S.I.A.I.S. Technical report n.1/2018

Sustainable and Climate Change Resilient Healthcare Facilities in Europe: The Challenge

Italian Society of Architecture and Engineering for Healthcare

SIAIS
Società Italiana dell'Architettura e dell'Ingegneria per la Sanità

S.I.A.I.S. Technical report n.1/2018

Sustainable and Climate Change Resilient Healthcare Facilities in Europe: The Challenge

Authors:
Daniela Pedrini
Simona Ganassi Agger
With the collaboration of:
Jonathan Erskine (European Health Property Network)
Simon A. Agger
SIAIS work group composed of:
Gianluca Borelli
Virginia Caracciolo
Angelo Conti
Heinrich Corradini
Amedeo De Marco
Filippo Terzaghi

This document is a technical report from the above SIAIS working group, made upon request by IFHE-EU to its members to get scientific contributions on selected issues, linked to its foundation documents. It aims to provide evidence-based support in the development of guidance and toolkits addressed to hospital management concerned with resilience to climate change-related risks to hospitals and health facilities.

March 2018 / Revised June 2018.

Italian Society of Architecture and Engineering for Healthcare

SIAIS
Società Italiana dell'Architettura e dell'Ingegneria per la Sanità

Sustainable and Climate Change Resilient Healthcare Facilities in Europe: The Challenge

Table of Contents

1. Introduction

1.1 Climate-related natural disasters

In recent years, numerous studies have provided scientific proof of the links between extreme weather disasters and climate change.[1] Furthermore there is compelling evidence that changes in the hearth's climate cannot be explained without taking into account human influence, especially, but not only, through the emissions of greenhouse gases (GHGs).[2]

Climate change and global warming are frequently used to indicate the same set of problems; however, it needs to be stressed that climate change has more complex and widespread impacts than simply producing warmer temperatures. In addition, it is clear that climate change has a range of consequences on human health and the built environment. Scientific studies predict that the sequences will become more serious. Some of them will have long term impacts (e.g. rising sea level, threat to Australia's coral reefs, changes to patterns of human diseases), while others will have immediate impacts such as floods, storms and heat waves, with obviously also long lasting consequences related to their damages.

While considering the importance of tackling climate-related events becoming evident in a longer span of time, it is necessary to recognize that they require complex, strategic interventions planned and implemented by different levels of public authorities, with international coordination, set up and then monitored for their effective impact. For this reason, this study focuses basically on "extreme weather events", which result in natural disasters with immediate impact, requiring involvement of health infrastructures.

The major objectives of this study are:

a) To enhance awareness of the problems created by climate change for people who provide health care services.
b) To provide evidence of the contribution that organizations such IFHE and SIAIS can give in defining the engineering measures necessary to mitigate the effects of climate change-related damages.

Attention is focused on Europe and on climate related disasters such as:

- Increased precipitation and flooding
- Extreme heat waves and cold waves
- Storms and high winds

[1] Among others an important document of the European Parliament was produced in 2005 by the DG INTERNAL POLICIES OF THE UNION "Climate Change and Natural Disasters: Scientific evidence of a possible relation between recent natural disasters and climate change"- (IP/A/ENVI/FWC/2005-35).
[2] Intergovernmental Panel on Climate Change (IPCC) has been producing reports on these matters starting in 2001 http://www.ipcc.ch/ipccreports.

- Other related events, such as landslides and fires.[3]

Scientific studies and climate modelling indicate that the measures to counteract climate change may not have short-term impact, consequently, we are very likely to experience an increase in extreme weather events.

This highlights the need for more effective **mitigation actions,** to be planned with priority and implemented urgently and efficiently. The preparedness of healthcare institutions, primarily hospitals organisations, in ensuring the adequacy of their physical infrastructure, is essential to ensure adequate mitigation for the communities and their environments. The extent and scope of preparedness is commonly referred to as resilience of the infrastructure (as discussed in section 3).

1.2 Concepts and key definitions

The concepts and key points supporting this study can be summarized as follows:

- There is scientific evidence that changes in the earth's climate is taking place. Since the 1950s, many of the observed changes are unprecedented. These cannot be explained without taking into account human influence. Recent anthropogenic emissions of greenhouse gases are the highest in history.
- Recent climate change has had widespread impacts on human and natural systems.[4]
- Climate change has increased frequency and severity of the extreme weather and climate related events in several regions across Europe[5] and the responses illustrate a lack of efficient mitigation actions.
- The effects of the impact from climate change-related events depend not only on the severity of them, but also on the vulnerability of human and environment systems.
- Vulnerability is influenced by social, economic, cultural and technical factors.
- An appropriately systemic approach to this range of factors to date has been undertaken by national governments only in a limited number of cases, as far as it is possible to know from the available and accesible documentation.
- Given the increasing severity of extreme events, improved mitigation and adaptation measures are needed, based on these fundamental assumptions:
    - Natural disasters happen when extreme events strike vulnerable areas.
    - Reducing vulnerability can reduce the impact of extreme events.

[3]See the study "Increasing risk over time of weather-related hazards to the European population" www.thelancet.com/panetary-health Vol 1 August 2017.

[4]The Assessment Report(AR5)of the Intergovernmental Panel on Climate Change (IPCC) has been published under the title "Climate Change 2014", http://ar5-yr.ipcc.ch/ipcc/ipcc/resources/pdf/IPCC_SynthesisReport.pdf is the link with the Synthesis Report SYR

[5] European Environment Agency: "Climate change adaptation and disaster risk reduction in Europe" EEA Report/No 15/2017

- Adopting measures of the following three types: administrative/legal, **engineering**, and addressing human behaviour, all of which are important in decreasing the likelihood of harm from climate change-related events.[6]

- To recognise the need for measures of mitigation and adaptation, requires a not fatalistic acceptance of climate change and its negative consequences. First, developing mitigation measures constitutes a proactive approach focused on addressing the factors directly influencing climate change. Second, such recognition reinforces the need for a systemic vision, which involves a strategic set of actions for tackling other factors such as population growth, social justice and, above all, the present meaning of development and its destructive parameters of economic growth.

1.3 Scope of the study

This report aims to contribute to a better awareness of the issues concerning the healthcare sector and its associated physical infrastructure, mostly hospitals, and the need to build efficient **mitigation** against the possible destructive impact of natural disasters related to climate change. The exchange of knowledge aims to contribute to the development of tools to support and perhaps guide this activity, tools which are currently fragmented and not sufficiently consistent.

Given the core business of the association that has produced the study (SIAIS) and the one that has commissioned it (IFHE-EU), naturally the study is first addressed to the technical management and staff working in hospitals.

However, in addition, there are several reasons to conclude that:

1. The study can also contribute to policy developments and subsequent implementation in the frame work of the overall responsibilities of health policy makers and especially hospital managers;
2. The study could trigger further collaboration with public authorities which recognize that ‘ climate change is one of the great challenges of the 21st century’ and which deal with human and environmental health and related social justice and equity.[7]

The geographical focus mostly concerns European countries, but also considers lessons learned in other countries around the world, which have suffered in serious ways from natural disasters related to climate change.

[6] European Parliament – DG Internal Policies of the Union “Climate change and Natural Disasters” – (IP/A/ENVI/FWC/2005-35) Briefing Note - pdf

[7] IPCC – 2011 report http://www.ipcc.ch/report/srren/

2. Europe and natural disasters

2.1 The global vulnerability of health facilities

The media have frequently provided extensive coverage of climate change in the USA and in Asia. For example, we are all familiar with the effects of Hurricane Katrina (2005), which resulted in over 1500 deaths and major damages to local infrastructure, including a number of hospitals.

Brian Snyder / Reuters file

A coroners team prepares to remove the bodies of Katrina victims at the Louisiana State University Medical Center in New Orleans on Sept. 13. Officials on Wednesday deemed New Orleans' two public hospitals unsalvageable and said they will be torn down.

Similarly, in August 2017, Hurricane Harris caused 80 casualties in Texas, extensive infrastructure damage and the evacuation of at least one hospital.

From a European perspective, it may seem that catastrophic events caused by extreme weather happen in areas far away and the general attitude is that Europe does not suffer as acutely from such problems. As a consequence, and as we will see in the following chapters, few local governments have adequate emergency plans to cope with the consequences of extreme weather events and the importance of having hospitals prepared for emergencies of any nature is, in parallel, down played or at least not considered a high priority in the to-do list of healthcare policy makers and/or hospital management.

2.2 The most relevant aspect of European vulnerability

This subsection will examine some of the most relevant types of disastrous events related to climate change affecting different areas of Europe and how they produce serious disruptions of vulnerable communities.

2.2.1 *Floods and excess precipitation*

The media descriptions reported below illustrate the extent and scope of severe damage caused by flooding across Europe in recent years.

August 2002: Mail Online News

"Europe is wrestling with the aftermath of violent storms that swept the continent two weeks ago. Flooding spread further through east Germany today, leaving emergency crews scrounging for sandbags to shore up crumbling dikes as the country faced its biggest relief effort since World War II. German authorities reported three more deaths, bringing the Europe wide toll to at least 109.In Hungary, the Danube River peaked at a historic high in Budapest without causing major flooding after relief workers spent a frantic night bolstering dikes. The capital's high flood walls, built at the turn of the last century, held off the floodwater in the city centre, though one barrier gave way in a northern suburb. Floodwaters have ebbed in the Czech Republic and also were falling in Dresden, the biggest German city hit so far, allowing the start of a massive cleanup and rebuilding operation expected to cost some 20 billion euro Europe wide."

June 2013: International Commission for the Protection of the Danube River [8]

Reports of the floods in the Danube River Basin with a chapter dedicated to the key flood events in Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria.

June 2016: https://en.wikipedia.org/wiki/2016_European_floods

"In late May and early June 2016 flooding began after several days of heavy rain in Europe, mostly Germany and France, but also Austria, Belgium, Romania, Moldova, Netherlands and the United Kingdom. Among others, the German states of Bavaria, Hesse, Rhineland-Palatinate, Baden-Württemberg, and North Rhine-Westphalia were affected. Beginning at the

[8] /www.icpdr.org/main/sites/default/files/nodes/documents/icpdr_floods-report-web_0.pdf

river Neckar, the Danube, Rhine, Seine and their tributaries were highly affected by high water and flooding along their banks. At least 20 people have died to date."[9]

02 June 2016: The Guardian reports from France *"Seine could peak at 6.5 metres as Louvre closes doors"*.

10 July 2017: BBC
"Paris flooding: Record rainfall hits French capital.... A two-hour storm unleashed 54mm (2.1in) of rain on Sunday night in Paris, the equivalent of 27 days of rainfall. Weather services say ... Flooding closed 20 metro stations and three were still shut as commuters made their way to work on Monday morning."[10]

29January 2018: BBC
"*French floods: Seine river reaches peak in flood-hit Paris."*[11]

[9] https://www.theguardian.com/world/2016/jun/02/deaths-as-flash-floods-hit-france-germany-and-austria
[10] www.bbc.com/news/world-europe-40554842
11 http://www.bbc.com/news/world-europe-42856634

2.2.2 *Extreme weather conditions*

a. Heat waves

In a study of the European Environmental Agency Climate change adaptation and disaster risk reduction, it is reported that "*in Europe, since the 1950s, large areas have experienced intense and long heat waves, with notable impacts on human health and socio-economic systems.*"

In addition, extreme heat events are also related to droughts, with serious and well-known consequences also in agriculture. Paradoxically, heat extremes can increase the frequency and intensity of heavy precipitation events, with an associate increase of the probability experiencing storms and hailstorms.

The effects of heat waves on human health can be direct and dramatic. Vulnerable patients suffer the most from thermal discomfort and health facilities are more likely to be thermally efficient in cold weather than for heat waves. According to EM-DAT, The International Disaster database, heat waves were the deadliest extreme climate event in the period 1991-2015 in Europe, particularly in southern and western Europe.

