dominica following Hurricane Maria, ranging from moving one’s daily activities to the ground floor of one’s house because of upper floor and roof damage, to emigration from the country. Many were rendered homeless, with 1,862 people still in collective centres two weeks after the hurricane (Government of Dominica, 2017). Some Caribbean countries temporarily
opened their borders to help shelter Dominicans and provide education to children whose schools had been damaged or destroyed. After Tropical Storm Erika, people from severely affected areas whose houses had been destroyed, such as Petite Savanne, were moved to urban areas and were dispersed as the government and NGOs found a variety of places for them to live. The separation from community and rural life was traumatic, and the situation for these people was aggravated by Hurricane Maria.

The adjustment to the damage caused by Maria required psychological flexibility and resilience during displacements, such as moving into other accommodation at relatives’ or friends’ homes, moving back from shelters to damaged properties, children being moved to different schools within the country or abroad, and family members and loved ones seeking new employment and sources of income in other parts of the country or abroad. Problem-solving abilities were stretched to the limit as people faced reduced access to basic needs such as food, water and utilities and increased risk of disease. Sleep deprivation was reported by several interviewees. Co-operation with family members, friends, neighbours and colleagues became a critical resilience strategy: co-operation and collaboration will be considered in more detail in the sections on response below.

News media often report that natural disasters are accompanied by various forms of antisocial behaviour, such as looting and interpersonal violence. Scholars point out that citizen responses to disaster vary widely, and many citizens respond primarily by assisting others (Helsloot & Ruitenberg, 2004; Tierney, Bevc, & Kuligowski, 2006). In Dominica, there was a lot of evidence of cooperation and mutual assistance, as will be detailed below. However, in the initial period, there was extreme disruption, and for around a week after Hurricane Maria, there was widespread looting across Dominica. Interviewees reported that the looters took a wide variety of goods, not restricted to basic necessities such as food and water. (Government of Dominica, 2017).

Defence Forces from several CARICOM countries were deployed in Dominica, and assisted in re-establishing order, as well as in logistical support for humanitarian relief efforts.

4.3 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. The informants also stressed needs for healthy foods and employment (Ravaliere & Murphy, 2017).

Risks to safety and mental health result from displacement. After Hurricane Maria, people gathered in hurricane shelters and collective centres and sought refuge in homes that were not their own. Risks included various sorts of abuse from other people gathered in these settings, such as theft and sexual assault. Loss of employment and increased drug and alcohol use also created conditions of vulnerability for gender-based violence, though no additional cases were officially reported by November 2017 (Government of Dominica, 2017).

The 2017 PDNA indicates that alcohol and drug use increased after both Tropical Storm Erika and Hurricane Maria, but no figures were available (Government of Dominica, 2017).
Among long-term and permanent residents of a hurricane-affected country, there may be stages of psychological reaction to a disaster. The Dominica CMHT noted that the initial period among many survivors may be termed a psychological "honeymoon" as people bond with others in joint efforts to recover and share stories that are full of hope. This was encouraged in the month following Hurricane Maria in Dominica by seeing the extent of international and local agency response to the emergency. After about a month, people started to do an inventory of their real-life situation. As the month of October rolled into November “the reality check would have informed persons that they are facing multiple demands on their lives and that the resources to respond physically and emotionally were being depleted. Therefore, it is expected that the disillusionment phase of the psychosocial response would be driving the behaviour of each member of the Dominican population” (Dominica Community Mental Health Team, 2017), page 7. 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. Previously employed persons with economic and financial commitments remained disoriented for an extended period. 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 (Dominica Community Mental Health Team, 2017). It should be noted that these phases of response may apply to emergency and health care workers as well as the general citizenry. The effects on health care workers will be considered in section 6.2.

4.4 Gastro-intestinal disease

Symptoms of gastro-intestinal disease, such as nausea, vomiting and diarrhoea, can result from the proliferation of pathogens and the breakdown in water, sanitation and hygiene services following a hurricane. CARPHA Member States (CMS) carry out syndromic surveillance of diseases affecting the gastro-intestinal tract, which may result from a variety of food-borne and other environmental sources. The Dominica Health Vulnerability and Adaptation Assessment identified gastroenteritis as 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, as shown in Figure 8. The high number of cases at the beginning of 2017 in Dominica appears to be associated with unusually high numbers of cases across the Caribbean region from the early part of the year until April 2017. This increase in numbers of cases across the region in early 2017 is shown in analyses of CARPHA data in Figure 9.
It was not possible to determine the diseases causing the increase in gastro-intestinal symptom cases (the etiology). CARPHA and PAHO offer opportunities for case investigation of gastro-intestinal symptoms by laboratory tests on samples. However, samples are not often sent to these institutions, so this opportunity for strengthened surveillance is sometimes not taken up by countries.

A further way to examine the health impact of these events is to compare health indicators between countries that were severely affected by hurricanes with countries that were not. The following diagrams compare patterns of gastroenteritis cases in 2017 between countries that were struck by Hurricanes Irma and Maria at Category 4 or 5 strength and other Caribbean countries. As noted above, territories neighbouring those struck by the hurricanes at these levels of force were also affected by strong winds, heavy rains and storm surges. The analysis is limited in not differentiating by level of impact; it dichotomises between states that were directly struck by Category 4 and 5 hurricanes and those that were not. As such it measures the additional health impact of being struck by Category 4 or 5 hurricanes rather than the total impact of the hurricanes on CMS.

The diagrams below 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, with evidence of large numbers of gastroenteritis cases until around mid-April. 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. The proportional increase appeared to be larger and lasted longer in countries affected by Hurricane Irma than in Dominica which was struck by Hurricane Maria. The rises in cases just after each hurricane can reasonably be attributed to the effects of the hurricanes at these levels of strength on sanitation and hygiene. As illustrated in section 5.1, water and sanitation infrastructure were severely damaged by the hurricanes, making it difficult to maintain standards of hygiene such as handwashing and in meal preparation, increasing the risk

---

**Figure 7: Number of gastroenteritis cases per week in Dominica in 2015 (Tropical Storm Erika) and 2017 (Hurricane Maria), compared with six-year average 2012-17**

![Graph showing number of gastroenteritis cases per week in Dominica in 2015 (Tropical Storm Erika) and 2017 (Hurricane Maria), compared with six-year average 2012-17.](image-url)

*Source: Data reported to CARPHA, analyses by Caroline Allen*
of infections. Damage created conditions for extensive food spoilage and contamination. Displacement of people also prevented them from maintaining their hygiene habits and brought them into contact with additional people who may be sources of infection. These conditions increased risk of gastro-intestinal upset and infections spread through ingestion.

**Figure 8: Impact of Hurricanes Irma and Maria at Category 4 or 5 strength on numbers of gastroenteritis cases by week in CMS in 2017**

Source: Data reported to CARPHA

**Notes:** Countries and territories included in the analyses illustrated by these diagrams are as follows.
- Affected by Hurricane Irma at Category 4 or 5 strength that reported to CARPHA: Anguilla, Antigua and Barbuda, The Bahamas, British Virgin Islands, St. Maarten, Turks and Caicos Islands.
- Affected by Hurricane Maria at Category 4 or 5 strength that reported to CARPHA: Dominica
- Other countries that reported gastroenteritis cases to CARPHA: Barbados, Belize, Bonaire, Cayman Islands, Curacao, Grenada, Guyana, Jamaica, Saba, St. Eustatius, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname.
4.5 Malnutrition: under- and over-nutrition

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). The literature review did not reveal specific studies of the impact on malnutrition of the 2017 hurricanes in Caribbean countries. Section 5.3 looks at the impact on food security and nutrition which occurred because of the damage to agriculture and supply routes and loss of income. These led to a restricted and unbalanced diet for many Dominicans, 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 there was increased risk of NCD, and difficulties for people with specific dietary requirements such as those with diabetes.

4.6 Fever

As noted in section 4.2, the hurricanes prevented many people from maintaining their usual hygiene standards, leading to generalised risk of infection. Displacement and overcrowded settings also increased risk of infection. One of the major symptoms of infection is fever. Incidents of fever are reported to CARPHA by Member States weekly. The diagrams on the following show weekly fever figures, comparing countries affected by Category 4 or 5 hurricanes with CMS that were not.

Immediately following Hurricanes Irma and Maria, numbers of fever cases increased in the countries they struck at Category 4 or 5 strength. In the case of Irma, for the first month after the hurricane, the increase was slower in countries struck at Category 4 or 5, but then the numbers escalated rapidly in the fifth week post-Hurricane. In the case of Dominica, numbers of fever cases escalated rapidly in the two weeks immediately after Hurricane Maria but then fell and fluctuated throughout the rest of the year. The pattern in Dominica is erratic in part because of small numbers, making it difficult to ascertain a trend.

While increases are apparent post hurricane in the countries affected by the hurricanes at Category 4 or 5 strength, it is not easy to distinguish these patterns from those in countries who were not hit by the hurricanes at this strength. The other countries also experienced increases in fever cases over the period until the end of the year. This may reflect a general increase in fevers influenced by wet season conditions throughout the Caribbean.
Figure 9: Impact of Hurricanes Irma and Maria at Category 4 or 5 strength on numbers of fever cases by week in CMS in 2017

Source: Data reported to CARPHA

Notes: Countries and territories included in the analyses illustrated by these diagrams are as follows.

- Affected by Hurricane Irma at Category 4 or 5 strength that reported to CARPHA: Anguilla, Antigua and Barbuda, The Bahamas, British Virgin Islands, Saba, St. Eustatius, St. Maarten, Turks and Caicos Islands.
- Affected by Hurricane Maria at Category 4 or 5 strength that reported to CARPHA: Dominica
- Other countries that reported fever cases to CARPHA: Barbados, Belize, Bonaire, Cayman Islands, Curacao, Grenada, Guyana, Jamaica, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname.
4.7 Respiratory conditions

Respiratory conditions may arise from infections or from poor air quality.

Fever with respiratory symptoms, e.g. coughing, sneezing, blocked nose, such as resulting from some forms of influenza, may be expected to rise following hurricanes because of population displacement and lack of hygiene facilities: the same reasons outlined for fevers and gastro-intestinal symptoms. Some people may be in shelters and in close proximity to people who can transmit infection through coughing and sneezing and lack of access to handwashing facilities. For Dominica, total fever with respiratory symptoms cases by week were compared for years 2015 (when Tropical Storm Erika occurred) and 2017 (when Hurricane Maria occurred) with Dominica’s six-year average numbers of fever cases by week since 2012. The patterns of fevers for 2015 and 2017 did not differ from the general pattern over the six years, except that the 2012-17 average showed a rapid increase in cases in November because of a major outbreak in 2016. In other words, Tropical Storm Erika and Hurricane Maria do not appear to have made a difference to the number of people reporting respiratory fever symptoms.

![Figure 10: Number of fever with respiratory symptoms cases per week in Dominica in 2015 (Tropical Storm Erika) and 2017 (Hurricane Maria), compared with six-year average 2012-17](source: Data provided by CARPHA)

Note, however, that the data on fever provide indications of infectious disease and do not provide information on other conditions, such as asthma and other conditions of the respiratory tract, that could be affected by atmospheric pollution. In section 5.5 we examine the various forms of air pollution that arose following Hurricane Maria.
4.8 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 mosquitoes 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). As will be seen below in section 5.4, the massive 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 (see section 5.2).

However, 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 (See Fig. 12 and Tables 4 to 6). 2014 was the year when the number of chikungunya cases peaked in the region, while 2016 was the peak year of Zika cases. Tables 4 to 6 show that CMS affected by Hurricanes Irma and Maria at Category 4 or 5 strength – Anguilla, Antigua and Barbuda, The Bahamas, British Virgin Islands, Dominica, Montserrat, 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.