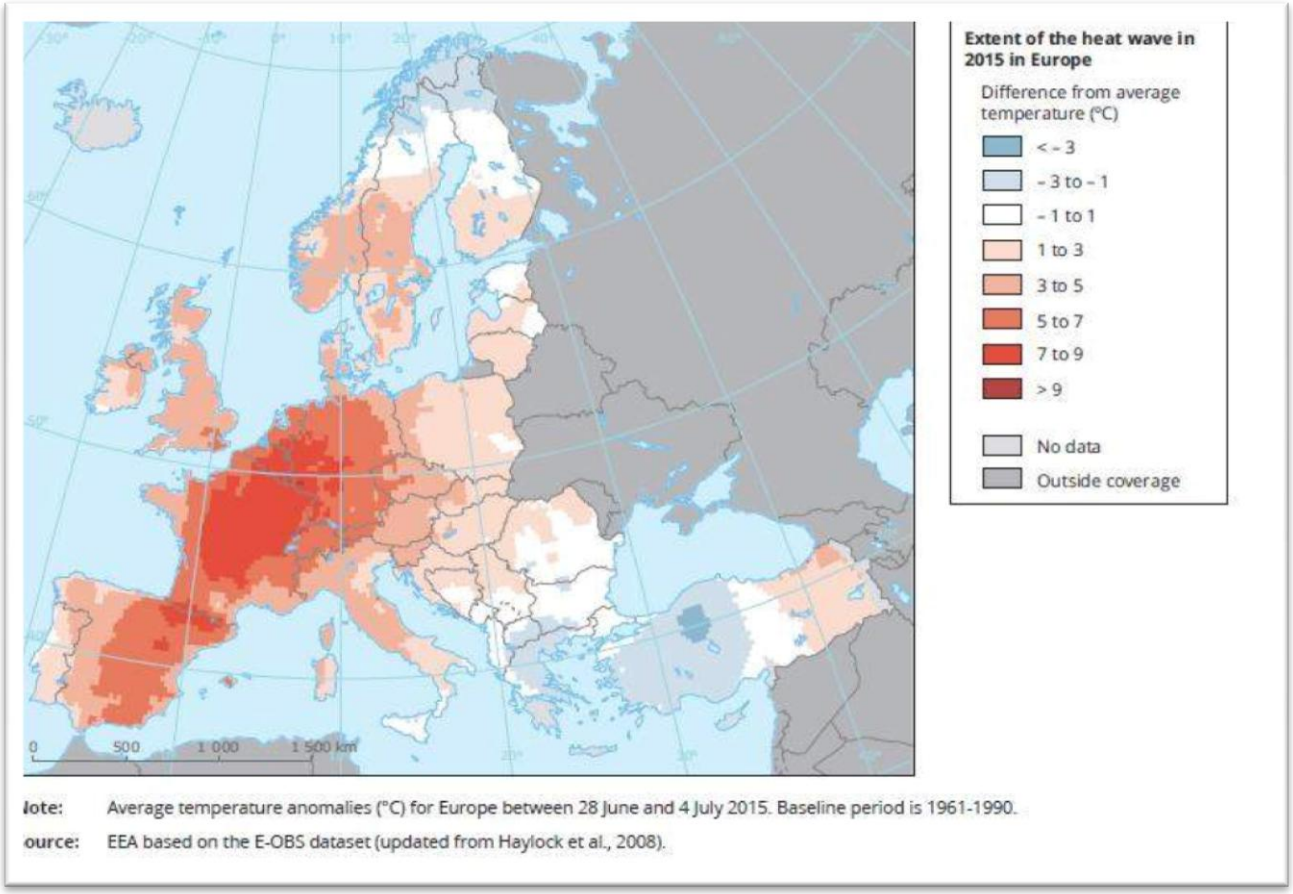
One case always cited is the 2003 summer heat wave (June-September 2003), with over 70,000 related deaths in southern and western Europe. Furthermore, the number of unusually warm days has increased by up to 10 days per decade between 1960 and 2016 in most of southern Europe and Scandinavia.

The projections reported by that document are: *''Periods with extreme high temperatures are projected to become more frequent and to last longer across Europe during this century. Different projections based on different sets of multi-model ensembles agree on increases in heat wave frequency and severity for most European regions during the 21st century under all RCP scenarios.*" (e.g. Fischer and Schär, 2010; Schoetter et al., 2014; Russo et al., 2014, 2015").[12]

[12] European Environment Agency « Climate change adaptation... " Report n.15/2017 page 48

Extent of the heat wave in 2015 in Europe

From: EEA Report on "Climate Change adaptation and disaster risk reduction in Europe"



b. Extreme cold waves

Cold weather events of have received less direct attention that other climate change-related disaster risks by scientists and specialised agencies and organisations. They have been regarded more as simply a consequence of other natural hazardous events, especially heavy storms. Frequently they have been treated with the same regard as heat waves in studies which aim to monitor and forecasting "extreme weather". Some scientists suggest the definition of "cold wave outbreak" for events producing long periods of unusual cold.

Media reporting of cold waves includes the following:

2004–2005 Southern Europe cold wave: Southern Europe suffered from an unusually hard winter in this period, with frequent ice storms and a cold front that caused snow in Algeria. Freezing temperatures were experienced in the north of Portugal, in Spain and Morocco.

2005–06 European cold wave: Temperatures were very low during the winter months. The whole European continent suffered from the effects.

2007: Some parts of Europe experienced unusually cold winter temperatures in March and April, after having early spring weather temperatures in part of February and March, creating additional difficulties for healthcare delivery and other economic activities, especially in the agriculture sector.

2009–10: European cold wave – 19 people died after record low temperatures and heavy snowfall across Europe. Infrastructure was damaged, and travel was disrupted throughout the continent. It was the coldest winter and longest cold spell in the past thirty years in the United Kingdom, whilst temperatures in the Italian Alpine peaks reached an extreme low of −47 °C.

Early 2012 European cold wave: On February 11, 2012 at least 590 people died during a cold wave with temperatures falling below −35 °C in some regions.

United Kingdom March-April 2013: The UK Spring 2013 cold wave was a prolonged spell of cold weather which brought with it very heavy snowfalls, it was the worst month of March in the past 30 years, while in other areas of Europe such a cold period was not recorded since 1947.[13]

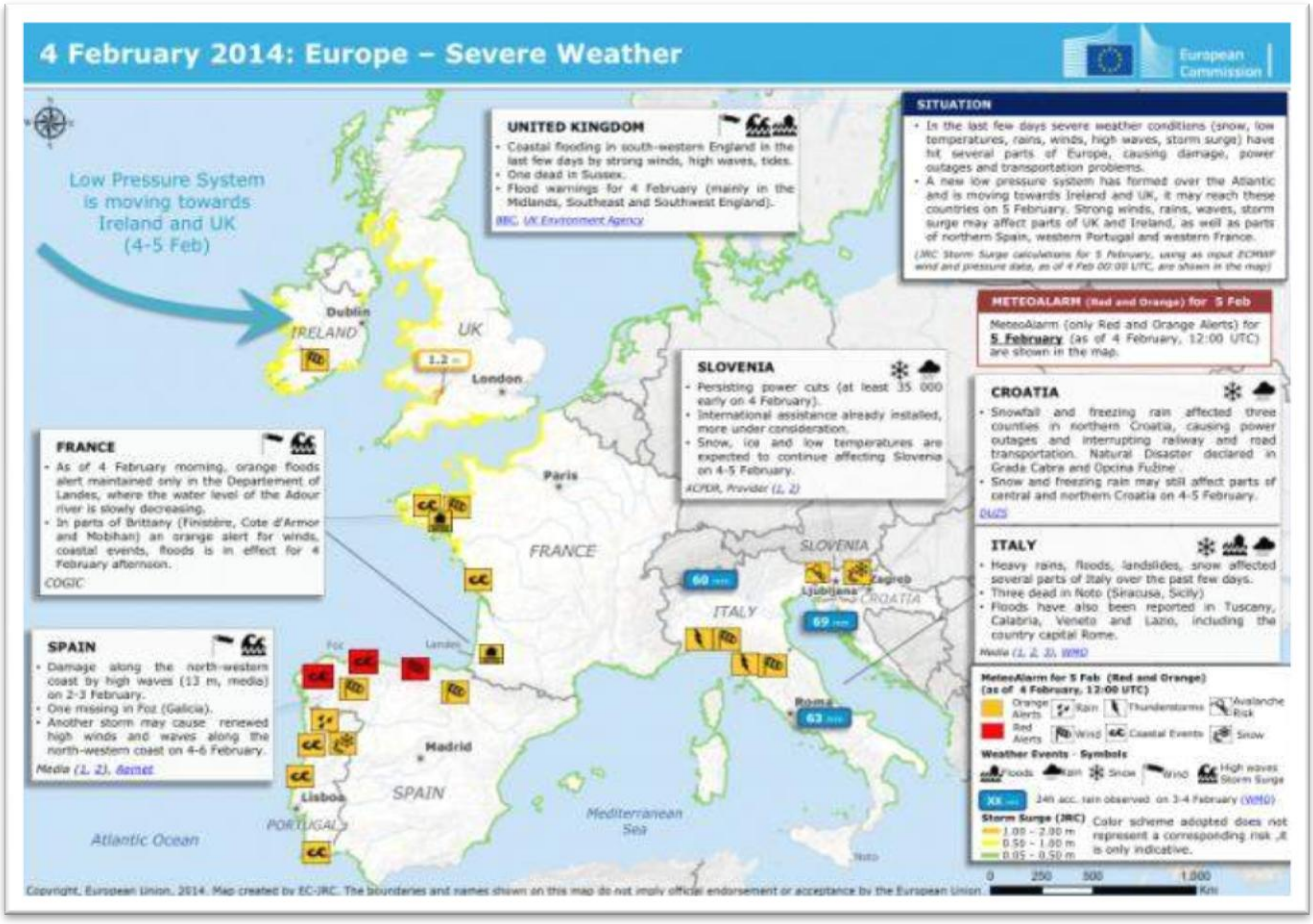
January 2017: European cold wave – A cold wave hit Central and Eastern Europe on January 5 with a massive snowfall. The lowest temperature was −45.4 °C degrees. The cold caused a death toll of 60 persons.

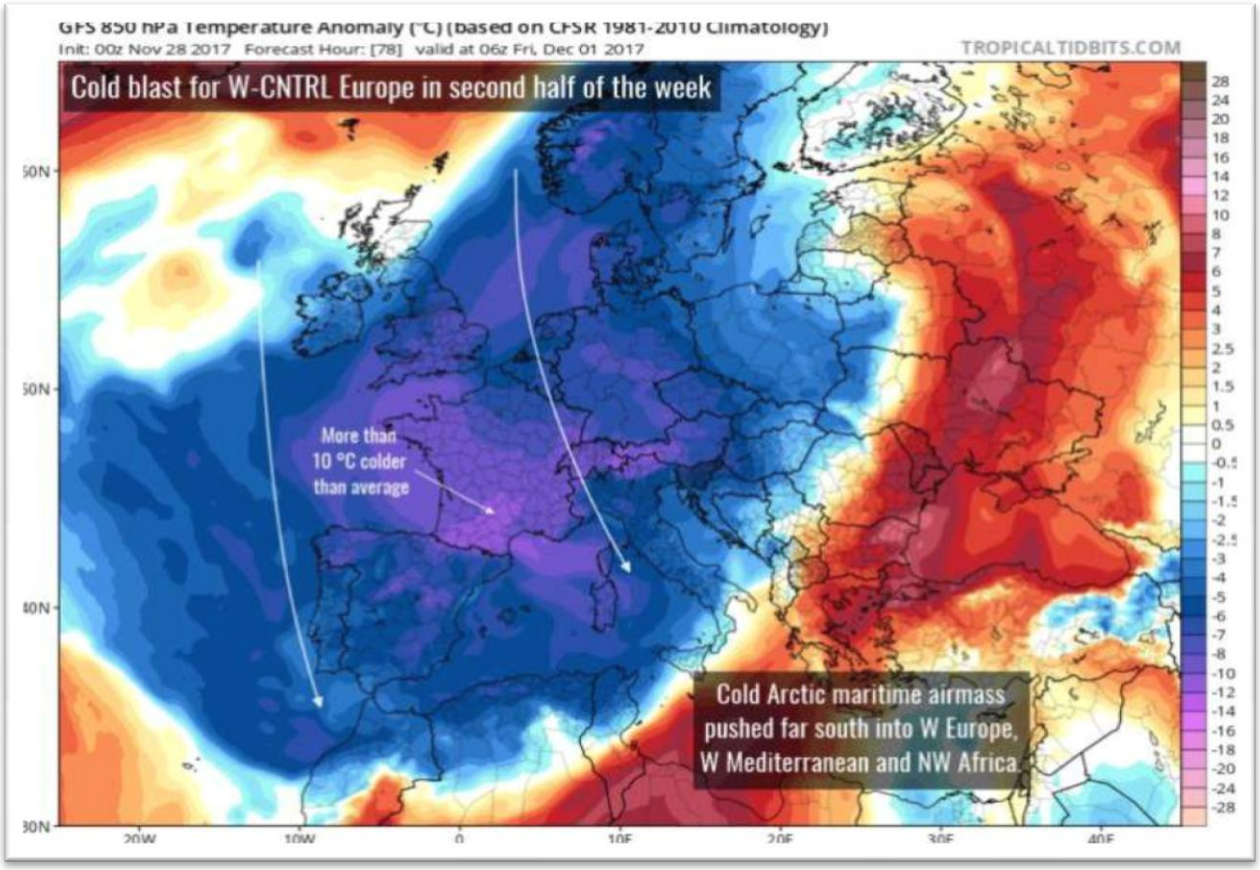
February 2018: Storm Emma swept across Europe, producing cases of extreme cold weather of unexpected intensity over a large part of Europe. The UK newspapers supplied ample evidence of the unpreparedness of the hospitals, which was mitigated by the positive behaviour of hospital staff, who in many cases managed to overcome the problems of reaching hospitals and could provide healthcare at all price.

The conclusion of one of the media has been:

> *"Heroic NHS staff are walking for miles in the snow or sleeping in hospitals overnight to ensure they can continue caring for patients during Storm Emma. As the UK is gripped by freezing temperatures and deadly blizzards, National Health Service workers remain incredibly dedicated to keeping everyone safe despite the constant strain of being underfunded and the added burden of treacherous weather."*[14]

[13] https://en.wikipedia.org/wiki/Cold_wave
[14] http://metro.co.uk/2018/03/02/


4 February 2014: Europe – Severe Weather
European Commission
Low Pressure System is moving towards Ireland and UK (4-5 Feb)
UNITED KINGDOM
• Coastal flooding in south-western England in the last few days by strong winds, high waves, tides.
• One dead in Sussex.
• Flood warnings for 4 February (mainly in the Midlands, Southeast and Southwest England).
BBC, UK Environment Agency
SITUATION
• In the last few days severe weather conditions (snow, low temperatures, rains, winds, high waves, storm surge) have hit several parts of Europe, causing damage, power outages and transportation problems.
• A new low pressure system has formed over the Atlantic and is moving towards Ireland and UK, it may reach these countries on 5 February. Strong winds, rains, waves, storm surge may affect parts of UK and Ireland, as well as parts of northern Spain, western Portugal and western France.
METEOALARM (Red and Orange) for 5 Feb
MeteoAlarm (only Red and Orange Alerts) for 5 February (as of 4 February, 12:00 UTC) are shown in the map.
SLOVENIA
• Persisting power cuts (at least 35 000 early on 4 February).
• International assistance already installed, more under consideration.
• Snow, ice and low temperatures are expected to continue affecting Slovenia on 4-5 February.
ACPDR, Provider (1, 2)
CROATIA
• Snowfall and freezing rain affected three counties in northern Croatia, causing power outages and interrupting railway and road transportation. Natural Disaster declared in Grada Cabra and Opcina Fužine .
• Snow and freezing rain may still affect parts of central and northern Croatia on 4-5 February.
DUZS
FRANCE
• As of 4 February morning, orange floods alert maintained only in the Departement of Landes, where the water level of the Adour river is slowly decreasing.
• In parts of Brittany (Finistère, Cote d'Armor and Mobihan) an orange alert for winds, coastal events, floods is in effect for 4 February afternoon.
COGIC
ITALY
• Heavy rains, floods, landslides, snow affected several parts of Italy over the past few days.
• Three dead in Noto (Siracusa, Sicily)
• Floods have also been reported in Tuscany, Calabria, Veneto and Lazio, including the country capital Rome.
Media (1, 2, 3), WMO
SPAIN
• Damage along the north-western coast by high waves (13 m, media) on 2-3 February.
• One missing in Foz (Galicia).
• Another storm may cause renewed high winds and waves along the north-western coast on 4-6 February.
Media (1, 2), Aemet
MeteoAlarm for 5 Feb (Red and Orange) (as of 4 February, 12:00 UTC)
Orange Alerts
Red Alerts
Rain
Thunderstorms
Avalanche Risk
Wind
Coastal Events
Snow
Weather Events - Symbols
Floods
Rain
Snow
Wind
High waves Storm Surge
24h acc. rain observed on 3-4 February (WMO)
Storm Surge (JRC)
1.00 - 2.00 m
0.50 - 1.00 m
0.05 - 0.50 m
Color scheme adopted does not represent a corresponding risk ,it is only indicative.
Dublin
IRELAND
UK
London
Paris
FRANCE
SLOVENIA
Ljubljana
Zagreb
CROATIA
ITALY
Roma
Madrid
SPAIN
Lisboa
PORTUGAL
Atlantic Ocean
Mediterranean Sea
Landes
Foz
0 250 500 1.000 Km
Copyright, European Union, 2014. Map created by EC-JRC. The boundaries and names shown on this map do not imply official endorsement or acceptance by the European Union.



2.2.3 *Storms, Medicanes and high winds*

Many studies of extreme weather events focus on the effect of high winds, since this type of events often has severe and damaging consequences for infrastructure. However, the reanalysis of the data concerning past trends seems to point to not totally convergent conclusions: "*A single study for the period 1871 to 2008 using global reanalysis data suggests an increasing trend in storminess (defined as above 95th annual percentiles of daily maximum wind speeds) across western, central and northern Europe, with storminess in the Northern Sea and the Baltic Sea region reaching its peak values towards the end of the 20th century*"[15]

Other reanalysis studies, based on high-resolution model-generated historical footprints, suggest a decline of wind storms, with much of the change attributed to the North Atlantic Oscillation.

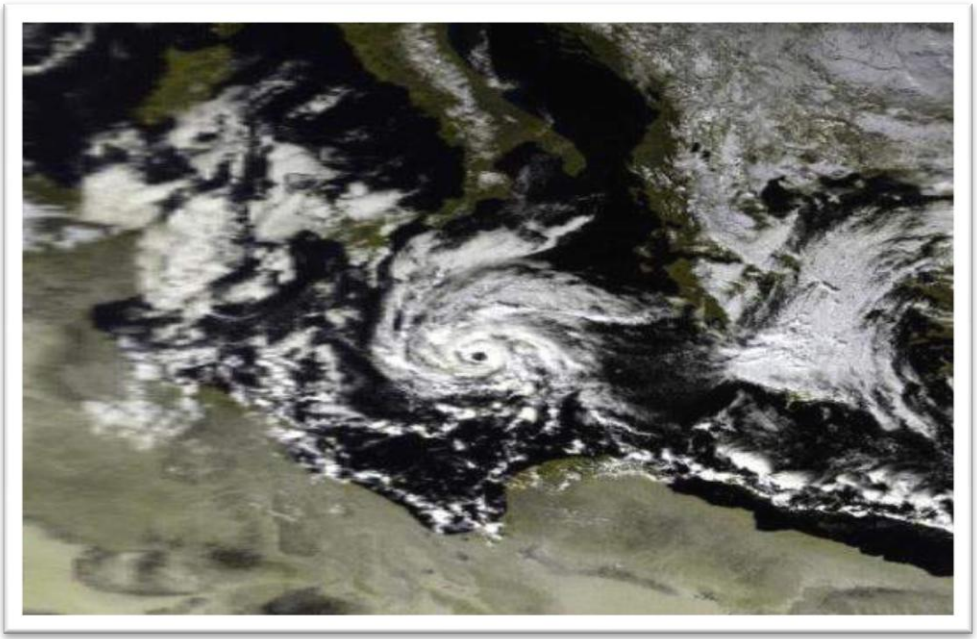
Studies have also addressed "Medicanes", the name attributed to Mediterranean tropical-like cyclones. These are serious events, even if relatively rare, and only in recent times they have been given more attention: "*Recent simulations based on CMIP5 data concludes that an eastward extension of the North Atlantic storm track towards central Europe, with*

[15]European Environment Agency « Climate change adaptation... " Report n.15/2017 – chapter 3.page 62

an increase in the number of cyclones in central Europe and a decreased number in the Norwegian and Mediterranean Seas."[16]

A comprehensive review study covering the North Atlantic as well as northern, north-western and central Europe shows large consensus among models. They perceive that the intensity of winter storms will increase in all European regions over the 21st century. Another recent study, focusing on central Europe, has concluded that models forecast an increased frequency and intensity of severe storms over central Europe.

Satellite imagery of a well-documented Mediterranean tropical-like cyclone on 16 January 1995



By NOAA / Satellite and Information Service - http://www.class.noaa.gov/Inventory ID: 2862083, Dataset Name: NSS.GHRR.NJ.D96281.S1202.E1349.B0912930.GC, Public Domain, https://commons.wikimedia.org/w/index.php?curid=1487397

2.3 Healthcare sector vulnerability awareness in Europe

A search for European studies and reports concerning climate related risks to the healthcare sector and the need for assessing the vulnerability of the sector, uncovers a complex set of characteristics.

The 2017 report of the EU Joint Research Centre concerning the "key criteria for adaptation to climate change in local plans"[17], indicates the critical infrastructure that should be considered in local plans for adaptation actions.

Table 1 reports the evaluation expressed by IPCC (Intergovernmental Panel on Climate Change), EEA (European Environment Agency), JRC, CID (Critical Infrastructure

[16] Ibidem – page 63

[17] JRC Technical Reports – 2017 "Covenant of Mayors: key criteria for adaptation to climate change in local plans"

Directive), and CoM (Covenant of Mayors). It gives a surprising result: the CoM dismisses the necessity to include healthcare systems in local plans for adaptation to climate change.[18]

Table 1. Critical infrastructure assets.

	IPCC	EEA	JRC	CID	CoM
Water facilities:		X	X		X
- Sanitation	X				
- Drainage	X				
Waste treatment facilities			X		X
Energy:		X			
- Power generation	X		X	X	X
- Power distribution networks	X		X	X	X
Heavy industries:					
- Metal			X		
- Chemical			X		
- Mineral + refineries			X	X	
Transport:					
- Roads	X		X	X	X
- Railways	X		X	X	X
- Airports	X		X	X	
- Ports			X	X	X
- Bridges	X				
- Island waterways			X	X	
- Pipelines			X	X	
- Ocean and short-sea shipping				X	
Communication technologies	X				
Security:				X	
- Policy forces	X				
Education			X		X
Healthcare systems:			X	X	
- Hospitals	X				
- Clinics	X				
- Emergency services	X	X			

Source: own elaboration.

The above Table is included to provide evidence of the lack of interest by the Covenant of Mayors for health infrastructure. It will be underlined in the final part of this report how this is an issue that is relevant at EU level and should be tackled.

The general approach of the Covenant of Mayors and of JRC seems to have somewhat relevant difference, with the latter having a more holistic approach, due in part to the fact that "Covenant of Mayors" was created having the focus on energy sustainability, as they were the "Sustainable Energy Actions Plans- SEAP" that the Mayors were requested to produce.