The lower number of cases of mosquito-borne diseases in the Caribbean in 2017 may have resulted from reduced prevalence of the viruses in the mosquito population or reduced mosquito numbers. The latter may have resulted from public health actions in the Caribbean prompted by the chikungunya and Zika epidemics, and from the longer-term response to endemic dengue fever in the Caribbean. These are described in CARPHA’s State of Caribbean Public Health Report 2016: Building Resilience to Immediate and Increasing Threats: Vector-Borne Diseases and Childhood Obesity (Caribbean Public Health Agency, Allen, & West, 2017).
Figure 11: Laboratory confirmed cases of dengue in the English- and Dutch-speaking Caribbean, 2004 - 2017

Source: Data derived from 4-Weekly Communicable Disease Surveillance Reports submitted to CARPHA as at May 28, 2018
### Table 4: Confirmed Cases of Dengue in the English and Dutch-speaking Caribbean, 2014 - 2017

<table>
<thead>
<tr>
<th>Country</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguilla</td>
<td>8</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Antigua and Barbuda</td>
<td>14</td>
<td>14</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Aruba</td>
<td>237</td>
<td>131</td>
<td>104</td>
<td>23</td>
</tr>
<tr>
<td>Bahamas</td>
<td>15</td>
<td>2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Barbados</td>
<td>336</td>
<td>113</td>
<td>429</td>
<td>85</td>
</tr>
<tr>
<td>Belize</td>
<td>4310</td>
<td>245</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bermuda</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>British Virgin Islands</td>
<td>34</td>
<td>114</td>
<td>108</td>
<td>67</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Curacao</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dominica</td>
<td>15</td>
<td>5</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Grenada</td>
<td>31</td>
<td>24</td>
<td>91</td>
<td>239</td>
</tr>
<tr>
<td>Guyana</td>
<td>713</td>
<td>363</td>
<td>667</td>
<td>253</td>
</tr>
<tr>
<td>Jamaica</td>
<td>30</td>
<td>12</td>
<td>169</td>
<td>15</td>
</tr>
<tr>
<td>Saint Lucia</td>
<td>30</td>
<td>25</td>
<td>80</td>
<td>66</td>
</tr>
<tr>
<td>St. Kitts and Nevis</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>St. Maarten</td>
<td>26</td>
<td>9</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>St. Vincent and Grenadines</td>
<td>10</td>
<td>13</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Suriname</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Turks and Caicos Is.</td>
<td>250</td>
<td>331</td>
<td>484</td>
<td>201</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6084</td>
<td>1404</td>
<td>2163</td>
<td>953</td>
</tr>
</tbody>
</table>

*Source: Data derived from CARPHA 4 Weekly Communicable Disease Surveillance Reports Submitted to CARPHA as at May 28, 2018*
Table 5: Confirmed Cases of Chikungunya in the English and Dutch-speaking Caribbean, 2014 – 2017

<table>
<thead>
<tr>
<th>Country</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguilla</td>
<td>56</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Antigua and Barbuda</td>
<td>18</td>
<td>18</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Aruba</td>
<td>587</td>
<td>223</td>
<td>8</td>
<td>55</td>
</tr>
<tr>
<td>Bahamas</td>
<td>97</td>
<td>8</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Barbados</td>
<td>140</td>
<td>-</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Bermuda</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Br. Virgin Islands</td>
<td>32</td>
<td>42</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>44</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Curacao</td>
<td>58</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dominica</td>
<td>153</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Grenada</td>
<td>26</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Guyana</td>
<td>136</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Jamaica</td>
<td>89</td>
<td>-</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Montserrat</td>
<td>14</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Saint Lucia</td>
<td>238</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>St. Kitts/Nevis</td>
<td>380</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>St. Maarten</td>
<td>8</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>St. Vincent and Grenadines</td>
<td>171</td>
<td>182</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Suriname</td>
<td>1862</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
<td>365</td>
<td>26</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Turks and Caicos Is.</td>
<td>19</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4496</td>
<td>505</td>
<td>38</td>
<td>60</td>
</tr>
</tbody>
</table>

*Source: Data derived from CARPHA 4 Weekly Communicable Disease Surveillance Reports Submitted to CARPHA as at May 28, 2018*
### Table 6: Confirmed Cases of Zika in the English and Dutch-speaking Caribbean, 2014 – 2017

<table>
<thead>
<tr>
<th>Country</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguilla</td>
<td>-</td>
<td>-</td>
<td>23</td>
<td>5</td>
</tr>
<tr>
<td>Antigua and Barbuda</td>
<td>-</td>
<td>-</td>
<td>13</td>
<td>-</td>
</tr>
<tr>
<td>Aruba</td>
<td>-</td>
<td>-</td>
<td>30</td>
<td>733</td>
</tr>
<tr>
<td>Bahamas</td>
<td>-</td>
<td>-</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>Barbados</td>
<td>-</td>
<td>3</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>Bermuda</td>
<td>-</td>
<td>-</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Br. Virgin Islands</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Curacao</td>
<td>-</td>
<td>-</td>
<td>297</td>
<td>-</td>
</tr>
<tr>
<td>Dominica</td>
<td>-</td>
<td>-</td>
<td>61</td>
<td>-</td>
</tr>
<tr>
<td>Grenada</td>
<td>-</td>
<td>-</td>
<td>324</td>
<td>-</td>
</tr>
<tr>
<td>Jamaica</td>
<td>-</td>
<td>-</td>
<td>72</td>
<td>-</td>
</tr>
<tr>
<td>Saint Lucia</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>St. Kitts/Nevis</td>
<td>-</td>
<td>-</td>
<td>26</td>
<td>-</td>
</tr>
<tr>
<td>St. Maarten</td>
<td>-</td>
<td>-</td>
<td>170</td>
<td>12</td>
</tr>
<tr>
<td>St. Vincent and Grenadines</td>
<td>-</td>
<td>-</td>
<td>76</td>
<td>-</td>
</tr>
<tr>
<td>Suriname</td>
<td>-</td>
<td>99</td>
<td>624</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0</td>
<td>102</td>
<td>1823</td>
<td>754</td>
</tr>
</tbody>
</table>

Source: Data derived from CARPHA 4 Weekly Communicable Disease Surveillance Reports Submitted to CARPHA as at May 28, 2018

### 4.9 Leptospirosis

Leptospirosis is a bacterial disease that affects humans and animals. The bacteria that cause leptospirosis are spread through the urine of infected animals, which can get into water or soil and can survive there for weeks to months. Sources of infection include floodwaters, which affect many parts of the Caribbean during the rainy/hurricane season.

Mice or rats infected with leptospirosis may also urinate on drink or food cans and other containers in warehouses, which then pose a risk to health when opened by consumers. The bacteria can enter the bloodstream through mucous membranes or abraded skin when they come in contact with contaminated environmental sources. The most important vectors are rodents (rats/mice), with domestic, farm and wild animals also spreading the disease. The incubation period is from 2 days to 3 weeks (US Centers for Disease Control and Prevention, 2017).

Leptospirosis has symptoms which can be confused with dengue, malaria and other vector-borne diseases, such as fever, headache, sore throat, vomiting and diarrhea. It is therefore sometimes underreported. Without treatment, Leptospirosis can lead to kidney damage, meningitis...
(inflammation of the membrane around the brain and spinal cord), liver failure, kidney dysfunction, respiratory distress, and even death.

The risk of infection can be greatly reduced by not swimming or wading in water that may contain animal urine, and by avoiding contact with animals who may be infected (US Centers for Disease Control and Prevention, 2017).

In Dominica in 2017, there were 11 suspected cases of leptospirosis. Only 7 of these were laboratory confirmed: the rest were not tested due to post-disaster damage to health infrastructure, including the National Laboratory. Environmental Health Officers stated in interviews that they had reported people with symptoms in flood-affected areas. However, it is not clear whether the cases reported in Dominica can be attributed to Hurricane Maria, since there had been an increase in numbers of confirmed cases in most Caribbean countries, including Dominica, since 2015, and the Dominican total for 2017 was lower than the 14 confirmed cases in the country in 2016. Overall increases in cases in Caribbean countries may be associated with trends in rainfall rather than specific storms. Joint surveillance of weather patterns and epidemiology would be necessary to determine this.

Figure 12: Number of confirmed cases of leptospirosis by CMS, 2013-2017

Source: Data reported to CARPHA
5. **ENVIRONMENTAL DETERMINANTS OF HEALTH**

Figure 13: Poster depicting climate change and health links, by the Environmental Health Department, Dominica

Source: Dominica Ministry of Health and Social Services, 2018

Note: This poster from the Dominica Ministry of Health and Social Services echoes the statement by the World Health Organization prior to the United Nations Climate Change Conference (COP-21) in Paris in December 2015, “Climate change is the greatest threat to global health in the 21st century.”

5.1 **Buildings and infrastructure**

**Impact**

In a Facebook post while Hurricane Maria stuck on September 18th, the Prime Minister of Dominica, Roosevelt Skerrit, made the link between infrastructural damage and health and expressed his profound concern for the injuries and deaths that may have arisen:

"Initial reports are of widespread devastation. So far, we have lost all what money can buy and replace. My greatest fear for the morning is that we will wake to news of serious physical injury and possible deaths as a result of likely landslides triggered by persistent rains. So, far the winds have swept away the roofs of almost every person I have spoken to or otherwise made contact with. The roof to my own official residence was among the first to go and this apparently triggered an avalanche of torn away roofs in the city and the countryside. Come tomorrow morning we will hit the road, as soon as the all clear is given, in search of the injured and those trapped in the rubble. I am honestly not preoccupied with physical damage at this time, because it is devastating...indeed, mind-boggling. My focus now is in rescuing the trapped and securing medical assistance for the injured. We will need help, my friend, we will need help of all kinds. It is too early to speak of the condition of the air and seaports, but I suspect both will be inoperable for a few days. That is why I am eager now to solicit the support of friendly nations and organisations with helicopter services, for I personally am eager to get up and get around the country to see and determine what’s needed."  

Figure 14: Damage from Hurricane Maria to buildings in Dominica, September 2017

![Damage from Hurricane Maria to buildings in Dominica, September 2017](https://example.com/damage.jpg)

Source: (United Nations, 2017)

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.

---

6 Prime Minister Roosevelt Skerrit, at https://www.facebook.com/SupportRooseveltSkerrit/posts/initial-reports-are-of-widespread/999579703517217/
Health Infrastructure

In Dominica, estimated damage to health infrastructure, in terms of necessary repairs to health facilities and equipment replacement, was US$10,291,218 as at October 27, 2017. The cost for improving on original structures by building for resilience was estimated at a further US$4,219,011 (Ministry of Health and the Environment, 2017). The following table shows damage to individual health facilities as reported at the end of October 2017. It shows that every parish of the country was affected by damage that rendered facilities partially or non-functional. Of the 10 parishes, 7 included non-functional facilities. Of the 50 health facilities in the country, 13 (26%) were not functional, of which one was completely destroyed by a landslide. A further 15 (30%) were partially functional, with either no water or no electricity. Thus, less than half of health facilities were functional, and even these facilities had suffered damage, such as to doors, windows and roofs, or difficulties in access because of damage to roads.