[18] https://ec.europa.eu/jrc/en/publication/covenant-mayors-key-criteria-adaptation-climate-change-local-plans

Only recently the broader issues of environment sustainability were introduced in their agenda. The JRC has been created with a broader vision and tasks.[19]

Our desktop survey of climate-related risks to healthcare infrastructure and associated levels of vulnerability covers hospitals, clinics and emergency services (the same categories as in Table 1), and was carried out using a range of key words in English and French. The conclusions from the survey are as follows:

a. There are several data sources concerning climate change-related damage and disruption. A key resource is the European Environment Agency (EEA). Many studies are based on the data provided by EM-DAT, The International Disasters Database, located in Belgium at the Centre for Research on the Epidemiology of Disasters (CRED), which was created it in 1988 with the initial support of the World Health Organisation (WHO) and the Belgian Government.

b. Reports and studies in this area take a variety of approaches, with some focusing on risk reduction measures, while others focus on evaluating economic impact or likely future scenarios, using statistics to evaluate different types of possible future disasters[20]. An example of the latter type of study is that carried out by a team from Newcastle University and the Willis Research Network, published in Environmental Research Letters: "Future heat-waves, drought and floods in 571 European cities".

c. A significant number of studies look at past disasters from the point of view of the health impact on the population, extending the studies of immediate effects also to the incremental and medium-long term consequences. One such study, published in December 2017 by Bio-Med Central in the category of Environmental Health, reports on the "Impact of extreme weather events and climate change for health and social care systems".[21]

The research was commissioned by the Research Councils UK Living With Environmental Change (LWEC) programme. The focus was the impact on social care systems in the UK of extreme weather events related to climate change, using evidence concerning past events to extrapolate to expected future impacts. The study is focused on the UK situation, but potential preparedness and adaptation measures are believed to be of international relevance.

The significance of this study is that it is one of the very few which includes analysis of the effects on health infrastructure:
"*Extreme weather events impact the operation of health services through the effects on built, social and institutional infrastructures which support health and health care, and also because of changes in service demand as extreme weather impacts on human health.*

[19] https://ec.europa.eu/jrc/en/publication/resilience-large-investments-and-critical-infrastructures-europe-climate-change
[20] "Increasing risk over time of weather-related hazard to the European population: a data-driven prognostic study" – www.thelancet.com/planetary-health Vol 1 August 2017
[21] https://www.ncbi.nlm.nih.gov/pubmed/29219105

Strategic planning for extreme weather and impacts on the care system should be sensitive to within country variations. Adaptation will require changes to built infrastructure systems (including transport and utilities as well as individual care facilities) and also to institutional and social infrastructure supporting the health care system."

In conclusion, from the desktop survey of extant studies it is clear that health facilities are almost never taken into consideration when considering the impact of climate change-related extreme weather events. The exception appears to be the above reported research, and a study dated 2005 of WHO-European Observatory "Extreme Weather Events and Public Health Responses". The report briefly mentions that "There are issues with **healthcare facilities** being overly stretched at times of disasters, and the fact that this will adversely impact normal service delivery, and not just on the healthcare provision for the disaster victims themselves. "[22]

Many scientific studies lead to the conclusion that climate change will increase the frequency and also the magnitude of extreme weather events and increase the risk for healthcare services as well.

The next section will examine what exists and what is missing with regard to guidance tools for hospitals in assessing climate related risks and in adopting the necessary strategies to become resilient.

The European Environment Agency has stressed in its publications that one of the difficulties in generically addressing the problems related to natural disasters comes from the fact that European Countries vary widely in their geographic characteristics, as well as in social conditions. There are consequently difficulties in finding common interests, especially in projects of prevention and definition of measures for adaptation.

The risks are not distributed evenly across Europe and frequently they don't derive from the same cause. When the risks involve multiple countries a common approach to mitigation is put in place as demonstrated by the "International Commission for the Protection of the Danube River" that has been able to make a "Flood Risk Management Plan for the Danube River Basin District", essential for coordinating the Plans of the involved Countries.[23]

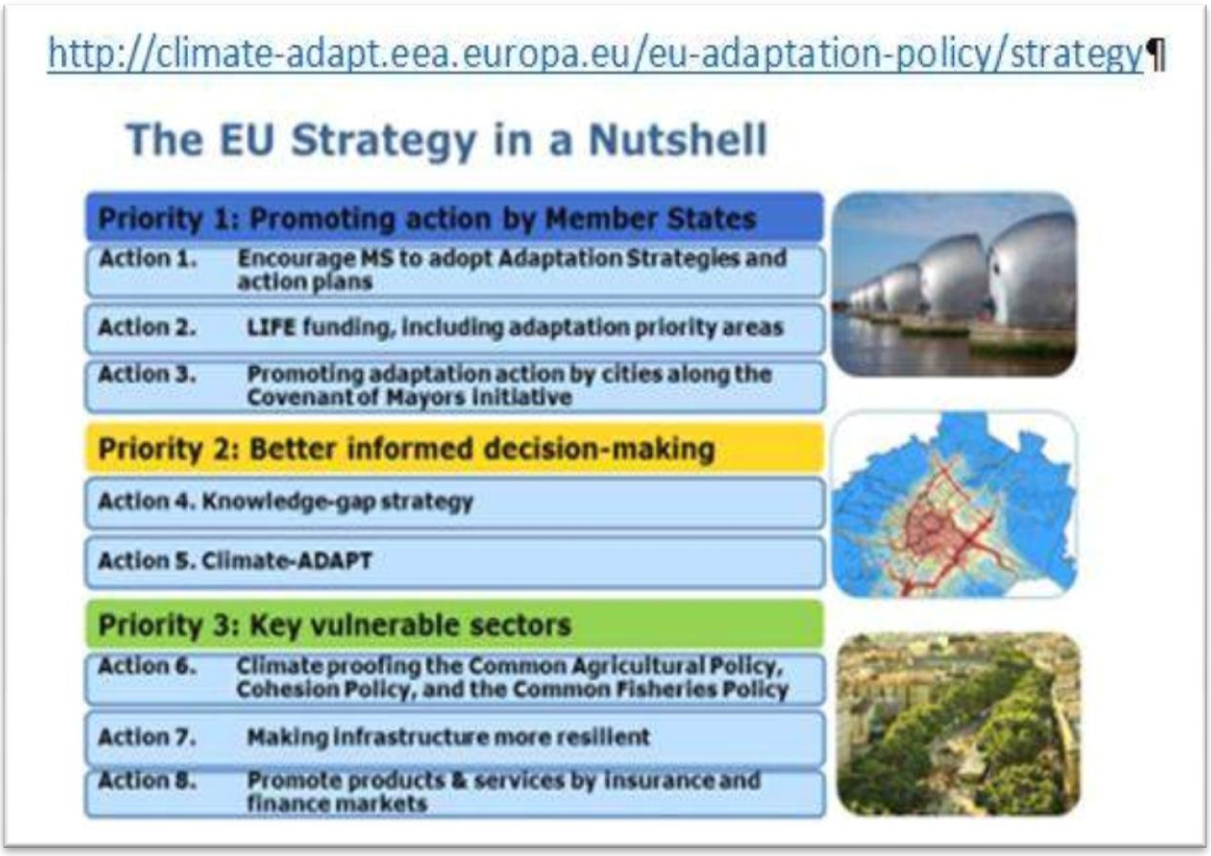
The European Environment Agency EEA, however does produce major tools, the most relevant of which are:

- the European Climate Adaptation Platform Climate-Adapt, dedicated to "*sharing adaptation information across Europe"*. This platform presents a strategy for adaptation to climate change[24]
- EIONET, "The European Environment Information and Observation Network"[25]

[22] WHO Regional Office for Europe- dated 2005 " Extreme Weather Events and Public Health Responses"
[23] https://www.icpdr.org/main/sites/default/files/nodes/documents/1stdfrmp-final.pdf
[24] http://climate-adapt.eea.europa.eu/eu-adaptation-policy/strategy
[25] http://www.eionet.europa.eu/

A deep analysis of the documents produced by these two agencies shows evidence of the difficulties involved in constructing a common front for the mitigation of climate-change related natural disasters. The most evident factor is the jointly acknowledged variance in Member States' prioritisation of the importance of developing awareness and strategies for adaptation. There is also an issue in relation to language barriers, which may constitute an objective obstacle to the diffusion of knowledge and experience.

Currently the core issues being highlighted by SIAIS in this study do not have a point of reference in the structures of the EC for high-level coordination, as shown in the following Figure.



Note that Priority 1 – Action 3 of the EU strategy for Climate Adaptation – is entrusted to the initiative of Covenant of Mayors. However, as we suggested in Table 1, the IRC (the official research institute of the EU) has highlighted the lack of importance given by the Covenant of Mayor to health infrastructure in this regard.

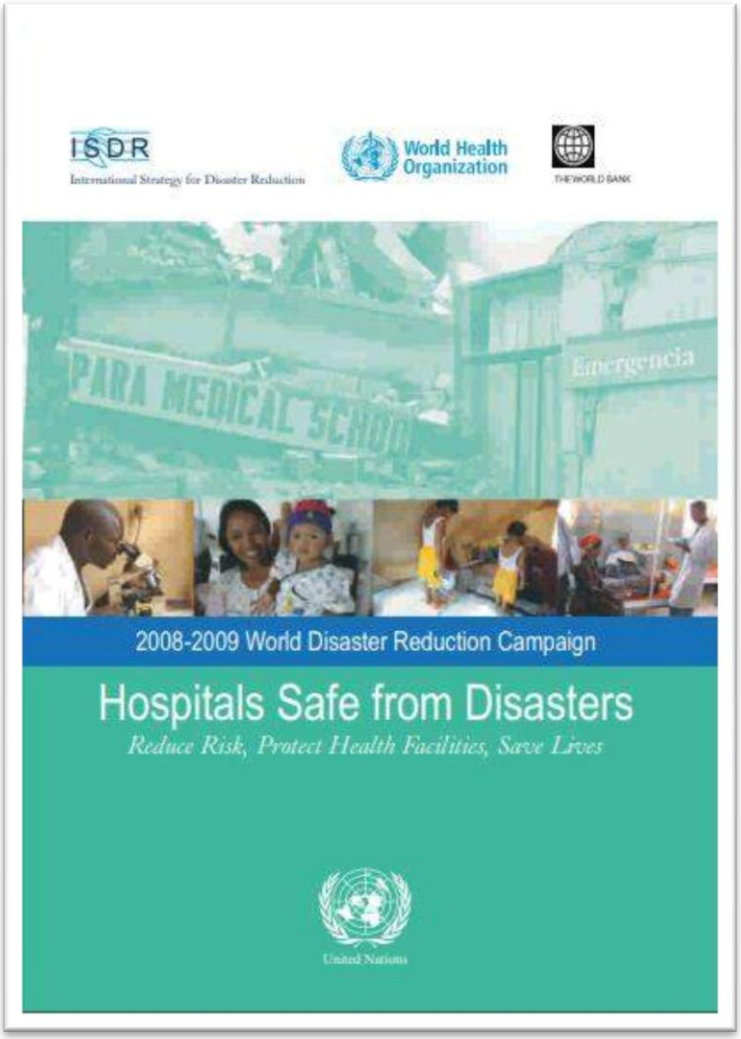
The next section concerns evidence of the awareness of the role played by healthcare facilities, mostly hospitals, in relation to climate change mitigation.

3. Worldwide methods and tools development for mitigation and disaster risk reduction

3.1 Conceptual framework

In this section we examine, from the perspective of international authorities and other, non-European countries, what has been produced in terms of attention to: 1) the role and 2) the needs of healthcare facilities, specifically hospitals, to face the problems created by climate change.

In the framework of the "2008-09 Disaster Reduction Campaign", the United Nations with WHO, the World Bank and the International Strategy for Disaster Reduction (ISDR), launched a campaign called "**Hospitals Safe from Disasters**".

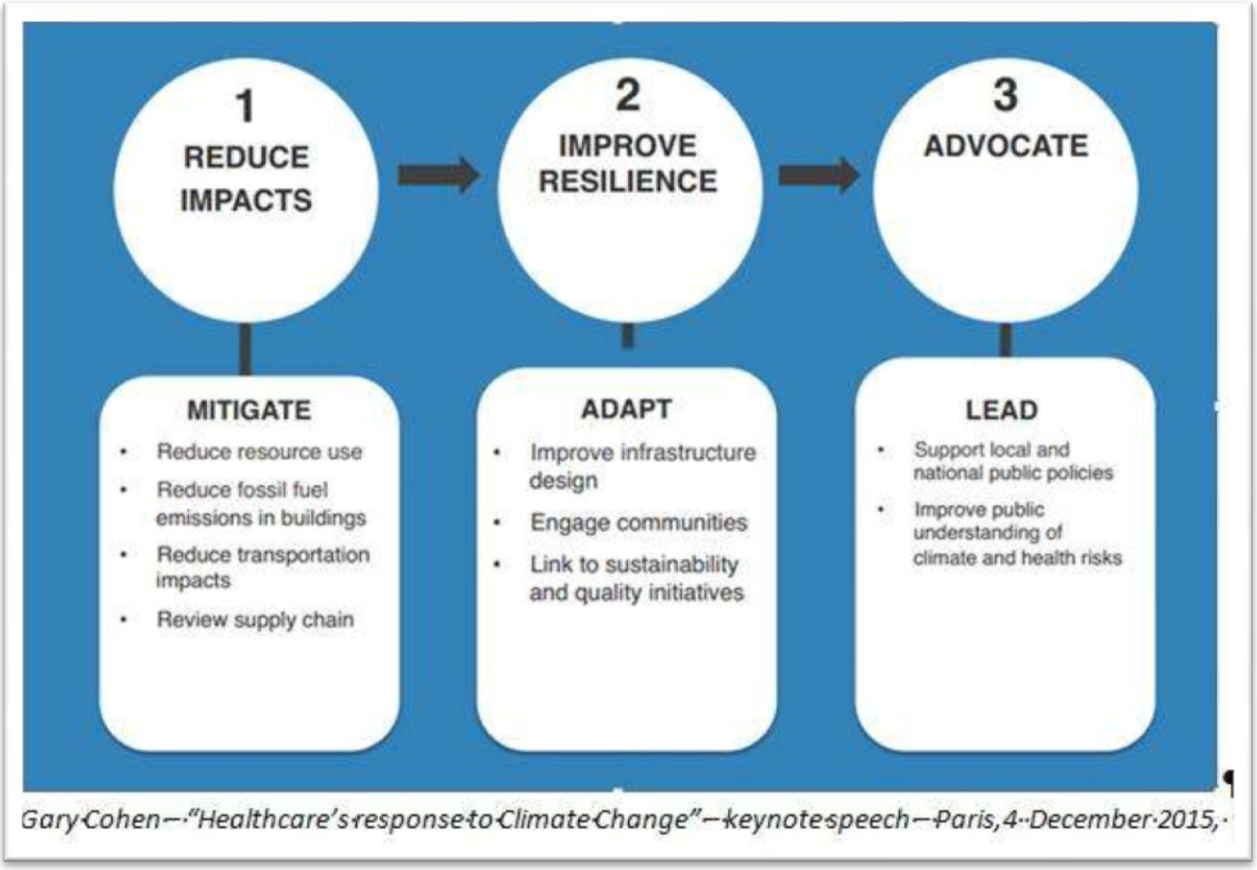


The key message from Mr Sálvano Briceño Director, International Strategy for Disaster Reduction, titled "A safety net for everyone, at all times" states:

"*When disasters strike, aid agencies, communities, the media, and governments focus immediately on the victims. But, if our focus on victims is to have real meaning, we must prioritize a deeper understanding and support of medical care. Those who are injured need urgent medical attention, but those who escape injury have not escaped the long-term need for medical care and public health after the disaster is forgotten. When health services and hospitals fail due to disaster, people die and suffer needlessly both during the disaster and long into the future … As disaster risk reduction is everyone's business, and unsafe hospitals are potentially damaging to everyone, I would like to call on all members of our global community – decision makers, decision implementers and the public at large – to join the Campaign."*[26]

This statement raises an important question: what are, and what may be, the roles that hospitals can play with regard to natural disasters related to climate change?

Garry Cohen, President and Co-Founder of HCWH (Health Care Without Harm) in a presentation of 2015 in occasion of events related to the COP 21 (Conference of Parties) of Paris, answered the question about the role of hospitals, by pointing out three fundamental sectors for reacting to the major challenge of our times posed by climate change.[27]



Gary Cohen – "Healthcare's response to Climate Change" – keynote speech – Paris, 4 December 2015,

[26] https://www.unisdr.org/2009/campaign/pdf/wdrc-2008-2009-information-kit.pdf

[27] www.noharm.orgHealth Care Without Harm Org. Archives Garry Cohen presentation – Paris 4th December 2015 –

There is no doubt that the healthcare system, and hospitals in particular, have to be involved in all three aspects. As underlined by many studies, including the EU project RES-Hospitals, in which SIAIS was one of the partners and the project manager was the main researcher of the present study, health facilities can give a significant contribution to reducing GHGs emissions and to diffuse the renewable energy systems use. On the other hand, hospitals can also play a role in community education and increase awareness of the importance of environmental sustainability.

Research suggests that the most important contribution that health facilities need to give to their communities is to be safe, in condition to operate and give complete support, even when communities are hit by natural disasters. In other terms, to be **resilient.**

3.2 US and Canadian Documents

3.2.1 *Community oriented toolkits*

The National Oceanic Atmospheric Administration US has produced a "U.S. Climate Resilient Toolkit" that is not specifically oriented to health facilities, but has a general methodological value, summed as follows: "Individual, businesses and communities all face challenges related to our changing climate. The steps to Resilience can help you to identify your vulnerabilities and select actions to address them"[28]

This toolkit identifies a "smart approach" to protect community values and the investments, which can also boost local economies, create jobs, and improve the health of local ecosystems. When the community is ready to make the passage from talking to acting, the document indicates the following guiding steps:

Step 1: Explore Climate Threats	Build a team, explore your regional climate trends and projections, and consider if things you value are threatened by climate.
Step 2: Assess Vulnerability & Risks	Determine which of your assets are most likely to be damaged or lost to climate impacts. Decide if you can tolerate the risk.
Step 3: Investigate Options	Brainstorm possible solutions and explore what other groups have done. Narrow your options to a list of actions stakeholders are willing to support.

[28] https://toolkit.climate.gov/content

Step 4: Prioritize Actions	Consolidate actions and determine the best sequence to protect your full range of assets. Align your resources to focus on your largest risks.
Step 5: Take Action	Implement your plan and monitor your results. Modify your approach as needed.

The document gives detailed guidance about each step with the final recommendation:

- Identify further ways to improve the planned actions;
- Document and share the entire Steps to Resilience process.

3.2.2 *US Department of Health and Human Services Initiative*

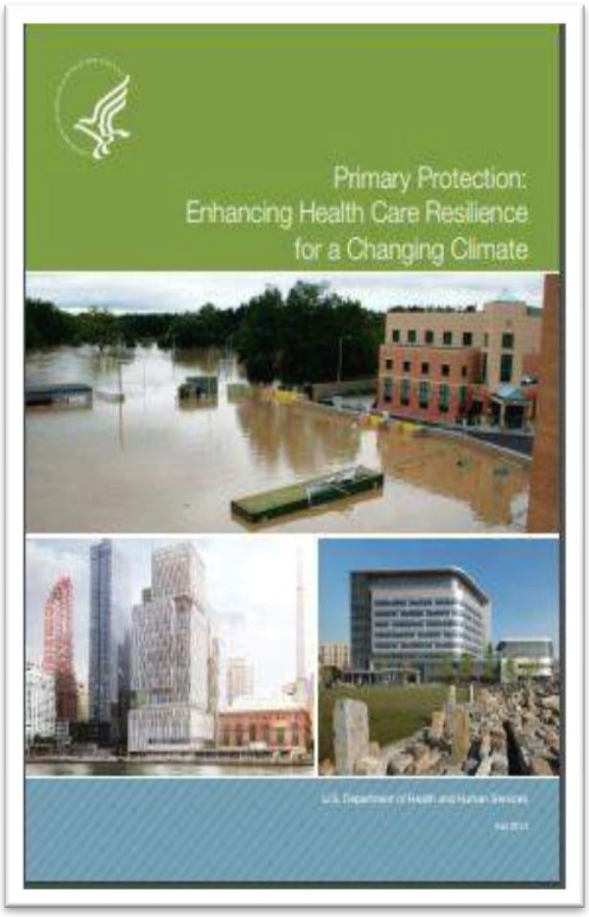
This branch of the US Government has produced a comprehensive study[29], which is composed of 5 "elements"[30], each one with a check list. The title is "Building Health Sector Climate Resilience"

Element 1 – Climate Risks and Community Vulnerability Assessment
Element 2 – Land Use, Building Design and Regulatory Context
Element 3 – Infrastructure Protection and Resilience Planning
Element 4 – Essential Clinical Care Service Delivery Planning
Element 5– Environmental Protection and Ecosystem Adaptation

Each element is divided into steps and resources and is completed with a detailed check list.

The study is complemented by a publication titled "Primary Protection: Enhancing Health Care Resilience for a Changing Climate - A Best Practices Document under the HHS Sustainable and Climate Resilient Health Care Facilities Initiative".[31]

[29] https://toolkit.climate.gov/topics/human-health/building-climate-resilience-health-sector
[30] https://toolkit.climate.gov/sites/default/files/SCRHCFI%20Resource%20Sheet%20Composite%20082615.pdf This link give access to the 5 elements
[31] https://kresge.org/sites/default/files/Healthcare-Climate-Resilience-Guidance-HHS.pdf



The publication analyses the "*Current State of Health Care Infrastructure Climate Resilience to Extreme Weather Risks*" and then proposes solutions for future infrastructure that may improve health care climate resilience. It also draws some key lessons from "*reviewing post-disaster health care failures and evacuations".*

This study reports several other case studies concerning the US, and its conclusions are interesting:

"*Measurement of resilience is important but elusive.* ***Establishing metrics is imperative if progress is to be measured. Any effort to compare benefits of increasing resilience with the costs of improvements requires a basis of measurement.*** *At the moment, there is no unified, consistent metric for measuring resilience of health care infrastructure. Resilience is not something health care organizations are experienced with measuring. However, many organizations have attempted to measure resilience, or vulnerability, for the U.S. using both community-based, bottom-up approaches and top-down, centralized measurement.*

For example, the Coastal Resilience Index provides an example of a community-based approach to a self-assessment process to derive an index of resilience to storm events. The results are a Low, Medium, and High rating on specific elements, such as critical infrastructure, which are then correlated to produce an overall state-of-the-community

resilience score, along with an estimate of the time it would take for reoccupation of the community following a disaster." [32]

The table with the five steps, to which it refers, is reported above and the link is in note n.30.

3.2.3 *The Canadian contribution: healthcare facilities resilient to the impact of climate change*

The edition of the International Journal of Environmental Research and Public Health published in December 2014, through the Multidisciplinary Digital Publishing Institute (MDPI), is one of the most informative documents on the impacts of climate change on health facilities, as based on the Canadian experience[33]

The publication starts by underlining the fact that "*climate change will increase the frequency and magnitude of extreme weather events and create risks that will impact health care facilities. Health care facilities will need to assess climate change risks and adopt adaptive management strategies to be resilient, but guidance tools are lacking*". The situation reported by the study in December 2014 is still basically the same, especially in Europe, as we have reported.

Information is not lacking, but the guidance is still fragmented and with that the awareness of the necessity for action, as well as consideration of the costs associated with the impacts of disasters, compared with interventions which improve resilience. The document is focused on describing "*the methods undertaken to produce a climate change resiliency assessment toolkit for use by health care facility officials"*. The toolkit consists of:

(1) a checklist for officials who work in areas of emergency management, facilities management and health care services and supply chain management;
(2) a facilitator's guide for administering the checklist; and
(3) a resource guidebook to inform adaptation.