Table 7: Damage to health facilities in Dominica, as at 27 October 2017

<table>
<thead>
<tr>
<th>District</th>
<th>#</th>
<th>Facility</th>
<th>Damage</th>
<th>Functionality</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>St George</td>
<td>1</td>
<td>Princess Margaret Hospital</td>
<td>Severe</td>
<td>Functional</td>
<td>A detailed damage assessment is provided elsewhere.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Roseau HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Power from mains, roof OK, water to most of facility</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Bellevue Chopin HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Roof lost, operating from school next door</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Giraudel HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Tree fell on building, services moved to Eggleston. Recommend consolidate services between Giraudel &amp; Eggleston</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Laudat HC</td>
<td>Minimal</td>
<td>Functional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Wotton Waven HC</td>
<td>Minimal</td>
<td>Not Functional</td>
<td>No access to facility, rented</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Eggleston HC</td>
<td>Moderate</td>
<td>Partial</td>
<td>Doors, water damage, no water, no electricity</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>New Town CMS</td>
<td>Minimal</td>
<td>Functional as medical stores</td>
<td>MOH approved to retrofit to bring it to standards of a Health Centre. Catchment population of approximately 9000 people.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Fond Cole HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Partial roof damage, severe water damage, missing furniture and equipment, no water, no electricity.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Morne Prosper HC</td>
<td>Severe</td>
<td>Partial</td>
<td>No water, no electricity, roof damage, retired nurse working part time</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Trafalgar HC</td>
<td>Minimal</td>
<td>Functional</td>
<td></td>
</tr>
<tr>
<td>St Luke</td>
<td>12</td>
<td>Pointe Michel HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>15% of galvanised roof lost, windows, doors damaged</td>
</tr>
<tr>
<td>St Mark</td>
<td>13</td>
<td>Scottshead HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Roof lost</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Soufriere HC</td>
<td>Moderate</td>
<td>Functional</td>
<td>Access issue, roof damage. Repair of storm drains needed. Temp roof tarpaulins. Water tank OK. Providing services for Scottshead</td>
</tr>
<tr>
<td>St Patrick</td>
<td>15</td>
<td>Grand Bay Polyclinic</td>
<td>Minimal</td>
<td>Partial</td>
<td>Leaking roof. Windows and doors damaged. Genset generator OK. No water or tanks (needs tank)</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Tete Morne HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Doors, windows damaged. Genset OK. Roof OK.</td>
</tr>
<tr>
<td>District</td>
<td>#</td>
<td>Facility</td>
<td>Damage</td>
<td>Functionality</td>
<td>Comments</td>
</tr>
<tr>
<td>------------</td>
<td>-----</td>
<td>----------------</td>
<td>----------</td>
<td>---------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Pichelin</td>
<td>Severe</td>
<td>Destroyed</td>
<td>Destroyed by landslide. Recommend mobile unit, not rebuild.</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Bagatelle HC</td>
<td>Moderate</td>
<td>Partial</td>
<td>Partial roof damage, some doors damaged. No water, roof still leaks.</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Delices HC</td>
<td>Moderate</td>
<td>Partial</td>
<td>Ceiling lost and galvanise lost. Damaged with flying debris, water damage.</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Boetica HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Roof lost</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>La Plain (temp facility)</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Services moved to community centre. Temporary facility lost 2/3 roof, no water, no power, significant water damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>La Plain HC</td>
<td>Minimal</td>
<td>n/a</td>
<td>Under PAHO Smart Project - retrofit works halted because of hurricane</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Castle Bruce HC</td>
<td>Minimal</td>
<td>Partial</td>
<td>No water, genset works but limited fuel. Lost some windows and doors.</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Salybia HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Water tank full, no genset. Roof OK, doors lost, windows OK.</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Atkinson HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>No genset. Roof OK. Some damage to windows and doors.</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>San Sauveur HC</td>
<td>Moderate</td>
<td>Partial</td>
<td>Vulnerable community. Roof OK. Doors lost, no water, no electricity.</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>Grand Fond HC</td>
<td>Moderate</td>
<td>Partial</td>
<td>Leaking roof, water damage.</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>Riviere Cyrique HC</td>
<td>Moderate</td>
<td>Partial</td>
<td>Flooded, windows broken.</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Marigot Hospital / HC</td>
<td>n/a</td>
<td>n/a</td>
<td>New Hospital to be constructed - plan to demolish old and build new on same site</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marigot HC (rented)</td>
<td>Moderate</td>
<td>Partial</td>
<td>Water pump broken, no genset (new Marigot Hospital being built)</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>Wesley HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Operates Accident and Emergency department for Marigot. 2.5kVA genset (inadequate), no fuel, needs maintenance. Water OK.</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Woodford Hill HC</td>
<td>Severe</td>
<td>Partial</td>
<td>Roof lost, trying to operate from ground floor.</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>Anse de Mai</td>
<td>Moderate</td>
<td>Partial</td>
<td>Was supposed to be relocated before Maria. Located in swamp with vector problems. Annex roof lost.</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>Dos D'Ane</td>
<td>Severe</td>
<td>Partial</td>
<td>Roof gone</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>Thibuld</td>
<td>Minimal</td>
<td>Functional</td>
<td>No water or electricity</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>Vielle Case</td>
<td>Minimal</td>
<td>Functional</td>
<td>Windows and doors damaged.</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>Penville HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Roof destroyed. Potable water OK.</td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>Portsmouth Hospital &amp; HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Lost some windows and doors. Power and water from mains available. Roof OK.</td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>Clifton HC</td>
<td>Moderate</td>
<td>Partial</td>
<td>Flooded, doors lost.</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>Mahaut River HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Located in river mouth - facility covered in river debris. 2/3 roof lost, community has epidemiological concerns.</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Dublanc HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Located in river mouth - facility covered in river debris. 2/3 roof lost, community has epidemiological concerns.</td>
</tr>
<tr>
<td>District</td>
<td>#</td>
<td>Facility</td>
<td>Damage</td>
<td>Functionality</td>
<td>Comments</td>
</tr>
<tr>
<td>----------</td>
<td>----</td>
<td>----------------</td>
<td>--------</td>
<td>---------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>St Joseph</td>
<td>41</td>
<td>Colihaut HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Rented facility, between rivers. New facility at new location is planned.</td>
</tr>
<tr>
<td>St Joseph</td>
<td>42</td>
<td>St Joseph HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Working genset, insufficient fuel. Rainwater is available from PAHO tank. Roof OK.</td>
</tr>
<tr>
<td></td>
<td>43</td>
<td>Coulibistrie HC</td>
<td>Severe</td>
<td>Not Functional</td>
<td>Located in river mouth. Facility covered in 2' (0.6m) river debris. Recommendation to relocate.</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>Salisbury HC</td>
<td>Moderate</td>
<td>Functional</td>
<td>Part roof damage. Windows and doors damaged.</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>Belles HC</td>
<td>Moderate</td>
<td>Not Functional</td>
<td>Isolated, difficult to access. Ceilings and doors damaged. Water damage, facility not cleaning.</td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>Massacre HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>On river bed, some water damage</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>Mahaut HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Leaking roof, but structure intact. Next to drainage and below road level so always floods. Recommend relocation.</td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>Campbell HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>Water damage, roof OK</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>Cochrane HC</td>
<td>Minimal</td>
<td>Functional</td>
<td>In same site as community centre. Pipe borne water OK. Needs rehabilitation.</td>
</tr>
</tbody>
</table>

Key:

- **Functional**: Access to water and electricity, able to provide 'normal/ emergency' health services
- **Partial**: Health staff at facility, but either no water or no electricity available
- **Not Functional**: Facility damage level severe, staff not at facility, services not being provided at this facility
- **Minimal**: Small number of windows and/or doors damaged; minimal to no damage to roof; water available in storage tanks; electricity or working generator on-site
- **Moderate**: Damage to some windows and doors, no genset, damage or loss of plumbing lines/pump/ water tanks, partial roof damage
- **Severe**: Over 50% roof structure lost, significant water damage to interior and loss of furniture and equipment

Source: (Ministry of Health and the Environment, 2017)

The comments by the Post-Disaster Needs Assessment (PDNA) assessors indicate a wide variety of damage scenarios. One health centre had roof damage, neither water nor electricity and was being operated part-time by a retired nurse, drawing attention to human resource constraints that will be the subject of section 6.2. Water and roof damage was extensive among the 50 health facilities. Furniture and equipment was damaged or missing in several. Some of the functioning health facilities provided services to communities normally served by facilities that were now not functioning. One health centre began to operate from a nearby school, and another in a community centre, because of
damage to their buildings. Some of the functioning facilities lacked a genset/ power generator or the generator had limited fuel, so had limited capacity during the lengthy power outages.

Some recommendations for building back better were made in the PDNA. For instance, two non-functional health centres were located in the mouths of rivers and had been covered in river debris. One was built below the level of the road and drain and had experienced frequent flooding in the past as well as during the hurricane. One was built on an unstable cliff. It was noted that the nurses’ accommodation next to one facility was close to a moving slope. The relocation of these facilities was recommended. These scenarios draw attention to the topographical vulnerability of Dominica to severe weather events, with its many hills and mountains. Interviewees further noted that Dominica has active volcanoes and has experienced earthquakes, rendering the island highly vulnerable to natural disasters.

Figure 15: Damage to Princess Margaret Hospital Laboratory, Dominica, September 2017

Source: Dr. C.J. Hospedales, Executive Director, CARPHA (personal communication)

The main tertiary health institution, the Princess Margaret Hospital in Roseau, experienced varying levels of damage to its facilities. The hurricane took place at a time when the Hospital was in transition, with new hospital buildings being constructed or having been completed on the same premises. The design of the new facilities was informed by the PAHO Smart Hospital initiative which is being implemented across the Caribbean to achieve climate resilience (PAHO, 2013, n.d.). Work on the new buildings was stopped after Hurricane Maria. The Chinese construction team left the country and did not return in 2017.
The following table categorises the hospital buildings by level of damage sustained and by whether they were part of the new hospital facilities. The damage was accompanied by a 42.8% reduction in the number of beds available at the hospital (95 of 222 beds became unavailable) (Government of Dominica, 2017). It is notable that the Intensive Care Unit was not operational and the blood bank was destroyed: both these facilities may be regarded as especially important given the need for injury treatment following a hurricane.

<table>
<thead>
<tr>
<th>Operational (repairs needed)</th>
<th>Partially operational</th>
<th>Not operational</th>
<th>Destroyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational Therapy</td>
<td>Ambulatory Procedure Unit – Oncology</td>
<td>Female surgical and gynaecological ward</td>
<td>Isolation Unit</td>
</tr>
<tr>
<td>Psychiatric Unit</td>
<td>Central Medical Store</td>
<td>Intensive Care Unit</td>
<td>Blood bank</td>
</tr>
<tr>
<td>General ward</td>
<td>Laboratory</td>
<td>Male surgical ward</td>
<td>Incinerator</td>
</tr>
<tr>
<td>Administration</td>
<td>Central Medical Store</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accident and Emergency</td>
<td>Morgue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Louis Pasteur Polyclinic</td>
<td>Paediatric/ neonatal/ antenatal ward</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Theatre</td>
<td>Maternity ward</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central Sterile Supply</td>
<td>Dialysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Department</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen plant</td>
<td>Nursing Hostel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Key: Italics = Buildings to be part of new hospital*

*Source: (Ministry of Health and the Environment, 2017), based on assessments done by experts from the Ministry of Health and the Environment (MoHE) and PAHO.*

Reports from the Hospital Facilities Manager and the PDNA indicate the following regarding damage and repair to the Princess Margaret Hospital in 2017 (Ministry of Health and the Environment, 2017). Initially, the generator failed and the oxygen generator malfunctioned. Electricity was restored within 3 days. During the event it was necessary to relocate several wards, though some were overcrowded because of the hurricane. Internal repairs were done to the building housing the Maternity and Neonatal Units and patients moved back in by the end of September. The male surgical and female surgical and gynaecological ward were repaired eight weeks post Maria and patients were moved back. Minor repairs were done on the medical ward and patients moved back six weeks after. Central Medical Stores lost some supplies due to water damage, and a tarpaulin was placed over the building. Alternate sites were used for restocking and storage. Temporary covering (tarpaulin) was placed on the building housing the Dialysis Unit and patients began dialyzing at the end of the week.
of Hurricane Maria. Fluoroscopy, portable X-ray and all blood bank equipment were lost. Five weeks post Maria no elective surgery was being done and services were contracted. Repairs to the Administrative Building were completed by the end of 2017. During 2017, plans were also made for replacing damaged or lost roofs using new building codes for improved resilience.

Figure 16: Damage by Hurricane Irma to the health facility at Capoons Bay, Tortola, British Virgin Islands

An assessment of damage to health facilities in the British Virgin Islands one week after Hurricane Irma found that 42% of them were not functional. The health facilities and shelters had some level of water from the cisterns or other water storage facilities. However, due to the lack of electricity and the disruption of water services, there was potential for problems related to hygiene and sanitation. Disruption to the solid waste management system led to accumulation of household waste at kerbsides. Vast amounts of debris were still to be cleared, leading to potential for accumulation of standing water and vector borne disease (CARPHA, 2017c).

---

Information from correspondence with the Facilities Manager, Princess Margaret Hospital
Residential and office buildings

Figure 17: Impact of Hurricane Maria flood waters on a house in Dominica, September 2017

_Hurricane Maria inflicted huge damage to housing in Dominica, with housing damage amounting to 38% of all the costs of hurricane damage, and housing also accounting for 39% of the needs identified in the PDNA. The effects of the hurricane on the built environment were primarily due to the wind vulnerability of wood structures and unreinforced masonry buildings that predominated on the island. Houses along the coast line were damaged due to storm surges, while those located in riverbeds were damaged or destroyed by river debris and flooding. The mountainous terrain of the island led to major landslides across the country, affecting yet another share of houses located in the hilly regions (Government of Dominica, 2017).

One of the infrastructural challenges concerns the location of the capital city, Roseau, beside a river which burst its banks. Hurricane Maria resulted in the deposit of several inches of mud, silt and debris on the streets of Roseau, following the deluge of water with wood and other debris from the hills. Widespread damage occurred throughout the capital to residential buildings, offices and businesses, including destruction of electronic equipment such as computers, and paper documents. Vehicles were destroyed and damaged, and many had to be dug out from the mud. The Category-5-strength winds removed roofs, doors and windows in the capital and elsewhere in the country.

Some hurricane shelters were damaged by the hurricane, making it apparent that they were not adequately designed as such. Some were re-purposed schools and other public buildings. The need to provide specially designed shelters became clear. Some people who owned more sturdy houses provided shelter to others._
Utilities

For two to three days after the hurricane, almost all Dominican residents had no access to utilities. Water, electricity, solid waste management, landline and Internet services were unavailable. Internet services were re-established in the Roseau area and north-west of the island first, enabling the use of mobile phone and computer apps for communication. The hardest hit areas, mostly in the South West, were not re-connected for weeks and some areas remained without phone and Internet services at the end of 2017.

Electricity was cut to several areas. The Ministry of Public Works, Water Resources and Ports re-established the national electricity supply by the end of October 2017, after residents had endured six weeks without electrical power. There were substantial delays in re-connection of electricity in the many buildings that had damaged or lost roofs. At the end of 2017, many households and workplaces remained without electricity or with electricity only re-established to part of the building, since the conditions for safe re-connection, to prevent electric shock, had not yet been met. This was mostly because of the damage to roofs and walls that allowed water into buildings. Households without electricity faced difficulties in accessing safe food given the impacts on refrigeration and cooking facilities. Absence of lighting and communication facilities affected safety and economic productivity. The many inconveniences associated with lack of electricity and living in damaged properties affected mental health. The Electrical Division of this Ministry scheduled visits to communities and went house to house to inspect the damage and recommend such repairs as may be needed before re-connection of electricity could take place.
The DSWMC experienced challenges because of the centralisation of its services. When not out being used, their garbage trucks, other vehicles and heavy equipment were mostly stationed in Roseau. Some of the vehicles in Roseau were damaged by floodwaters, and several required digging out or removal of debris before they could be used. Damage to bridges and roads prevented their deployment to various areas of the country where they were needed to clear debris from the storm and organic waste and thus prevent disease. Many communities were still not accessible at the end of 2017. These challenges led to a strategic rethinking of the organization of solid waste management, which are discussed below.