It might be questioned whether this publication has in reality produced a 'toolkit' or 'guidance', but in either case the tables included in the text are a very useful contribution, especially Table 1, "*Climate change resiliency indicators for health care facilities*" at least as an effort to start on the path toward a toolkit flexible, according to specific local conditions and comprehensive.

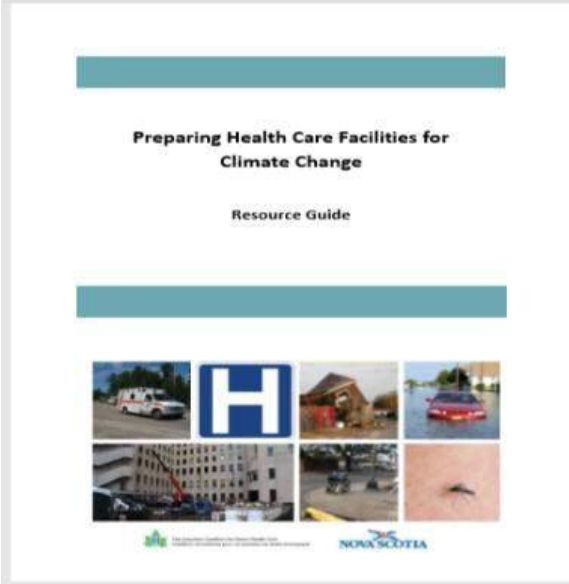
A complementary set of documents is provided by the "Canadian Coalition for Green Health Care" with the title Health Care Facility Climate Change Resiliency Toolkit[34].
This is composed of three components:

[32] https://kresge.org/sites/default/files/Healthcare-Climate-Resilience-Guidance-HHS.pdf
[33] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4276665/
[34] http://www.greenhealthcare.ca/climateresilienthealthcare/

Facilitators Guide
The Facilitators Guide is a presentation which facilitators can tailor to the specific needs of their health care facilities. The presentation outlines instructions for conducting the resiliency assessment and can be used to facilitate the assessment discussion, engage facility officials, and capture information.

Assessment Checklist
The checklist includes questions in many areas, such as: emergency management, facilities management, health care services and supply chain management. Completion of the assessment checklists by officials with knowledge and experience in these areas will increase awareness and inform resiliency activities.

Resource Guide
The Resource Guide is intended to be an educational resource for those looking for more information about climate change, health care, and resiliency. It provides summaries and references for a wide range of accessible resources on topics including emergency management, supply chain management, health services, facilities management and infrastructure.



3.3 Australia's National Adaptation Research Plan

The documentation provided by the Australian Government and other Australian public bodies deals indirectly with health facilities. The "National Climate Change Adaptation Framework"[35] is notable for the comprehensiveness of its goals:

- Support decision-makers with practical guides and tools to assist in managing climate change impacts.
- Establish a new centre for climate change adaptation to provide decision-makers with robust and relevant information on climate change impacts, vulnerability and adaptation options.
- Provide, for the first time, climate change projections and regional scenarios at scales relevant to decision-makers.
- Generate the knowledge to understand and manage climate change risks to water resources, biodiversity, coasts, agriculture, fisheries, forestry, human health, tourism, settlements and infrastructure.
- Work with stakeholders in key sectors to commence developing practical strategies to manage the risks of climate change impacts.
- Assess the implications of climate change and possible adaptations for important regions such as the Murray-Darling Basin, south-west Western Australia, the tropical north, and the drying regions of eastern Australia.

[35] http://www.environment.gov.au/climate-change/adaptation/publications/national-climate-change-adaptation-framework

3.4 The World Health Organisation (WHO)

The World Health Organisation has published in 2015 relevant documents, some of them already reviewed in the first version of this study. More documentation from WHO was brought to the attention of this research group by the Secretary of International Federation of Health Engineering of Europe, who has participated to the working team of WHO, that has been tackling the issues related to hospitals safety for many years in the framework of the programme "Safe hospitals Initiative". The "Comprehensive SAFE HOSPITAL FRAMEWORK" makes the precision that the framework "*takes into account the critical role that different types of health facilities play in ensuring a safer health systems ...*" [36]

In this report it will be highlighted the documentation published, as said above, in 2015, however taking into account that the major study/contribution, that is the "Hospital Safety Index – Guide for Evaluators" was published originally in 2008 by WHO and PAHO, the Pan American Health Organisation. The one that we will review, published in 2015 is, in fact, as labelled "second edition".

We will start to examine the contribution of WHO that seems closer to the subject of our research, that is hospitals resilience. Then we will present the substantial "safe hospitals" contribution of WHO, which has been a fundamental contribution in indicating possible lines of action to be taken into account in the near future work of IFHE-EU.

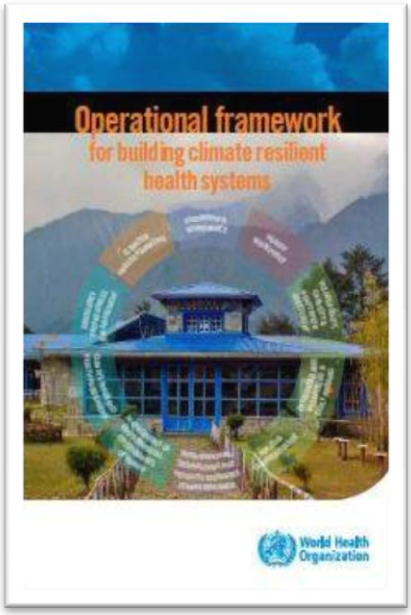
3.4.1 *Operational framework for building climate resilient health systems*

The first publication of WHO presented here is the most general one, which goals and objectives are "*to provide guidance for health systems and public health programming to increase their capacity for protecting health in an unstable and changingclimate".* [37]
It is clear that the contribution of the work is especially focused on highlighting concepts and the general aim is to provide precisely an holistic understanding of the actions that need to be undertaken. One of the most important concept introduced is the one of resilience:

"In the simplest terms, resilience refers to the holistic ability and agility of a system to change and flex − according to circumstances − and continue to function under stress, while undergoing change. Resilience is much more than just the absence of vulnerability; it is about whole system capacity …. With regard to health, resilience relates to the capacity of the system itself to cope with and manage health risks in a way that the essential functions, identity and structure of health systems are maintained. While health adaptation seeks to moderate harm or exploit beneficial opportunities, the preservation of a certain level of quality and sustainable performance of the system itself is not ensured. The incorporation of a climate-resilient approach to health systems contributes to assuring the performance of the

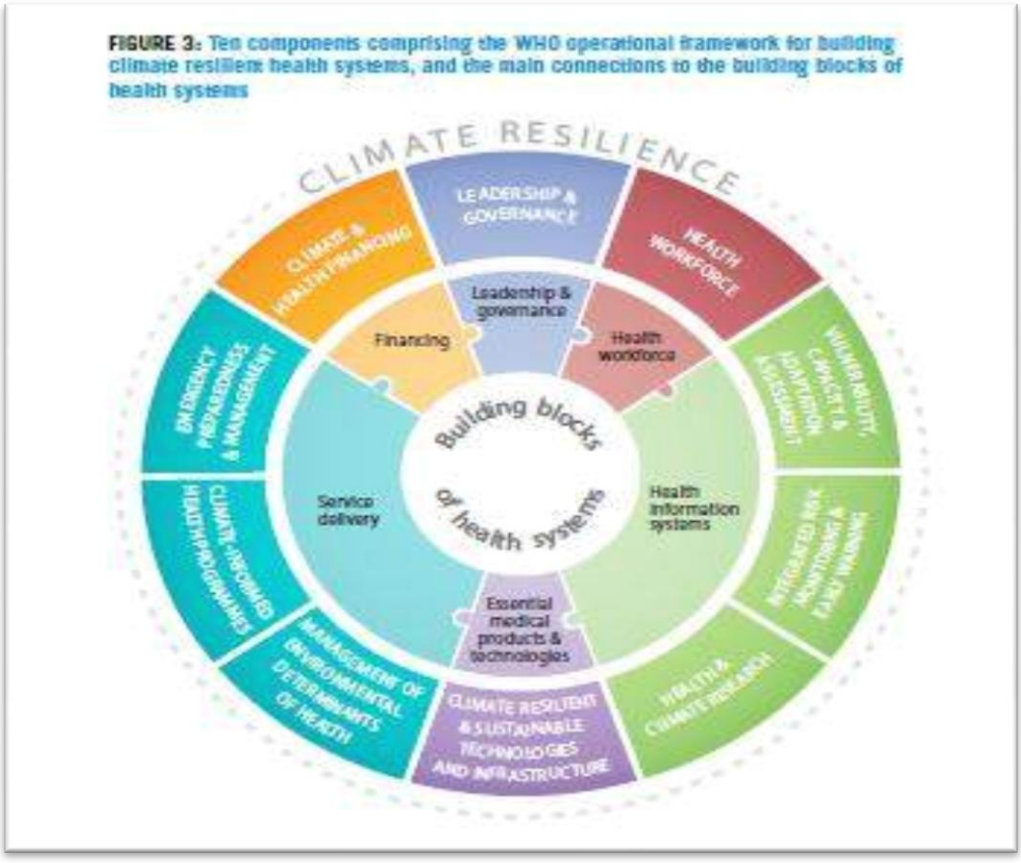
[36] Comprehensive SAFE HOSPITAL FRAMEWORK – page 1.
http://www.who.int/hac/techguidance/comprehensive_safe_hospital_framework.pdf
[37] http://www.who.int/globalchange/publications/building-climate-resilient-health-systems/en/

system, and therefore, the sustainability and maximization of value for money of health investments.



However, it is important to remember that maintaining system resilience may not always be possible. The magnitude of climate-induced changes or shocks may be so significant that it is outside human abilities to maintain its essential functions, and thus the system may collapse or fail."

The study suggests that the resilience approach applied to health systems is composed of ten components visualised in the following figure:



d

Each one of the components is analysed in the study. The component 6 "Climate resilient and sustainable technologies and infrastructure" enters in the area of interest of our work.

The contribution that WHO publication gives is, also in this case, conceptual and systemic. It suggests also in this case in "simplest terms" which are the aspects to be taken into account to enhance climate resilience "*through the use of new technologies or approaches for better delivery of health interventions, particularly through the use of information technology*"[38]

The conclusions help to understand what is and can be the usefulness of this contribution for the goals of this study.

"Climate change, interacting with a range of other factors, places increasing stress on health. The structured framework presented here aims to ensure that health systems provide a comprehensive, efficient and equitable response, and ultimately continue to protect and improve population health in light of the varied current and future risks presented by climate variability and climate change. This approach is grounded in the core functions of the health sector, but linked to the wider environmental and social determinants of health. In addition to changes in climate and other environmental and social determinants of health, health systems themselves are also changing rapidly. For this reason, the framework should be implemented in a flexible way to take into account different country contexts, and iteratively, take advantage of new evidence, experience and lessons learned from within and outside the country, as well as changing circumstances. Applied in this way, climate resilient health systems can help to promote and safeguard the provision of Universal Health Coverage, and make an important contribution to overall sustainable development."[39]

3.4.2 *WHO - Hospital Safety Initiative - "Comprehensive SAFE Hospitals Framework"*

This short publication, issued in 2015, as the others, is relevant to understand the complex of the work labelled "Safe Hospitals Initiative". It is, in fact, appropriately called "Framework". WHO basically draws from over twenty years of action, together with some partners, in promoting safe hospitals programmes. The publication shows that the focus of the action have been especially the countries around the world where hospitals were and are directly exposed and hit by major disasters that have occurred and are continuously occurring, not only climate change directly related, which are the representing the issues addressed by this study, such as floods, wind storms etc, but long lasting effects of climate change such as drought, ocean raising level and basically all natural calamities such as earthquakes, wars and violence etc.
The publication highlights with clear and efficient arguments the importance of hospitals safety, stresses that: "*Measures to ensure the safety, security and functionality of health infrastructure are needed at both national and community levels. Countries and communities need to prioritize the protection of new and existing hospitals and other health facilities from*

[38] Ibidem pages 25-26
[39] Ibidem: Conclusions page 49

identified hazards and should ensure the physical integrity of buildings, equipment and critical hospital systems "[40].