**Figure 19: Overflowing garbage collection facilities in the British Virgin Islands following Hurricane Irma**

![Overflowing garbage collection facilities](image)

*Source: [CARPHA, 2017c]*

Water and electricity infrastructure in Dominica suffered major damage from Tropical Storm Erika and Hurricane Maria. Both storms resulted in deluges of river and rainwater accompanied by debris. Because the water and electricity supply to many areas was channelled via pipes and wires over bridges and other infrastructure above the ground, destruction and damage to bridges and infrastructure cut off supply to many areas (Government of the Commonwealth of Dominica, 2015). For most residents after Hurricane Maria, pipe-borne water was cut for periods ranging from days to months. Many water storage tanks providing back-up supply were blown down. Forty-three (43) of the 44 water cisterns in Dominica were damaged. The 41 water supply areas were damaged by strong winds, flooding, landslides, falling trees and power outage: 16 were heavily damaged and 21 moderately damaged. Production and distribution pipelines were damaged or washed away, intake systems were blocked with sand and debris, storage tanks, pumps, physical structures and access roads were damaged. 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. On-site septic tank systems and latrines were damaged.
Infrastructural damage also led to chemical pollution, which itself is regarded as a major environmental determinant of health (WHO, 2018). At a beer factory, damage to pipelines led to spillage of ammonia refrigerant, necessitating evacuation of workers and organisation of a clean-up, removal and repair operation. The spillage killed fish in a nearby river.

Response

Figure 20: Picture showing aid agency tarpaulin amidst damage to buildings and a vehicle in Roseau

The re-building of health infrastructure was led by the MoHE with assistance of several agencies. Those involved in hospital re-building and technical support efforts included PAHO, Samaritan’s Purse, USAID and UNDP. Soldiers from Trinidad and Tobago, Guadeloupe and Martinique assisted with temporary roofing of several hospital buildings during immediate period following the hurricane. An engineer was brought in by PAHO to evaluate hospital structures and inventory facilities and make recommendations for building back better. PAHO assisted with medical evacuation of patients with critical care needs and with transporting kidney patients for dialysis treatment. Blood products and medical supplies were also replenished by this agency.
The PDNA recommended that permanent reconstruction to the facilities should incorporate PAHO Smart Hospitals standards for resilience (PAHO, 2013, n.d.), and low energy and water consumption. These included standards for roofs for health centres (for which the existence of the OECS Building Code 2015 was noted) and the main hospital to withstand hurricane force winds. It was recommended that a structural analysis be done before construction of flat reinforced concrete roofs (which are resilient to hurricanes) to ensure that the building will not be compromised in the event of an earthquake. The government further recommended that remote facilities that may become inaccessible, should be self-sustainable with back-up power supply, water storage, telecommunication, and adequate stocks to continue services (Government of Dominica, 2017).

For housing, the PDNA recommended focusing on roof repair for partially damaged houses to an improved standard of resilience, as well as the replacement of destroyed houses. It recommended providing homeowners with training to ensure proper understanding of basic techniques for strengthening houses to withstand the effects of high winds (Government of Dominica, 2017).

The massive damage to residences throughout the island resulted in huge costs for many citizens. The government announced tax exemptions for six months on food and construction material imports, in-kind grants of roofing materials to assist residents to rebuild their homes, and maintained temporary shelters while communities rebuilt (Government of Dominica, 2017). It was reported that many houses were not insured or were under-insured, while some people with insurance reported slow pay-outs and receipts lower than expected from insurance companies. Most costs of re-building were borne by private citizens, though building supplies were donated by some humanitarian agencies. Interviewees reported that citizens did their best to build more resilient houses following hurricane damage, but these aims were sometimes overtaken by the needs of immediate shelter and severe financial constraints. Nevertheless, some buildings in Dominica had already been built with climate resilience in mind, such as the building with the solar panel rooftop shown among damaged buildings in the picture below.
The Dominica Red Cross was supplemented by personnel from the International Federation of the Red Cross to respond to the emergency following Hurricane Maria. As part of the emergency response, they provided materials and training to citizens to construct emergency shelters. Hand-held devices using Global Positioning Systems were used by field officers to enter data on households in need of assistance, be it with construction or other economic needs. For instance, the distribution of cash transfers was guided by the data entered by field officers.

After the emergency phase, the Red Cross proceeded to the recovery phase, in which further construction materials and training were provided to citizens, in this case for re-building their own homes or constructing new ones. People from the local community with construction qualifications and advanced skills were provided with higher level training so that they could assist others. The training provided skills in “building back better” to achieve more hurricane-resilient buildings.

Damage to roads and transport exposed the vulnerability of rural areas which were cut off or which relied on Roseau to supply their needs, since infrastructure in Roseau was very severely affected by Hurricane Maria. In the light of this, proposals have been put forward to de-centralise in the interest of building greater resilience in local areas. Proposals under consideration include the conduct of medical needs assessments in the geographical areas covered by each health centre, to build a health profile of each person who has specific medical needs that may not be met from basic medical supplies commonly available at the health centre. These might include people with non-communicable diseases and HIV requiring specific and regular supplies of medication, and people requiring regular medical procedures, such as dialysis patients. Each health centre would obtain sufficient supplies to last for a month to provide to the people identified in the local community, which could be used in the event of a disaster that prevents access to regular sources. This proposal.
to build resilience adds costs to the health system, since drugs will be duplicated at local health centres and the facilities that patients attend regularly. An alternative is to decentralise treatment more thoroughly, so that patients visit local health centres to obtain their medication. This may challenge patient confidentiality, since people in local communities may discover the health status of people with stigmatized diseases, such as HIV.

A further domain in which a policy of decentralisation has been proposed is that of solid waste management. Hurricane Maria exposed the vulnerability of a solid waste disposal system centralised in Roseau. The DSWMC is a Statutory Corporation responsible for collection and disposal of waste. The Corporation collaborates closely with the Ministry of Public Works, Water Resources and Ports, who supply much of the heavy equipment and staff needed to remove large items of debris, and coordinate the clean-up of debris from infrastructure damage, e.g. to housing, other buildings, bridges and roads. The DSWMC interviewee noted that trucks and equipment stationed in Roseau had been covered in mud or debris following Hurricane Maria. The time taken to retrieve and service the vehicles and equipment delayed reaching many areas of Dominica that required assistance in removing debris and garbage. Four-wheel drive vehicles were necessary to access some areas initially following both Tropical Storm Erika and Hurricane Maria.

The DSWMC is working on plans to allocate garbage disposal trucks and other vehicles and equipment to specific districts. This would reduce the risk of being cut off from servicing some areas by road or bridge damage and reduce driving time by the trucks. The Corporation has obtained or is in the process of applying for international funding to strengthen its fleet with additional garbage trucks and skips to facilitate greater coverage of the island and more frequent waste removal. The DSWMC is examining the cost-effectiveness of investing in mobile incinerators to assist with disposal of waste. They are also examining the feasibility of removing junk prior to a hurricane that could cause injury and property damage if left where it is. It was noted that this is an expensive option, and that expenses could be reduced with effective public education to stress the importance of appropriate disposal of large waste items and of burial of organic waste in the days prior to a major storm or hurricane. Garbage trucks could also be placed in areas most likely to be affected by an approaching major weather system.

It was also proposed that each district allocate parcels of land to the disposal of solid waste so that it does not need to get transported to the central landfill, at least initially. DSWMC trucks will remove the waste periodically. The DSWMC has received funding for additional skips, which will be placed around the island and removed to dispose of debris, including wood from downed trees, building debris and damaged household items. This enables people to dispose of debris from the hurricane locally, reducing the difficulties of clearing up after the storm. Careful management of the additional landfill sites, and regular removal of items, is necessary to avoid risks to public health, such as proliferation of vectors such as mosquitoes in standing water gathering in waste items. The DSWMC interviewee noted that the Corporation is working with Village Councils, who organise local clean-up, to develop local-level plans.

A challenge faced from such a devastating storm is the sheer volume of waste created. It was remarked that Tropical Storm Erika created mainly water damage, while Hurricane Maria created a wide variety of waste in addition to water damage. By the end of 2017, it was estimated by the
DSWMC that 1.5 million cubic metres of debris had been created by Hurricane Maria. The DSWMC developed and implemented plans for scheduling pick-up for different types of waste. Private contractors assisted in some of the waste removal. The National Employment Agency, that provides employment to people in environmental clean-up operations, extended its work. In the weeks following the hurricane, the focus was on removal of harmful debris and re-establishing regular kerbside garbage collection. Later, attention began to focus on vacant lots and abandoned properties, where staff worked to separate different types of waste for disposal in different ways. Galvanized and corrugated metal roof and wall sheets were among the first items to be removed, in collaboration with the Ministry of Public Works, Water Resources and Ports, which sorts, bails, compacts and exports this waste. Metal sheets pose a health hazard as strong winds can lift and throw them, causing injury. This Ministry also implemented plans for the removal of soil waste, e.g. mud and silt from floods. Wood waste from the many downed trees can generally not be recycled. The Division of Forestry of the Ministry of Agriculture and Fisheries explored the feasibility of cutting wood waste into smaller chunks, since these would more rapidly decompose and would not pose such an environmental hazard as the large pieces of wood that wrecked bridges and other infrastructure. As detailed in section 5.5, much wood waste was left for people in local areas to clear away, with consequences including increases in use of fire to dispose of the wood.

Various recycling options were explored, to prevent further environmental and health damage. The Red Cross and the Swiss Embassy collaborated in a plan to recycle cans, glass and PET plastic, including plastic from the millions of bottles of water that were donated to Dominica. The Red Cross worked with citizens to separate their waste at source so that it could be removed to different facilities for sorting and shredding. The DSWMC communicated with a recycling company based in Barbados to facilitate shipping recycled material out of the country. It was noted that the shredder that existed at a factory in Dominica belonging to an international beverage company was damaged by the Hurricane and thus could not initially meet the need for plastic bottle recycling.

Figure 22: Debris left by Hurricane Irma in the British Virgin Islands

Source: (BVI National Emergency Operations Centre, 2017)

---

8 Information provided by the Chief Medical Officer of Dominica.
In the British Virgin Islands (BVI), a *Debris and Waste Management Plan* was produced on 15 September 2017, within 10 days of having been struck by Hurricane Irma on 6 September. 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). Debris was to be collected in segregated streams at Community Collection Points or by drive through collection and delivered to Debris Management Hubs for initial processing and storage. Procedures for recycling of some types of debris to generate revenue were specified. The plan involved a strategy for community involvement in sorting waste and putting it at collection points, as illustrated in the following diagram (BVI National Emergency Operations Centre, 2017).

![Diagram of debris management plan](image)

*Figure 23: The British Virgin Islands’ plan for debris management following Hurricane Irma*

Re-building of the water infrastructure in Dominica aimed to enhance resilience but has had to be balanced with immediate everyday needs for water. The Ministry of Public Works, Water Resources and Ports has worked with donor and technical support agencies to re-build transport infrastructure, including bridges which carry water pipes. These include temporary Bailey bridges such as those that were reportedly donated by the Government of St. Vincent and the Grenadines. Water lines have been re-established across these bridges, with sturdy pipe fittings designed to be more permanent structures on bridges that have undergone major reconstruction to achieve greater strength and resilience. DoWASCO is also working on the establishment of water pipes running under rivers and that will withstand not only hurricanes but other natural disasters such as seismic activity and earthquakes, to which Dominica is also vulnerable. At the end of 2017, water supply had been re-established to most areas, but the costly plans to build secondary pipes under rivers to achieve greater resilience had not yet been enacted. An interviewee from DoWASCO noted that five projects to strengthen the resilience of the water infrastructure were planned following Tropical Storm Erika, but progress with these projects was compromised by Hurricane Maria.
5.2 Safe drinking water and sanitation

Impact

As detailed in section 5.1, there was extensive damage to the water supply infrastructure during Hurricane Maria. The sewage network was also seriously affected. The main sewage treatment facility in Roseau was compromised because the electrical panel flooded. Pump stations were also damaged, and a major sewage pipeline under one of the bridges in Roseau was broken. Much of Roseau was covered in mud and silt, in places also sewage, for a few days following the hurricane. Other parts of the country also experienced cuts in water supply and risk of exposure to sewage, as water and sewage pipes were broken.

Watersheds were also compromised. Forest coverage and shade of these bodies of water was reduced as the hurricane removed leaves and branches of trees. It was estimated that 80 to 90% of 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. The laboratory at the Dominica Water and Sewage Company (DoWASCO),

Source: https://medium.com/international-medical-corps/dominica-devastated-by-hurricane-maria-but-determined-to-rebuild-cfc7160938fa
assisted by a senior member of the national laboratory staff, therefore monitored water quality, conducting chemical, physical and bacterial analyses. An environmental health specialist from CARPHA also visited to conduct tests of water quality.

Hygiene was also compromised by difficulties experienced by the DSWMC in reaching areas to remove waste (discussed in section 5.1). The difficulties led to the accumulation of organic waste, with potential for disease spread by vectors such as flies, cockroaches and rodents. Conditions were favourable to outbreaks of infectious disease resulting from poor sanitation.

In the first few days after Hurricane Maria, hygienic conditions in shelters for displaced people were poor, with no potable water or stored water and very little food. Few had toilet facilities and shelters were overcrowded. This combination of factors produced a high-risk public health situation, as unsafe water and food supplies were being used by occupants in the interim, and there was high risk of propagation of disease through the shelter population (CARPHA, 2017a).

Response

Several agencies stand out in their focus on addressing the environmental determinants of health following Hurricane Maria, including the Dominica Water and Sewage Company (DoWASCO), the EHD and the Health Promotion Resource Centre (HPRC) of the MoHE. Their efforts supplemented the infrastructural work to environmental determinants such as building construction and solid waste carried out by other agencies and described in the section on infrastructure above. They also worked with national and international health partners.

DoWASCO mobilised quickly to re-establish clean water supplies and sewage infrastructure after the hurricane. Staff removed debris left by river flooding to access manholes and flush pipes using high-pressure spray to clear and disinfect them. The flushing and disinfection work commenced from the day after the Hurricane in Roseau, to prevent proliferation of micro-organisms and pests such as rats and cockroaches. DoWASCO then moved on to repairing pipes and other damaged infrastructure such as pump stations. It developed plans to “build back better”, such as establishing secondary pipe facilities underground as back up to pipes running overground. These plans were still being finalized at the end of 2017. A consultant from the UK Department of International Development was deployed to work on developing long-term construction and operational plans for the water sector.

Intermediate solutions adopted included stockpiling pipe and other construction materials to enable swift repair in the event of further environmental disasters. As DoWASCO moved from immediate repair to reconstruction phases, the population endured periodic cuts in water supply while the reconstruction was underway. DoWASCO aimed to minimize disruption by scheduling these major works on public holidays and out of normal working hours and issuing notices in the media.

DoWASCO used a map to chart geographical areas where flushing, cleaning and reconstruction were needed, and coordinated these activities, moving from community to community throughout the rest of 2017. Forty-three (43) of DoWASCO’s 44 water cisterns throughout the island had been damaged and a schedule for repair was followed. Coordination with the road and bridge re-construction programme led by the Ministry of Public Works, Water Resources and Ports (the parent Ministry of DoWASCO) was necessary for the efficiency of this process. Technical and voluntary assistance in rebuilding DoWASCO’s main facility was received from The Netherlands and Canada. Areas of the
South of the island were especially devastated, and at the end of 2017 water supply had not yet been re-established to parts of Galion, Grand Bay, Grande Savanne, Morne Rachette, Pichelin and Scotts Head.

DoWASCO also collaborated with agencies such as the MoHE, PAHO, UNICEF and USAID as part of the Water, Sanitation and Hygiene (WASH) Programme. Water supplies were chlorinated, in collaboration with the EHD of the MoHE. The level of chlorination was increased, which may have had marginal negative impacts on health, but was necessary to prevent infectious disease. Environmental Health Officers monitored the chlorine level of the water supply weekly in each District but were unable to conduct tests for pathogenic micro-organisms because the national laboratory was not functioning. They worked with PAHO to monitor the quality of water being trucked to the Princess Margaret Hospital.

The EHD also distributed over a million aquatabs to enable citizens to clean water they collected, since some were using springs and streams to supplement what they could access from elsewhere. Information on how to use the aquatabs was provided verbally and via a leaflet produced in collaboration with UNICEF. Water purification filters were supplied to communities at higher risk. Aid agencies including IsraAID, the Red Cross and Samaritan’s Purse installed water purification units to treat river water that people were using. DoWASCO and international agencies trucked water in tanks and bladders (collapsible water containers) to areas and health facilities where a clean supply had been cut or compromised. Citizens were supplied by UNICEF with small water bladders and were enabled to visit filtration plants to collect additional water. Water was delivered to hurricane shelters. Millions of bottles of water donated from abroad were distributed. The WASH programme partners met weekly and were co-ordinated by UNICEF, who made use of Geographic Positioning Systems (GPS) to identify areas of need around the country and mobilise personnel and equipment to visit them. The result was a military-style operation, with interviewees from the EHD and HPRC referring to their work at that time as being that of “foot-soldiers.”

The EHD were responsible for monitoring health conditions in hurricane shelters and health facilities, including sanitation, food safety, overcrowding, moisture levels (as a risk for fungal infection) and waste disposal. Officers visited each of these facilities regularly in the weeks following the Hurricane.

EHD staff reported that they moved rapidly from tackling one crisis to the next as the repercussions of the Hurricane became apparent. Thus, they started by focusing on basic sanitation and shelter conditions, then found other challenges. Schools had to be inspected for safety before children could return to resume their education. Travel by Environmental Health Officers around the island revealed contaminated watersheds and other bodies of water due to lack of tree cover and nutrient enrichment of the bodies of water through decomposition of waste. The observed differences in colour, viscosity and sediment suggested the possibility that harmful micro-organisms and chemicals had contaminated the water sources. These were reported to DoWASCO, a CARPHA expert was recruited for a scientific assessment of the risk and the EHD also consulted with experts from PAHO and the UK Department for International Development to develop strategies for clean-up. Continued wet conditions following the hurricane led to the development of mould in many buildings, especially those that were damaged. Agencies involved in the WASH programme, notably the HPRC, then developed fliers and visited different parts of the country to educate people in how to remove mould.
safely and assist them in doing so. The public also expressed concern about exposure to asbestos in damaged buildings.

Staff of the EHD and the HPRC emphasized that they worked in partnership with a wide variety of governmental and non-governmental organisations in responding to health issues associated with Hurricane Maria, including the Air and Seaports Authority, Cancer Society, CARITAS (Catholic charity), credit unions, DoWASCO, the Drug Prevention Unit, insurance companies, the International Medical Corps, PAHO, Samaritan’s Purse and UNICEF.

5.3 Food security, safety and nutrition

Impact

With sustained winds of 175 mph and gusts off the scale of any equipment monitoring wind speed in Dominica, accompanied by widespread flooding, agriculture in Dominica was devastated. Bananas, which are an export crop earning much-needed foreign exchange, were not produced commercially in Dominica for the remainder of 2017. A similar fate befell other fruit and vegetables grown on trees and plants. Some root crops (ground provisions) suffered flood damage, but others proved resilient. Pineapples were an exception and remained available, because they are sturdy plants that grow at ground level. Livestock were killed or injured, and there was damage to the food supply of the animals. Fish stocks and fishing boats and equipment were damaged. Most secondary roads, critical to access arable land and transport labour and agricultural products to markets and ports, were left inaccessible (Government of Dominica, 2017).

The diet of residents became more limited, with little access to fruit and vegetables, or, indeed, any fresh food, and increased reliance on canned foods. The lack of electrical power reduced the availability and consumption of foods rich in protein, such as meat and fish, since they could not be refrigerated. It was estimated that 80% of the population outside the urban centres of Roseau and Portsmouth had backyard gardens where they cultivated vegetables, but most of these were damaged (Government of Dominica, 2017). Prices of fresh food rose, restricting access at a time of financial stress. People on low incomes, who relied on subsistence farming, or who were rendered unemployed were especially vulnerable to the impacts on food security.

The economic livelihood and thus the health of people working in the agriculture and food sectors was severely impacted Foreign-exchange reserves were depleted by the increased importation of food, especially after the depletion of the initial influx of food aid.

The dietary limitations are likely to have impacted especially negatively on people at risk of or living with NCDs, and physically frail and elderly persons. They may also have affected pregnant women and the health of their babies, because of possible lack of folate in their diets. The experience following another Caribbean hurricane is instructive. From 10 to 18 months following Hurricane Gilbert in Jamaica in 1988, it was observed that there was a sharp rise in births of babies with neural tube defects. The mothers of these babies were included in a case control study in which they were interviewed about their diet in the period following the hurricane. It was found that the mothers with babies with neural tube defects had significantly less folate in their diets in the peri-conceptional period than the mothers in the control group whose babies did not have neural tube defects. The
authors noted that, though there was not an overall lack of food following Hurricane Gilbert, there was a considerable reduction in consumption of fresh produce and increase in use of packaged foods and relief supplies (Watson-Duff & Cooper, 1994). By the end of 2017, it was not yet possible to see such a potential impact of Hurricane Maria in Dominica. The findings of the Jamaican study suggest that pregnant women should be closely monitored and ideally given folate supplements to prevent a similar occurrence.

There was also a major risk to food safety due to damaged infrastructure and lack of water. Spoilage and contamination of foodstuffs resulted from cuts to electricity and damage to places where food was stored. The risks of rodent and insect infestation increased. Lack of water prevented the maintenance of hygienic food handling and preparation standards.

**Response**

The PDNA made a number of recommendations to increase agricultural production and improve security, but it was noted that it would take periods of months or years, depending on the type of food produced, to re-establish food self-sufficiency to previous levels. In the interim, there was a recommendation to focus on rehabilitating agricultural production by and for vulnerable populations, such as Kalinago people and others in poorer rural areas. The government also focused on accessing and providing agricultural inputs and fishing equipment to farmers and fisherman to help them build back supply (Government of Dominica, 2017).

In the WASH sector, the reconstruction of infrastructure and rapid movement of water to citizens in tanks and bladders described in section 5.2 was accompanied by a major education campaign. For drinking, food preparation and washing their hands, people were instructed only to use the water supplied by DoWASCO and its partner agencies in the WASH programme. In part because each person was generally allocated only two gallons of water per day, many people used rivers for laundry and washing. The riversides became a place where people met to discuss their experiences and develop hurricane recovery strategies. The WASH partners apprised people of the dangers of river or standing water for drinking, food preparation and washing their hands.
The HPRC and the EHD played major roles in public education in support of the WASH programme and infectious disease prevention. Within a couple of days of the hurricane, staff of both entities went on the road, driving and walking to various parts of the country to deliver health promotion messages concerning hygiene. They emphasized the critical importance of handwashing and removing receptacles where standing water could gather and mosquitos and pathogens could breed. Advice on boiling and storing water was also provided. Megaphones were used to ensure people could hear the messages, even when other forms of communication were down. Officers held meetings on the block, in community centres and for children in schools, and talked to people on the road, to put across health messages. They appeared regularly on the radio and television to reinforce messages about hygiene. Since electronic communications surveillance systems were largely unavailable, they responded to word-of-mouth reports as to where in the country to inspect and intervene. Some of the information they used to direct their response was received from radio call-in programmes. PAHO donated T-shirts to EHD staff so that they could be easily recognized while out in communities.
In addition to the WASH programme, the HPRC was involved in visiting hurricane shelters and community centres to provide sexual and reproductive health education for displaced persons. They helped distribute blankets, food and lights to these persons. The HPRC worked with the telephone companies to issue health promotion text messages when telecommunications were re-established. Posters were developed and placed in community settings. The HPRC collaborated with an insurance company to improve the nutritional quality of food supplied in hurricane shelters, with a focus on older persons and people with NCDs.

The EHD staff rapidly embarked on public health inspections in a variety of settings. Food safety inspections were conducted at dining establishments, shops and markets, looking for spoilage, adulteration of food and checking for expiry dates. Street vending of food was suspended until late November as a precautionary measure. EHD staff helped clean up the fresh produce market in Roseau. The conditions where food preparation took place were examined. Hospital kitchens were among the facilities inspected. Those dining establishments which had been damaged or had otherwise 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.
5.4 Disease vectors

Impact

Damage to buildings, terrain and infrastructure were the main sources of vulnerability of vector-borne disease after Hurricane Maria. Water gathered in puddles and debris. Challenges to solid waste management and in re-building the water infrastructure (see section 5.1) prevented the immediate clearing of debris, while water leaks adding to the challenges brought by heavy rain for most of September to December. Rats and other rodents were able to access more easily places where food and drink were stored and other human living and working environments, increasing risk of leptospirosis and other infectious diseases.
Response

The immediate environmental health response to Maria involved people mobilising, with very little use of technology, in part because of the infrastructural damage. Communication about vector-borne disease via megaphone and radio supplemented that about sanitation and hygiene. Environmental Health Officers and nurses were among the people reported to have given direct, physical assistance in removing sources of standing water and filling in puddles. Basic technologies supplemented communication with the public: fogging was carried out to kill mosquitos. PAHO procured an extra vehicle and equipment for vector control and supplied chemicals to control the mosquito and rodent populations. The Government of Cuba also supplied a biological treatment for rodents developed in Cuba.

While there were few cases of mosquito-borne disease in the Caribbean in 2017 (see section 4.6), these measures were important in ensuring that the population in Dominica was protected from potential reservoirs of infection.
5.5 Air quality and pollution

Impact

The force of wind and water during Hurricane Maria moved and broke organic and chemical materials, releasing particles into the air. When mud and organic materials dried, dust increased. These increased the risk of breathing difficulties in the population, especially among people with pre-existing conditions such as asthma.