The document make reference to the United Nations conference of 2005 in Hyogo, Japan on Disasters (Risk) Reduction, that produced as conclusion a document called "Hyogo Framework for Action 2005-2015"[41].

It is also explicated that the document is addressed not only to the health policy makers, but also to Governments, Regional and Local Authorities, Financial Institutions.

This is well represented in the following scheme:

In addition to the well defined role of the hospitals, considering the target audience of the document, it is relevant for our study to point out the relevance of the clear and precise form of exposure of a safe hospital programme perceived components.

Few comment to the figure that follows: all the four points are important.

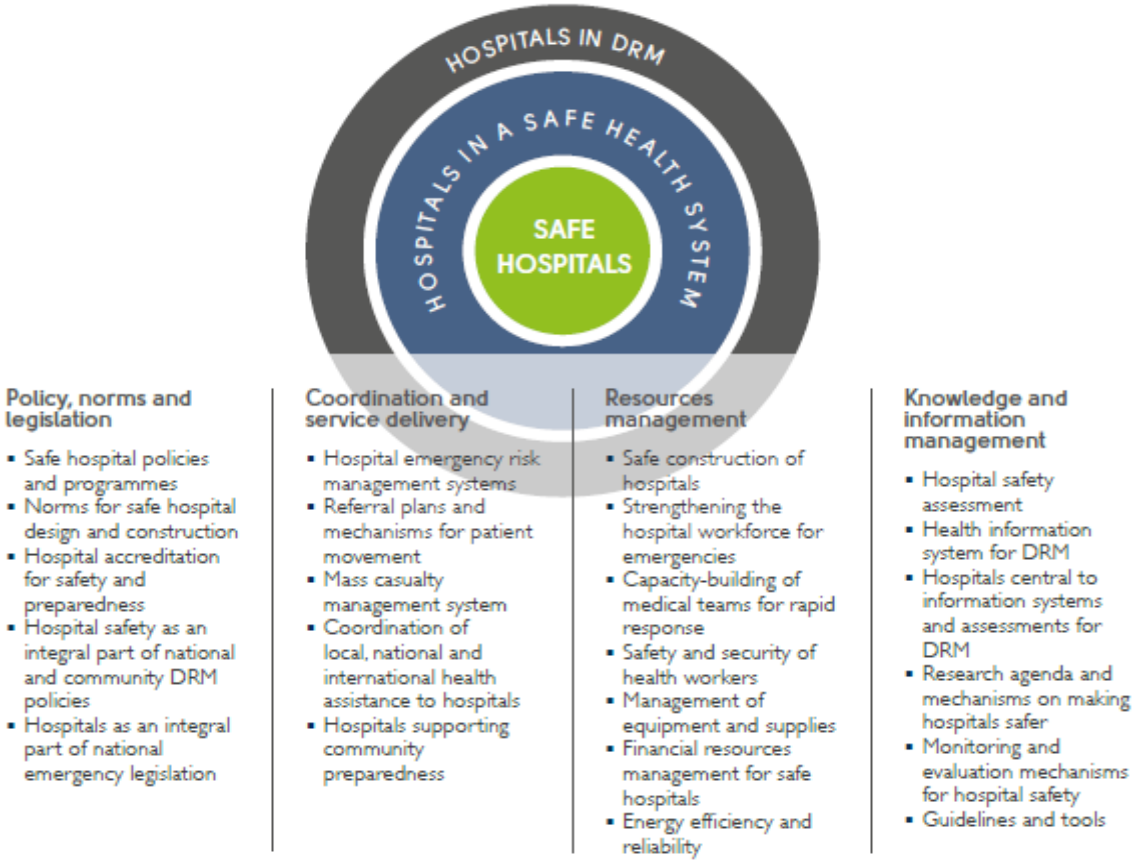
From the analysis exposed in previous paragraphs of this report regarding the low level of attention paid up to know, to the strategic role of hospitals in Europe by the top institutional levels, it is important to focus the attention of our associations on the "knowledge and information management" that should start with a deeper awareness among all levels of hospital's staff and in the health systems of Europe, of the reality our continent a is not a free of risks related to climate change.

Furthermore it has to be universally recognised the need that hospitals "*function both as individual entities and as part of the larger response mechanism in emergency*".

[40] http://www.who.int/hac/techguidance/comprehensive_safe_hospital_framework.pdf - page 1

[41] https://www.unisdr.org/2005/wcdr/wcdr-index.htm -UN International Strategy for Disaster Risk Reduction Hyogo Framework for Action 2005-2015 - PdF

FIGURE 1. COMPONENTS OF THE SAFE HOSPITAL PROGRAMME



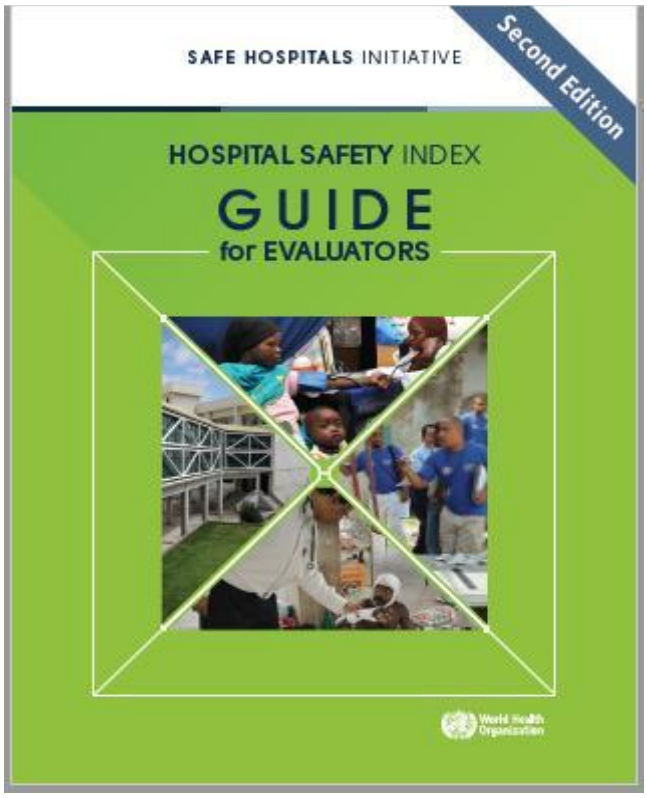
In the *Progress to date* (year 2015) the document stresses that: "*seventy-seven countries across the world have reported that they are implementing safe hospital activities.... . The safety and preparedness of over 3500 facilities have been assessed and action has been taken to implement recommendations to make hospitals safer and better prepared for emergencies."*

As pointed out before, there are elements in the document that seem to be focused on areas of the world outside Europe.
The partnership with the Pan American Health Organisation for the first step of the work published in 2008 is an indication, as well as the training programmes finalised to increase the capacity of hospital staff. They have been conducted, in fact, in South-East Asia and more recently in some of the most deprived nations of Africa.
The "risks" taken into account include the largest possible risks, and among others "risks related to climate change". This makes the document valuable also for this specific research and we identify a commune goal in one of the four major expected results of WHO programme, that is: "*Hospitals (should be)recognized as critical and high-priority assets for communities, and as main stakeholders in and contributors to building societies that are safer and more resilient to emergencies and disasters*" [42] As said before, the WHO activity represents a contribution to define also actions needed to be pursued in Europe.

[42] http://www.who.int/hac/techguidance/comprehensive_safe_hospital_framework.pdf-pages 2/7-5

3.4.3 *Hospital Safety Index - HSI – Guide for Evaluators*

The most significant work of WHO in the framework of the "Safe Hospitals Initiative" is constituted by the "Hospital Safety Index – GUIDE for EVALUATORS".
The second edition published in 2015, as stated before, is the one that is presented and analysed in this report.



The breadth of the work that WHO and its partners have undertaken and conducted for decades and the methodology in producing this second edition, makes the results worth of full attention, even if they cover an variety of risks much larger than the scope of the present study and report and the raising of climate change related risks in Europe will certainly have particular, geographic, socio-economic, historic and infrastructural characteristics and will require studies and strategies tailored taking into account those specificities.
These remarks, however, don't undermine the great value of what has been produced by WHO and focus on the goal to improving safety and resilience of hospitals and health systems in all contexts in Europe, with that also contributing to the more general goal of WHO of an assessment tool that can be used in all contexts across the world.

The basic purpose of the Guide is defined in Chapter 2 as follows:
"The purpose of this Guide for evaluators is to provide guidance to evaluators on applying the checklist, rating a hospital's safety and calculating the hospital's safety index. The evaluation will facilitate the determination of the hospital's capacity to continue providing

services following an adverse event, and will guide the actions necessary to increase the hospital's safety and preparedness for response and recovery in case of emergencies and disasters. Throughout this document, the terms "safe" or "safety" cover structural and nonstructural safety and the emergency and disaster management capacity of the hospital..." The objectives of this Guide for evaluators are:

- *to give evaluators an objective and standardized approach to applying the Safe Hospitals Checklist, so that they can make an initial determination about whether or not the hospital will be able to function in the immediate aftermath of emergencies and disasters;*
- *to provide standard criteria for elements that will be evaluated in different contexts so that there is a common basis for reviewing the safety and needs of a number of hospitals;*
- *to simplify recording and classifying of information about the strengths and weaknesses found in a hospital, both individually and as part of a health-service network, and communities' capacity to manage emergencies and disasters;*
- *to recommend activities and measures to improve hospital safety and preparedness."*[43]

The fundamental and certainly unique part of the Guide is constituted by the "Checklist" for the evaluation, which structure is presented in session 7 of the document.

The first partition of the evaluation form is:

Form 1. - Deals with the General Information about the Hospital

- General information
- Hospital treatment and operating capacity

Form 2. - Dedicated to the Safe Hospitals Checklist

The checklist is divided into four sections or modules.
The WHO document indicates that Module 1 regards the hazards directly affecting the safety of the hospital and the ones producing effects outside the hospital that should require services in emergency from the hospital. Furthermore it specified that the identified hazards are not included in the calculation of a hospital's safety index. Consequently this report, when giving the full list of the Modules, is focusing in the subsequent three others.

Module 1: Hazards affecting the safety of the hospital and the role of the hospital in emergency and disaster management

Module 2: Structural safety
- 2.1 Prior events and hazards affecting structural safety
- 2.2 Building integrity

Module 3: Nonstructural safety
- 3.1 Architectural safety
- 3.2 Infrastructural protection, access and physical security
- 3.3 Critical systems
- 3.4 Equipment and supplies

[43] http://www.who.int/hac/techguidance/hospital_safety_index_evaluators.pdf page 11

Module 4: Emergency and disaster management

- 4.1 Coordination of emergency and disaster management activities
- 4.2 Hospital emergency and disaster management response and recovery planning
- 4.3 Communication and information management
- 4.4 Human resources
- 4.5 Logistics and finance
- 4.6 Patient care and support services
- 4.7 Evacuation, decontamination and security

In the present summary it is not possible to review the many aspects and passages, as well as the conditions requested or recommended before starting the procedure of evaluation. It will also be impossible to go into the detailed procedures of relative weighing and standardization of items, sections, sub-modules and modules that determine the final safety score attributed to the single hospital.

This report will be aiming to provide evidence of the WHO work importance, its inherent value. It intends also to make emerge some of the aspects of what should be the further work, in terms of a better contextualisation to the European situation, as well as to contribute in making the steps, still lacking, to go from a guide to a comprehensive toolkit.

Module 1 – **Hazards affecting the safety of the hospital**

The document states that " it is used to determine the hazards that may directly affect the safety of the hospital and those for which the hospital may be expected to provide health services in response to emergencies and disasters. Module 1 and the hazard identified are not included in the calculation of a hospital's safety index."
Page 28 of the "Guide" see footnote [43]

For this reason the report will focus of Modules 2 / 3 / 4 , which are the ones dedicated to Hospital Safety

Module 2 – **Structural Safety**

It is certainly of great interest for associations such as IFHE and SIAIS. The document states, in fact, that the issues dealt with in this structural module should be assessed by structural engineers.
It is divided into two sub-modules, namely:

- 2.1 Prior events affecting building safety
- 2.2 Building integrity

All together 18 items are considered.