A further challenge to air quality was the proliferation of fungal spores because of the decomposition of organic matter and the continued wet weather and heat throughout the remainder of 2017. Mould developed in many buildings and was released into the air when it dried.

Threats to air quality resulted from the actions of persons to re-gain control over their environments. Damage to the national electricity grid led to increased use of privately-owned electricity generators, which released fumes into the air, including poisonous carbon monoxide. People also increased the burning of waste because of the vast amounts of waste created by the hurricane and the insufficiently frequent collection of waste by the DSWMC. Residents reported breathing difficulties and headaches from the many fires being set around the island.

It was estimated that 15-25% of trees fell during Hurricane Maria (Government of Dominica, 2017). Wood waste could not generally be recycled, in part because of the violent damage to the wood itself. While decomposition may be the most environmentally-friendly solution to wood waste, many people found it difficult to live next to decomposing vegetation which is difficult to remove because of its size and weight. This was a major contributor to the increased burning of waste and associated air quality challenges.

The following picture illustrates the damage to vegetation caused by the 2017 hurricanes. In addition to the air quality difficulties just outlined, such widespread damage decreased the natural cover provided by trees, increasing sun and heat exposure and the distribution of dust and pathogens in the air.

**Figure 29: Trees de-foliated by Hurricane Maria, September 2017**

*Source: Sylvester St. Ville, Senior Environmental Health Officer, Dominica (private communication)*
Response

Air quality was monitored by the EHD, who included information about it in their regular radio programmes, with advice for people experiencing breathing difficulties. Masks were handed out to people who required protection from the dust.

The public education on the prevention and treatment of mould, provided by the WASH partners, assisted in the reduction of mould and its release into the air.

6. BUILDING BLOCKS OF HEALTH SYSTEMS

6.1 Leadership and governance

Impact

The functioning of government was temporarily affected by the hurricane in various ways. In the immediate aftermath, Ministers and public servants experienced the impact of damage to transport and communications networks. Many could not reach their offices by car. A senior public servant recounted that he walked for four hours to get to Roseau to attend a meeting of the Health Emergency Operation Centre. On reaching their offices, most found some level of disarray, with damage ranging from broken windows to destruction of computers and hard copies of documents. Some legal documents in public records offices were destroyed. The lack of digitisation and lack of Internet backup of some documents led to difficulties in proceeding with work and to legal delays for people to whom the contents of documents applied.

Response

Figure 30: Painting envisioning a climate-resilient development strategy for Dominica, on display in the Ministry of Public Works, Water Resources and Ports, May 2018

Source: Photo by Caroline Allen during visit to Dominica, 21-26 May 2018
Leadership and governance play a critical role in managing and providing policy parameters for environmental determinants of health and the building blocks of health systems. Hurricane Maria was followed rapidly in Dominica by the mobilisation of multiple agencies under the leadership of the Prime Minister and guided by the existing disaster preparedness plans.

The Prime Minister mobilised international support for Dominica by communicating with people around the world via social media, speaking at the United Nations and other regional and international forums.

Speaking at the 72nd Session of the United Nations General Assembly on 23rd September 2017, Mr. Skerrit spoke of Dominica as being on the "front line of the war against climate change", though the people of SIDS have little responsibility for creating this war:

_We as a country and as a region did not start this war against nature. We did not provoke it. The war has come to us! .... We in the Caribbean do not produce greenhouse gases or sulphate aerosols. We do not pollute or overfish our oceans. We have made no contribution to global warming that can move the needle. But yet, we are among the main victims...on the frontline! _

This speech heightened international interest in the impact of climate change on SIDS and helped motivate people of countries which contribute much more than the Caribbean to global warming to contribute to SIDS’ recovery and adaptation efforts. It also highlighted the moral responsibility of countries and companies that were major contributors to global warming to improve their record of mitigating action.

_Central coordination of health and humanitarian response_

The Regional Response Mechanism (RRM), coordinated by the Caribbean Disaster Emergency Management Agency (CDEMA) through its Regional Coordination Centre in Barbados, was convened the day after Hurricane Maria struck Dominica, on 19 September 2017, and by 20 September a Rapid Needs Assessment Team (RNAT), led by CDEMA, was on the ground in Dominica to conduct a health sector assessment focusing on WASH (CARPHA, 2017a). CARPHA contributed the health sector assessment focusing on WASH as part of this team and in response to the impact of Hurricane Irma in the British Virgin Islands in 2017 and Hurricane Matthew on the Bahamas in 2016 (CARPHA, 2017c; CARPHA & CDEMA, 2016). The RRM is an arrangement for the coordination of disaster response among CDEMA participating States, and regional and international agencies.

The United Nations launched a “flash appeal” for assistance, providing the budget for priority activities in various sectors including health and WASH, and directing potential donors to agencies planning and coordinating activities in each sector (United Nations, 2017).

The Government’s Emergency Operation Centre (EOC) held weekly meetings with national response committees and international organizations, coordinating the response, with the support of CDEMA and the United Nations Office for Coordination of Humanitarian Affairs (UN-OCHA). Coordination meetings were held at the National EOC. Sector groups met regularly: Early Recovery; Education and

---

Protection; Emergency Telecommunications; Food Security and Livelihoods, Health; Logistics; Shelter/Camp Coordination and Camp Management; and WASH. The sectors covered by these groups assisted in addressing environmental determinants of health.

Upon request of the Prime Minister, the UN established a Crisis Management Unit led by UNDP and OCHA to support the government coordination efforts from relief to recovery. Seven UN agencies, at least 13 non-governmental organizations, USAID, PAHO and the International Federation of Red Cross and Red Crescent Societies (IFRC) provided humanitarian assistance in Dominica. The European Union Civil Protection mechanism was activated with emergency support and relief supplies provided by France, the United Kingdom, Belgium and the Netherlands (Government of Dominica, 2017).

The National Emergency Planning Organisation (NEPO) is the national coordinating authority for emergencies and disasters in Dominica. It was established in the 1980s and was partly a response to the devastation caused by Hurricane David in 1979 (Lawrence, 1979). NEPO includes sector subcommittees, including the Health Subcommittee. NEPO is convened by the Prime Minister and meets at least monthly. The Prime Minister also convenes the EOC and the sector EOCs in the event of emergencies. The Health EOC met every day for approximately two months in the aftermath of Hurricane Maria, though some people were unable to attend every meeting in person. During this period, they assumed a coordinating role for the various health agencies involved in emergency response and recovery. From that time until the end of 2017, the Health EOC met approximately bi-weekly to continue recovery, adaptation and mitigation efforts. Personnel from the MoHE also spoke at the Prime Minister’s daily media debriefings to the public in the days following the hurricane. The Director of Primary Health Care was the Disaster Coordinator for the MoHE and monitored the response and worked towards producing a report and a human resource plan for NEPO in 2018.

Many agencies from across the Caribbean and the rest of the world came to the assistance of Dominica following Hurricane Maria. CARICOM liaised with regional agencies, including CARPHA, and national governments to mobilise teams to assist. In Dominica, a Liaison Officer for the Humanitarian Response was employed within the Ministry of Health and the Environment. One of the important roles of this Officer was to work with agencies involved in the Water, Sanitation and Hygiene (WASH) programme – the WASH cluster. In Dominica, leadership of the cluster was shared sequentially by PAHO and UNICEF. The Environmental Health Department was also represented in the WASH Cluster. Following the initial activities in hurricane relief of multiple agencies, they strengthened alliances, moving towards the establishment of the Climate Resilience Execution Agency for Dominica (CREAD), including government, donor and technical agencies, in 2018.

While largely centrally managed, some assistance from abroad also came through professional and personal networks. For example, the Massy Foundation provided a team of psychologists and psychiatrists from a higher education institution in Trinidad and Tobago, known as the Trauma Team, to work alongside the Community Mental Health Team (CMHT) in responding to the

---

10UNICEF is the global lead agency for the WASH sector under the Inter-Agency Standing Committee (IASC) cluster approach. The IASC is the primary mechanism for inter-agency coordination of humanitarian assistance, including United Nations and non-United Nations agencies. Launched in 2005, the cluster approach addresses gaps in response and enhances the quality of humanitarian assistance by strengthening partnerships and coordination between UN agencies, the Red Cross/Crescent movement, international organizations and NGOs. In emergencies where the cluster approach is applied, UNICEF leads national coordination efforts of the WASH sector. ([https://www.unicef.org/wash/3942_4458.html](https://www.unicef.org/wash/3942_4458.html))
psychological distress brought by Hurricane Maria. Members of the visiting team complemented the work of the CMHT by providing counselling and accompanying the CMHT in their appearances on radio programmes and other forms of communication with the public such as community meetings (described below in the section on health information systems). The Massy Foundation had previously worked with the CMHT in 2015 following Tropical Storm Erika. The Pentecostal Assemblies of the West Indies also supported the CMHT by attracting the services of mental health professionals in Trinidad and sending two or three persons every two weeks for around two months after the Massy Foundation team had left.

More generally, interviewees reported that professional contacts, friends and family members based in other countries visited to lend their skills and time to the national response and assisted remotely through the mobilisation and provision of human, material and financial resources.

Decentralisation

The advance preparation of Disaster Preparedness Plans by multiple agencies facilitated the emergency response. These agencies included the hospital, health centres and Village Councils. Each of the seven Health Districts had a Disaster Plan and worked with local agencies such as Village Councils to determine an optimal response. The plans specified roles for individuals as well as procedures. However, interviewees noted that plans were generally not accompanied by a listing of persons with special needs in the community, such as physically frail elderly persons, people with NCDs and other long-standing illnesses, pregnant women, people with special medical needs such as dialysis and oxygen supplies, and economically vulnerable persons such as single, unemployed parents and their families. Such listings can assist in developing strategies to allocate relief supplies, evacuate persons according to needs and generally protect the health and welfare of these persons in emergencies. The EHD has officers in each District, which facilitated rapid deployment to different areas of the country.

Village Councils were often responsible for distribution of supplies on the ground, and the allocation of roles to individuals was said to have worked well most of the time. Challenges were said to have included the party-political affiliation of some Village Council members which were suspected to have influenced who received aid supplies. It was noted that some aid supplies were dropped from helicopters or aircraft without advanced warning to local authorities such as Village Councils, making it difficult to achieve a rational allocation of supplies according to needs. Until road and communication networks were re-established, the achievement of rational allocation of food, water and medical supplies down to the district and village levels was extremely difficult.

In light of the experiences following Hurricane Maria, plans were put in place for decentralisation of solid waste management to avoid challenges associated with damage to the transport network. These plans are discussed in Section 5.1.
Evidence-based policy

Responsible and responsive policy-making is linked to the quality and connectivity of the health information system (described in section 6.3). Preliminary results of the Vulnerability and Adaptation Assessment (Dominica Ministry of Health and the Environment, 2016) were used in the development of the draft National Resilience Plan (Government of the Commonwealth of Dominica, 2015). This assessment began in 2015, prior to Tropical Storm Erika, with updated analyses and recommendations following Erika. The PDNA for Hurricane Maria has also guided national action.

Policy is linked to global good practice as defined by international agencies. PAHO’s Strategy and Plan of Action on Climate Change (PAHO, 2011) and WHO’s Operational framework for building climate resilient health systems have been used as guiding documents in the drafting of a national strategy and plan of action on climate change and health being developed by health stakeholders.

Environmental considerations have been integrated into national policies for some time in Dominica. Following the Earth Summit in 1992, a Sustainable Development Council was formed in 1995. The Environmental Coordinating Unit (ECU) was established in 1999 to manage funds to address environmental issues, including funds from the Global Environment Facility, and coordinate agencies working in this field. The ECU serves as the focal point for the implementation of all Multilateral Environmental Agreements to which Dominica is a signatory. The government has also established a Disaster Vulnerability Reduction Project and an Office of Disaster Management.

These developments and the evidence from assessments have been incorporated into national policy guidelines and documents, including the Low Carbon Climate Resilient Development Strategy 2012-2020 and the National Resilient Development Strategy (Government of Dominica, 2012, 2018).

6.2 Health workforce

Impact

Hurricane Maria took place at a time when the nursing contingent was below capacity, with some posts having not been filled for several years, resulting in a shortfall of around 25% in the number of nurses employed (322) of the established number of 434 by the end of 2017. In 2013-’14, 8 nurses resigned; in 2015-’16, 32 resigned and 9 retired, and in 2017 (both before and after the hurricane), 14 resigned and 2 retired.\textsuperscript{11} The shortage of nurses was reported to be part of a Caribbean trend of attrition of nurses through migration and retirement. Migration was said by several informants to be encouraged by nurse recruitment agencies operating in several Caribbean countries, who offer relatively attractive pay and conditions for nurses to work in metropolitan countries such as the United Kingdom and the United States. There were also challenges in training of nurses, with only around 10 nurses qualifying from the Dominica State College per year, while the College has capacity to train up to 25. Challenges to training include the limited opportunities for scholarships and fee support for potential candidates, with Hurricane Maria having exacerbated the challenge since the State College infrastructure was damaged so that some training programmes were put on hold for

\textsuperscript{11} Information from a Cabinet paper cited by the Principal Nursing Officer.
the rest of 2017. Nursing attrition was described as a chronic issue which became acute with the challenges posed by Hurricane Maria.

The shortage of nurses is said to have accelerated following Hurricane Maria, with recruitment agencies continuing to operate in Dominica and nurses attending recruitment centres within Dominica and travelling to other Caribbean countries for examinations and interviews or being interviewed via online communication applications. The shortage put strain on those that remained. Humanitarian agencies supplemented the number of health personnel temporarily, with PAHO meeting some of the cost of extra nurses that were deployed. Several Caribbean countries sent nurses in the immediate aftermath of the Hurricane, but these people returned home within about a month. The Government of Cuba, as part of its tradition of humanitarian assistance to developing countries, pledged to send around twenty nurses to work in Dominica on a longer-term basis. However, damage to the Nursing Hostel at the Princess Margaret Hospital prevented the uptake of this offer. The Principal Nursing Officer wrote to her counterparts in several Caribbean countries to request additional nurses. It was reported that the response was weak since the salaries on offer in Dominica were not competitive.

A further challenge to the availability of human resources was the damage to the infrastructure of Ross University, the only medical school on the island in 2017. While most of the students of this University were not from Dominica, the academic staff of the University and some students were said to have offered technical assistance and occasional medical support to the services supplied by the Government of Dominica. After Hurricane Maria, students and staff were evacuated from the island, and the University has since re-located to another Caribbean country.

Like other citizens of the country, Hurricane Maria affected the ability of health care workers to do their jobs, or to do them in the ways to which they were accustomed. Based on interviews and focus groups conducted, the following were some of the ways that health care workers were affected.

Many health care workers experienced damage to their accommodation, such as missing roofs and lack of water and electricity. Some of their houses were destroyed. Arrangements had to be made for the care and education of their children, especially given damage to schools. Some children were sent to other Caribbean islands to study or moved within Dominica to schools that were less damaged than their own. Other dependents, such as elderly persons and people with pre-existing health conditions, also required special care following the hurricane. These additional care obligations were likely to have a particularly severe impact on women, given their traditional responsibility for “reproductive labour”, comprising care work and domestic chores to sustain the population (Allen & Christophe, 2018). The nursing workforce, comprising mostly women, was especially affected. Their additional caring and domestic responsibilities went alongside their work to repair and rebuild damaged homes and other family possessions, and their professional responsibilities.

Male health care workers were also challenged to fulfil their professional responsibilities alongside their work to repair and rebuild their homes and other family possessions. Skills traditionally assigned to men, such as building construction, electrical repair and motor mechanics (Allen & Christophe, 2018), were heavily utilized following the storm. Male health care workers contributed these skills to their families and the rehabilitation of accommodation and properties. Building and repair professionals were in high demand, and participants reported difficulty in contracting these services, with some waiting for months for professional assistance. Therefore, men in the health care
profession had additional tasks to fulfill to repair and rebuild so that they and their families could be safe and move towards the levels of material comfort they were used to prior to the hurricane.

Many people did not have adequate insurance protection for the damage sustained to their property, and difficulties in accessing insurance money were reported, increasing the pressure on people to carry out their own repairs without financial resources to do so. Health care workers, like others with full-time jobs, also lacked the time to carry out personal recovery work. In this context, the recommendation to "build back better", with structural modifications to homes so they can better withstand severe weather events, became very difficult. Participants reported anxiety that many homes would not be "hurricane-ready" by the beginning of the 2018 hurricane season.

**Response**

Following Hurricane Maria, the chronic challenge of nursing attrition and general scarcity of human resources for health became more severe and apparent. The government responded positively to proposals to attempt to retain and attract nurses, including:

- Increases in allowances for certain types of work
- Community Health Aide training designed to increase the pool of people with nursing skills in the community
- Granting of tenure of employment to nurses
- Provision of a uniform allowance.
- Provision of a duty-free allowance to nurses for purchase of vehicles.

These proposals had not yet been implemented by the end of 2017, but the Cabinet Paper with these proposals was accepted by the government.

Additionally, there have been team-building and mutual support activities and events, designed to enable nurses to talk and discuss the challenges they face, especially those experienced since Hurricane Maria. The Minister of Health has attended several functions organised by the nurses and addressed them to show understanding and to respond to nurses’ concerns.

Interviewees noted that, following Hurricane Maria, many health professionals went beyond their usual responsibilities to meet the health needs of the population. For instance, some hospital nurses were unable to get to their usual places of work for a few days following the Hurricane, because of damage to roads and transport systems. Some responded by assisting with the health response around their home area. Some health centres were destroyed or severely damaged. Interviewees reported that workers from these centres retrieved what health supplies they could from the damaged facilities and some opened their own homes to provide health care. Relief medical supplies supplemented what was available from the centres.

Dominica’s national workforce was supplemented, in the aftermath of Hurricane Maria, by the physical presence and technical expertise of personnel from agencies external to Dominica. Several Caribbean country governments and NGOs sent personnel as well as assistance in kind and cash. Agencies in the United Nations system played a major role. Stakeholders told of technical assistance by PAHO, both through the deployment of their personnel on the ground and remotely via electronic communication. The involvement of PAHO was facilitated by having a country specialist on the ground, with experts making visits of various lengths. There were also instances of direct assistance.
by this agency. One example of assistance to the health workforce was the provision of an extra bus to facilitate nurses in travelling to and from the main Princess Margaret Hospital. This was deemed necessary given the damage to street lighting which was a hazard to nurses who arrived at or left work during hours of darkness. Training was also initiated to prepare for hurricane seasons in the future. This included PAHO-led courses on Mass Casualty Management and Emergency Management and Treatment.

The CMHT has collaborated with PAHO following both Tropical Storm Erika and Hurricane Maria to implement training in psychological and mental health first aid to non-health professionals, thus increasing the bank of skills in the population to respond to distress at times of crisis, including natural disasters. Workshops have been held in all seven districts of the islands. District Medical Officers selected a variety of people who had influence in their district for the training, such as community leaders, teachers, social workers, fire officers and police officers. Around 30 people in each district have received training, resulting in capacity-building for around 210 persons across the 7 districts of Dominica. These professionals worked independently and were encouraged to work alongside and collaborate with primary health care staff to meet mental health care needs following the hurricane. The WHO is also collaborating with the Team to provide mental health gap training, scheduled to take place every five years.

The CMHT consists of four persons: two psychiatrists, a psychologist and a social worker. They provide occasional training to frontline health care workers in primary health care facilities, especially nurses, who also use their mental health skills gained as part of their professional qualifications. Three of the nurses have specialist qualifications in psychology. Primary health care workers refer patients to the Team as appropriate and request the CMHT’s advice and assistance when needed. In this way, longer-term mental health issues are addressed in Dominica. The supplementation of this with the training of professionals outside the health sector in mental health first aid effectively increases the capacity of the health care system to address the mental health impact of severe weather events.

Following Hurricane Maria, the CMHT has made policy recommendations regarding the provision psycho-social support in the context of environmental disasters. These topics of these recommendations include:

1. The development and deployment of skills in psychological first aid.
2. Shelter management: addressing psychological issues among people accessing hurricane shelters.
3. Providing regular de-briefing opportunities to health care workers.
4. Training mental health workers in disaster management.
5. The benefits of community meetings to enable people to discuss and develop responses to the environmental and economic challenges that are associated with psychological stress.
6. The development of a Caribbean expert panel of psychiatric and psychological experts from the University of the West Indies and other regional institutions that would visit the country several months after a severe weather event, report on progress and make recommendations.

These recommendations aim to increase the capacity of the health workforce, in part by involving non-health personnel and strengthening the mental resilience of the population. The CMHT emphasizes that community involvement in developing solutions to environmental and economic
challenges posed by severe weather events is key to promoting mental resilience and health (Dominica Community Mental Health Team, 2017).

6.3 Health information systems

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-Guillemond et al., 2015). Monitoring includes surveillance of health and weather conditions and the integration of these information sources is recommended. To be effective, these information types must be communicated effectively to relevant stakeholders. There is also a need for communication with the public so that they can take appropriate action to protect themselves and enhance their resilience. The capacity to produce and communicate health information can itself be affected by severe weather events. Assistance in building health information systems is an important aspect of the response.

Impact

One of the challenges highlighted by the severe weather events was the need to complete digitization of and to secure health and other information. 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, as well as other documents important to health and health policy-making (such as legal documents and working documents of government departments) existed only in hard copy, on paper and in files. Many of these documents were damaged – some irreparably – or lost during Hurricane Maria. This was one of the consequences of the location of the capital city in a flood-prone area.

A contrasting challenge was that digital communication was cut by damage to infrastructure for a few days after Maria, and cellphone and Internet communication were re-established unevenly across the island and at different times. 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 surveillance using a popular phone messaging app (Ahmed, Francis, Russell, Ricketts, & Hospedales, 2016). Following Maria, which knocked out mobile phone communication and the Internet followed by intermittent service, 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.

In this context, low technology and time-honoured forms of communication, such as radio and spoken word, assumed increased importance. The staff of at least three health Departments – Environmental Health, Health Promotion and Community Mental Health – appeared repeatedly on the radio, sometimes as part of a series, to communicate with the public about ways that they could protect their health and access assistance following Hurricane Maria. The CMHT appeared on the radio twice daily for three weeks. Staff of all three of these departments went out in vehicles using megaphones and public-address systems and conducted community meetings to share health promotion messages and direct people to sources of care and support. Interviewees noted that the Dominican public generally listens to the radio and that there is a tradition of health care workers discussing health topics on the radio, making this an effective form of communication, in addition to
its advantage in remaining available when electricity and Internet services are not. Some health care workers are well known for their expertise on particular topics, and members of the public expect them to engage in debate on call-in programmes, speak out and offer advice. Ham, or amateur, radio was also used to communicate between people following Hurricane Maria (CARPHA, 2017a).

The CMHT carried out its community meetings on the invitation of community-based organisations such as Village Councils and churches. During these meetings, the CMHT helped mobilise people on how to respond to the disaster in terms of making lists of needs and accessing available resources.

Risks and warnings must be communicated effectively to the public so that they can take action to avoid risk and ensure safety. A health care worker interviewed for the current assessment shared the view that weather forecasts on radio and television channels used meteorological terms – for example, “low level trough” – which are not commonly understood by laypersons. He opined that the public needed to know more about how weather conditions were likely to affect their health, property and environment than about the weather conditions themselves. He recommended the use of everyday language and local idioms in describing the likely weather scenarios, along with discussions of likely effects of projected weather on local conditions affecting health, such as the projected extent of flooding and the geographical areas likely to be most affected. The enactment of this recommendation is likely to require discussion between meteorologists, public broadcasters, community representatives and possibly educators to ensure that weather information is relayed to the public in an accessible and comprehensible manner.

The speed of escalation of Maria from a Category 1 to a Category 5 hurricane (see section 3.1) highlighted the need for rapid communication to the public. Interviewees stated that local radio and televisions stations did not carry the news of the escalation to Category 5 until it had already been reported in US-based news networks. Some received the news of the escalation through phone calls from relatives abroad who had heard the news from US channels. Lack of speed in communication of the escalation may have contributed to the health impact of the hurricane, since people did not adopt the level of precautions they may otherwise have done. Interviewees also noted that many members of the population had not sufficiently heeded public announcements during hurricane season that encouraged preparedness, including stocking up with food and other daily essentials, first aid and basic construction supplies.

Response

In the aftermath of Hurricane Maria, support from agencies was provided for assessments of the damage and losses and to make recommendations for re-construction, adaptation and resilience strategies. A central strategy was the conduct of the Post-Disaster Needs Assessment, (PDNA) which was carried out on the official request of the government and was coordinated by the World Bank in conjunction with the European Union, the United Nations and related agencies to assess the disaster impact to inform recovery and reconstruction needs (Government of Dominica, 2017). The assessment targeted those sectors identified by the government as the most critical: health, transport, tourism, agriculture, housing, commerce and industry, employment livelihoods and social protection, education, water and sanitation, telecommunications and energy. The PDNA included a budget for Consultant-led reviews of primary care services and of policies and legislation for climate resilience.
The government and its partners have also engaged in longer term vulnerability, capacity and adaptation assessments. In December 2015, the Commonwealth of Dominica partnered with CARPHA to conduct a National After Action Review of Events relating to the Impact of Tropical Storm Erika on the Commonwealth of Dominica, focusing on lessons learned for the health sector to optimize disaster response (CARPHA, 2015). The 2016 Assessment of Climate Change and Health Vulnerability and Adaptation in Dominica was, similarly, developed through partnership between the MoHE and regional and international partners. The latter included ground-breaking data analyses including time series of weather and health associations and modelling of health risks, including vector-borne, food and water-borne diseases and impact on food security. It also examined adaptive capacity to prevent health risks, by the health sector and by individuals and agencies in various sectors and presented adaptation options (Dominica Ministry of Health and the Environment, 2016).

In May 2017, CARPHA in concert with the EHD conducted an assessment of laboratory support for water quality monitoring in Dominica (CARPHA, 2017b). Assessments were undertaken following Hurricane Maria, including an examination of health surveillance systems, by PAHO, and an assessment of primary health care, by PAHO in collaboration with the Director of Primary Health Care and other national stakeholders.

The EHD is working with the Health Information Unit to develop a surveillance system that incorporates disease, climate and environmental monitoring indicators, with the latter including vector control, water quality and food quality monitoring. This was a recommendation of the Vulnerability and Impact Assessment following Tropical Storm Erika (Dominica Ministry of Health and the Environment, 2016). They are working with the Meteorological Office to develop software to integrate the different sorts of information. However, it was remarked that some important information is not yet digitized, challenging its inclusion in an integrated surveillance system.

DoWASCO has worked with staff of the national laboratory and CARPHA to carry out studies of water quality and make recommendations for re-building and enhancing the resilience of the water supply following Hurricane Maria.

The World Bank Climate Change Knowledge Portal provides data and graphics showing environmental vulnerabilities and populations affected for various countries, including Dominica (World Bank, nd).
6.4 Medical products and technologies

Impact

In Dominica, prior to Hurricane Maria, informed in part by the experience of Tropical Storm Erika and as part of their Disaster Preparedness Plans, each government health care facility stocked medical supplies to ensure that first aid and a basic list of drugs were available to the populations they primarily served. These supplies were boosted in quantity at the beginning of each hurricane season, with quantities aiming to provide coverage for one to two months. However, the extent of damage to health facilities challenged the availability of these supplies and threw into question their adequacy in meeting population needs.

Challenges included:

- Electricity outages, that prevented refrigeration and air conditioning, leading to spoilage of medical supplies and samples.
- Damage to refrigerators, medical and laboratory machinery. The laboratory at the Princess Margaret Hospital was severely damaged and remained unusable at the end of 2017.
- Destruction or severe damage to health centres and parts of the hospital, including areas where medical supplies were stored (see report)
- Road infrastructure damage that prevented the transport of drugs and other health supplies to patients, and of patients to health facilities. This affected people with both acute and chronic conditions. Some people with long-term illnesses who relied on regular treatment, such as dialysis and HIV patients, were unable to obtain this treatment for periods stretching into weeks. Some dialysis patients were eventually flown abroad for treatment, through humanitarian assistance to the government.

Response

The challenges to the delivery of medical products and technologies were caused by damage to infrastructure of various sorts. Section 5.1 provides details of initiatives to build back better with regard to Dominica’s infrastructure.

6.5 Service delivery

The WHO notes that the enhancement of resilience in service delivery requires:

1) The integration of climate change considerations, particularly the use of meteorological information, into existing programmes for control of climate-sensitive diseases (e.g. vector-borne diseases);
2) Improved management of the environmental determinants of health, such as water and sanitation, nutrition and air quality, taking into account the modifying effect of socioeconomic conditions; and
3) Disaster risk reduction, emergency preparedness and management, in relation to the health consequences of extreme weather events (Shumake-Guillermot et al., 2015).

These three requirements of the service delivery "building block" of health systems have been discussed earlier in the current document. In summary:
1) The EHD and the Health Information Unit are working together with external partners to develop integrated information systems with meteorological information and data on climate sensitive diseases. However, the health information system itself was damaged by Hurricane Maria, with some data having been lost, infrastructural and equipment damage and impacts on the human resources of the Unit.

2) Management of environmental determinants of health has been undertaken by a wide variety of agencies, as detailed in section 5 of this chapter. It was hampered by massive infrastructural damage, but agencies and people cooperated to enact plans to repair the damage and build back better.

3) Disaster risk reduction is multi-faceted, including management of environmental determinants of health and strengthening building blocks of the health system in general. Emergency preparedness and management has been described in section 6.1 on leadership and governance. Again, the enormity of Hurricane Maria meant that plans were not always enacted as expected. Following initial emergency activities, stakeholders worked together to re-think strategies to enhance the resilience of Dominica to disasters.

6.6 Finance

Impact

Hurricane Maria had a massive economic impact on Dominica. The World Bank estimated damages and losses of about 226% of 2016 GDP. The damage assessment estimated rehabilitation and reconstruction costs of public and private structures, and the likely impact on the productive capacity of the different economic sectors. The economic impact estimates also drew on the experience of previous natural disasters in Dominica.

Based upon an initial assessment of impacts to each affected sector, the most damages from Hurricane Maria were sustained in the housing sector (38 percent), followed by the transport sector (20 percent), and these two sectors had the greatest needs for re-construction and “building back better” for resilience. The greatest economic losses were sustained in the agriculture sector (32 percent), followed by the tourism (19 percent) and transport sector (14 percent) (Government of Dominica, 2017).
Table 9: Dominica: distribution of damages, losses and needs by sector inflicted by Hurricane Maria, November 2017

<table>
<thead>
<tr>
<th>Sector</th>
<th>Damage % of total</th>
<th>Losses % of total</th>
<th>Needs % of total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PRODUCTIVE SECTOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>19.1</td>
<td>53.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Fisheries</td>
<td>5.9</td>
<td>32.7</td>
<td>5.3</td>
</tr>
<tr>
<td>Forestry</td>
<td>0.3</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Commerce and Micro Business</td>
<td>3.2</td>
<td>0.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Tourism</td>
<td>7.6</td>
<td>1.8</td>
<td>5.4</td>
</tr>
<tr>
<td><strong>SOCIAL SECTOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>38.0</td>
<td>7.5</td>
<td>38.5</td>
</tr>
<tr>
<td>Education</td>
<td>7.9</td>
<td>0.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Health</td>
<td>1.2</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Culture</td>
<td>0.5</td>
<td>0.8</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>INFRASTRUCTURE SECTOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>19.6</td>
<td>13.8</td>
<td>22.4</td>
</tr>
<tr>
<td>Electricity</td>
<td>3.6</td>
<td>8.7</td>
<td>6.0</td>
</tr>
<tr>
<td>Water and Sanitation</td>
<td>2.6</td>
<td>10.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Telecommunication</td>
<td>5.1</td>
<td>2.2</td>
<td>3.5</td>
</tr>
<tr>
<td>Airports and Port</td>
<td>2.0</td>
<td>0.9</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>CROSS-CUTTING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disaster Risk Management</td>
<td>0.3</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Environment</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Gender</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL (Million US$)</strong></td>
<td>931</td>
<td>380</td>
<td>1,349</td>
</tr>
</tbody>
</table>

Source: Analyses based on figures from (Government of Dominica, 2017)

The damage in Dominica to housing, transport and agriculture has been discussed above. In the tourism sector, one hotel was completely destroyed by Tropical Storm Erika, and the remainder were severely damaged by Hurricane Maria. The heaviest damages of Maria in the tourism sector were to hotel accommodation. Of the stock of 909 rooms, 39% were considered severely damaged and would not be put back in service at least for a year, while a further 34% may be available within the year. The cruise season was considered lost, in part because the piers necessary for the ships to dock were damaged. This affected expenditure by cruise ship passengers and revenue to tour operators, vendors, and other support services such as taxis. The decline in tourism affected transport and wholesale and retail trade services (Government of Dominica, 2017). Travel and tourism made a direct contribution to the economy of 9.5% of GDP and 8.8% of total employment (around 3,000 jobs) in 2012. Tourism is especially important in generating foreign exchange necessary to buy imports. Travel services are the only category of services trade in which the island runs a trade surplus; the country earns considerably more than it spends in this sector. Tourism is viewed by the government as a sector that is crucial to the development of Dominica's economy in order to compensate for
declines in other sectors, especially in the banana industry (Compete Caribbean, 2013). Since the economic slowdown of 2009, other sectors of the economy have remained stagnant, but tourism's growth jumped the sector from 15% of total GDP to 23.9% in 2016 (Government of Dominica, 2017). The increased reliance on tourism to earn foreign exchange needed for goods essential to health such as food and medication is a feature of many Caribbean countries.

**Figure 31: The relevance of tourism to Dominica's GDP, 2000-2015**

*Source: (Government of Dominica, 2017)*
Figure 32: Notice for guests at a hotel damaged by Hurricane Irma, Anguilla, May 2018

Dear Guest
Thanks for your continued patience and understanding through our restoration/recovery process from the damages caused by the recent Hurricane Irma.

Thank you, The Management & Staff

Source: Photo by Caroline Allen during visit to Anguilla, 2-5 May 2018

Figure 33: Seaside restaurant damaged by Hurricane Irma in Anguilla

Source: Photo by Caroline Allen during visit to Anguilla, 2-5 May 2018
The costs of health infrastructure damage outlined in section 5.1 were accompanied by a number of categories of additional cost as a result of the Hurricane, according to the PDNA. These included: fuel costs for vehicles and generators; increased staffing for six months; clean-up costs of rubble removal; accommodation, food and water for staff and volunteers; health promotion campaigns; environmental monitoring and surveillance; 6-month surge in vector control; psychosocial support; increase in treatment services; evacuation of patients; overseas treatment costs and vaccination increase to prevent tetanus. There was also loss of revenue at the hospital and from food handlers. The total of these extra costs was estimated at approximately US$6,951,000. Of this, $2,974,000 (43%) was for human resource costs, estimated at a 50% increase for 6 months over the 2016/2017 human resources budget estimate.

The PDNA estimated that there would be a 40% increase in the number of health care patients for up to 24 months. Cost of transport and of treatment of evacuated injured persons were also included in the PDNA. Outbreaks of estimated 6 months duration were budgeted for, with additional costs categories associated with these outbreaks listed as surveillance, information campaigns, vector control, vaccination and mental health (Ministry of Health and the Environment, 2017).

Response

Following Hurricane Maria, and demonstrating regional and global solidarity, Dominica received US$28 million (4.8 percent of GDP), including a payout of US$19.3 million from the Caribbean Catastrophe Risk Insurance Facility (CCRIF), and pledges for grants of US$8.8 million. This included grants and donations from the Eastern Caribbean Central Bank, Department for International Development (UK), Caribbean Development Bank, European Union, Royal Bank of Canada, The US Agency for International Development, the governments of Antigua and Barbuda, Grenada, St. Kitts and Nevis, New Zealand, and the Bahamas (Government of Dominica, 2017).

The authorities planned to maintain pre-storm levels of government employment and spending on goods and services to support basic needs using government deposits of near 30% of GDP. To help finance home rehabilitation, the government announced voluntary advances on government salaries and on non-contributory pension payments from the Social Security Fund.

Banks and credit unions resumed their services a few days after the hurricane to enable transactions. The National Bank of Dominica announced a 3-month loan moratorium, to relieve financing constraints during a transition. Substantial private insurance payout was expected to facilitate the repair and reconstruction of private housing and structures, tempering the risk of an increase in non-performing loans NPLs (Government of Dominica, 2017). However, interviewees reported that people with insurance experienced difficulties and delays in accessing insurance pay-outs.

In the tourism sector, the major effort was to re-build and re-open facilities, incorporating disaster risk reduction plans (Government of Dominica, 2017). A new category of tourism product – voluntourism – is being promoted to attract people who may wish to combine active assistance of the country with their stay on the island. 12

12 See http://dominicaupdate.com/voluntourism/
Financial responses thus combined the efforts and resources of the national government and private sector, regional governments and agencies, international agencies and agencies beyond the region. However, the scale of financial support did not meet the total costs of damages and losses, and government revenues were also depleted by the fall in output, which led to lower tax payments.

Challenges were experienced in attracting additional aid funding because of Dominica’s standing as a “middle income country” with high human development (see section 3.2). As the analyses above show, these classifications neglect the considerable vulnerability of SIDS and the extent of damage and loss to the resources of these countries due to severe weather events and other disasters.
CONCLUSION

“In order effectively to protect the health of the population, the health sector should strengthen and extend its sphere of influence and operations beyond itself mainly in relation to health-determining sectors, e.g. water, energy, food and agriculture and urban planning.” (Shumake-Guillemot et al., 2015), page 8

Hurricanes Irma and Maria threw into relief the need for the health sector to work with a wide variety of agencies, especially those concerned with environmental determinants of health, to strengthen the resilience of the population’s health to severe weather events. The case study of Dominica demonstrates a tradition of working cooperatively for climate resilience, but that the best laid plans may not unfurl as expected when faced with cataclysmic weather events. Caribbean people continue to strive to strengthen the building blocks of climate resilient health systems. International partners have assisted, especially in the immediate aftermath of these hurricanes. However, most of the costs of these events have been borne by Caribbean people, despite their having a miniscule role in global warming and creating the conditions for the stronger and more frequent hurricanes now being experienced. The Prime Minister of Dominica rightly highlighted the moral responsibility of major global companies and countries to increase their action to mitigate climate change and reduce its impact on Caribbean SIDS (Skerrit, 2017).
REFERENCES


https://www.nature.com/articles/nature03906#supplementary-information


PAHO. (n.d.). Smart Hospitals Toolkit: A practical guide for hospital administrators, health disaster coordinators, health facility designers, engineers and maintenance staff to achieve Smart Health Facilities by conserving resources, cutting costs, increasing efficiency in operations and reducing carbon emissions.