1. Prior major structural damage or failure of the hospital building(s)
2. Hospital built and/or repaired using current safety standards
3. Effect of remodelling or modification on the structural behaviour of the hospital
4. Structural system design
5. Condition of the building
6. Condition of construction materials

7. Interaction of nonstructural elements with the structure
8. Proximity of buildings (for earthquake-induced pounding)
9. Proximity of buildings (wind tunnel effect and fire)
10. Structural redundancy
11. Structural detailing, including connections
12. Ratio of column strength to beam strength
13. Safety of foundations
14. Irregularities in building structure plan (rigidity, mass, resistance)
15. Irregularities in elevation of buildings
16. Irregularities in height of storeys
17. Structural integrity of roofs
18. Structural resilience to hazards other than earthquakes and strong winds.

To proceed in the evaluation, as we will see also in the other modues, the document point out "*Although not specifically listed here, it is recommended that evaluators always refer to applicable national and local standards and building codes related to Module 2: Structural Safety when evaluating a facility.* [44].

Module 3 – **Nonstructural safety**

It is divided in four sub-models and composed of 111 items to be examined)

3.1 Architectural safety (from item 19 to 33)

3.2 Infrastructure protection, access and physical security (items 34 -37)

3.3 Critical systems (items from 38 to 90)

3.4 Equipment and supplies (items 39 – 111)

Just few examples, for each4 sub-models are:

3.1 Architectural safety

20. Condition and safety of doors, exits and entrances
21. Condition and safety of windows and shutters
22. Condition and safety of other elements of the building envelope (e.g. outside walls, facings)
23. Condition and safety of roofing
24. Condition and safety of railings and parapets

3.2 Infrastructure protection, access and physical security:

34. Location of hospital's critical services and equipment in the hospital in relation to local Hazards
35. Hospital access routes
36. Emergency exits and evacuations routes

3.3 Critical systems (the items from 38 to 90) are divided in 8 sections

[44] http://www.who.int/hac/techguidance/hospital_safety_index_evaluators.pdf – page 58

3.3.1 Electrical systems
3.3.2 Telecommunications systems
3.3.3 Water supply system
3.3.4 Fire protection system
3.3.5 Waste management systems
3.3.6 Fuel storage systems (e.g. gas, gasoline and diesel)
3.3.7 Medical gases systems
3.3.8 Heating, ventilation and air-conditioning (HVAC) systems.

Equipments and supplies: is divided in two sections:

3.4.1 Office and storeroom furnishings and equipment (fixed and movable)
3.4.2 Medical and laboratory equipment and supplies used for diagnosis and treatment.

A note at the end of this module suggests to the evaluators to take into account the characteristics of the hospital's location and if it is in hazard-prone area (e.g. floodplain areas, coastal areas subject to storm surge and tsunami, or near to seismic faults or hazardous facilities) according to the information collected in Module 1., "to assess the danger that hazards pose to nonstructural elements of the hospital".

Module 4 – **Emergency and disaster management**

"This module considers the level of the preparedness of a hospital's organization and personnel, and of its essential operations to provide patient services in response to an emergency or disasters. .....
Evaluation objectives for this module are to determine:
- *what organizational, personnel and operational aspects of the hospital should be considered for emergency and disaster management;*
- *what plans and capacities are available to enable the hospital to be ready to respond effectively to major emergencies and disasters, and to manage mass casualties;*
- *the relevant responses, ratings and score for this module of the Hospital Safety Index."*[45]

This module has 7 sub-modules, which cover a total of 40 items:
4.1 Coordination of emergency and disaster management activities
4.2 Hospital emergency and disaster response and recovery planning
4.3 Communication and information management
4.4 Human resources
4.5 Logistics and finance
4.6 Patient care and support services
4.7 Evacuation, decontamination and security

[45] Ibidem . page 112

This part should be considered and used to make/ or review and update by health authorities and management because hospitals need to be prepared to help the community, receive and treat patients in response to disasters when the hospitals are not damaged by the disasters.
Up to the present time in European Countries, contrary to other parts of the word hit by more catastrophic events, few hospitals have been destroyed or damaged by climate change related disasters. In the preceding parts they have been stressed, however, two aspects: the previsions of more serious risks also for European countries and a general low level of the consideration at various policy levels, as well as in hospital's management of the importance and urgency to take into consideration the preparedness for disaster's management.

3.5. Hospital Safety Index - HSI – An Overview of the ANNEXES

We have described the Guide relatively at length and we recommend the examination of the full document. Before concluding it is useful to have an idea of how the evaluation has been carried out. The document has, in fact, two types of forms:
Form 1. For the general information about the hospital
Form 2. For the "Safe Hospital Checklist"
Regarding the latter, which is the most indicative of the evaluation process, it is reported below one part of **Module 2 – Structural Safety** and of **Module 3 – Nonstructural Safety**

2.2 Building integrity	Safety level			Observations (evaluators' comments)
	Low	Average	High	
4. Structural system design *Safety ratings: Low = Poor structural system design; Average = Moderate structural system design; High = Good structural system design.*	☐	☐	☐	
5. Condition of the building *Safety ratings: Low = Cracks on the ground and first floors; Major deterioration caused by weathering or normal ageing; Average = Some deterioration caused only by weathering or normal ageing; High = No deterioration or cracks observed.*	☐	☐	☐	
6. Condition of the construction materials *Safety ratings: Low = Rust with flaking; cracks larger than 3mm (concrete), excessive deformations (steel and wood); Average = Cracks between 1 and 3 mm present (concrete), moderate and visible deformations (steel and wood) or rust with no flaking; High = Cracks less than 1 mm (concrete), no visible deformations; no rust.*	☐	☐	☐	
7. Interaction of nonstructural elements with the structure *Safety ratings: Low = Partition walls rigidly attached to the structure, suspended ceilings or facades interacting with the structures, damage would have significant effect on the structure; Average = Some of the preceding nonstructural elements interacting with the structures, damage would not affect the structure; High = There are no nonstructural elements affecting the structure.*	☐	☐	☐	
8. Proximity of buildings (for earthquake-induced pounding) *Safety ratings: Low = Separation is less than 0.5% of the height of the shorter of two adjacent buildings; Average = Separation is between 0.5% and 1.5% of the height of the shorter of two adjacent buildings; High = Separation is more than 1.5% of the height of the shorter of two adjacent buildings.* *IF THE HOSPITAL IS NOT IN A HIGH/MODERATE SEISMIC ZONE, THEN LEAVE BOXES BLANK AND PROVIDE COMMENT.*	☐	☐	☐	

3.1. Architectural safety	Safety level			Observations (evaluators' comments)
	Low	Average	High	
19. Major damage and repair of nonstructural elements *Safety ratings: Low = Major damage and no repairs completed; Average = Moderate damage, building only partially repaired; High = Minor or no damage, or building fully repaired.* *IF SUCH AN EVENT HAS NOT OCCURRED IN THE VICINITY OF THE HOSPITAL, LEAVE BOXES BLANK AND PROVIDE COMMENT.*	☐	☐	☐	
20. Condition and safety of doors, exits and entrances *Safety ratings: Low = Doors, exits and entrances in poor condition, subject to damage which would impede the function of this and other elements, systems or operations; entrance width is less than 115cm; Average = In fair condition, subject to damage but damage would not impede the function of this and other elements, systems or operations; or entrance width is less than 115cm; High = In good condition, no or minor potential for damage that would impede the function of this and other elements, systems or operations; and entrance width is equal to or larger than 115cm.*	☐	☐	☐	
21. Condition and safety of windows and shutters *Safety ratings: Low = Windows and shutters in poor condition, subject to damage which would impede the function of this and other elements, systems or operations (e.g. weak protective glazing); Average = In fair condition, subject to damage but damage would not impede the function of this and other elements, systems or operations; High = In good condition, no or minor potential for damage that would impede the function of this and other elements, systems or operations; protective glass (e.g. polycarbonate glazing, blast film) has been added in critical wards.*	☐	☐	☐	

What emerges from these forms makes evident that the value of the examination relays mostly in the knowledge, time and means available of the each evaluator and of his group.
The Guide makes at each step, as already mentioned, the note that national laws, norms and general official national guidance should be taken into account.
In addition, reference lists are provided for each module.
This is the example for Module 2.Stuctural Safety.
First the note:
"Although not specifically listed here, it is recommended that evaluators always refer to applicable national and local standards and building codes related to Module 2: Structural Safety when evaluating a facility."[46]

Then a long set of references follows, which include risk management documents, guidelines for designing healthcare facilities, norms for fire protection etc... according to what is applicable to the hospital being evaluated.

The reading of the complete document is certainly important to understand in depth what has been achieved in this case by a large group of experts, who have worked for years up to this second edition. Few other considerations will be exposed in the conclusions.

[46] Ibidem : page57

3.6 The Pan American Health Organisation (PAHO)

This organisation has been working, as reported above, with WHO and contributed in producing the 2008 version of the Guide for evaluator.

In addition it has produced a document titled "Smart Hospitals Toolkit", which aims to be "*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*"[47]

Smart Hospitals Toolkit and Components	Cost Benefit Analysis Full Reports
• pdfSmart Hospitals Toolkit - 2017 (4.4 MB) • pdfTechnical Standards for Retrofitting - A Guide (354.65 kB) • pdf Baseline Assessment Tool Workbook - Smart Initiative (5.14 MB)	• pdfPogson Hospital - St. Kitts &Nevis(1.12 MB) • pdfSt. Vincent Hospital (3.17 MB) • pdfCase Study: The Smart Hospital Project (4.28 MB)

This document is mostly targeted to situations characteristic of the Caribbean area, and covers events which are not climate change-related, such as earthquakes.

As previously mentioned, almost all our research focused on materials produced or diffused in English. What is directly concerned with health facilities has been documented in the references.

3.7 The concept of "Human Resilience"

As a final note in this section, we would like to draw attention to an article published in the American Journal of Preventive Medicine in 2008, written Mark E. Keim, who proposes to apply the concept of "resilience" to people.[48]

This contribution doesn't directly concern the hospital resilience, but it raises awareness of the impacts of climate change on human health as well as environment conditions.

In discussing the role of public health and relating human vulnerability to climate change, the author underlines the importance of the public health agencies, that are "uniquely placed to build human resilience to climate related disasters."

This article, dated 2008 has been followed by a large production by the same author and his group of documentation regarding disaster prevention and protection.

[47] http://www.paho.org/disasters/index.php?option=com_content&view=article&id=1742:smart-hospitals-toolkit&Itemid=1248&lang=en

[48] http://www.ajpmonline.org/article/S0749-3797(08)00687-9/fulltext

4. Essential factors to enhance the strategic role of health care facilities in climate change adaptation and disaster risk reduction

4.1 European Community Policy makers awareness

We have reported the difficulty of having a complete overview of the situation in Europe, due to the fact that the policies Member States are frequently presented in national languages and are only accessible through studies and research developed at European level with the appropriate translation facilities.

Our extensive literature research from English language resources has aimed to examine policies, strategies, guidelines at European Community level concerning the risks facing communities and health facilities from climate change.

The Directorate General Santé has been starting point. Its website defines its DG responsibility "*for EU policy on food safety and health and for monitoring the implementation of related laws*"[49]. The other Directorate General websites and documents examined were the ones of the DG Environment and DG Energy.

The search strategy in respect of the above DGs was conducted to identify if in the above DGs and other public entities acting under them, there was relevant documentation about:

- Climate change and health hazard mitigation and prevention
- Management of climate-related disasters or emergencies
- Consideration of healthcare facilities among the strategic infrastructure

The DG Santé produces two sets of documents: the health country profile[50] and Health at glance: Europe.[51]

The 'Health at a Glance: Europe report' *"provides a comparative overview, the profiles offer country-specific assessments of the strengths and challenges facing individual health systems*." The document is updated every two years. The last available is dated 2016.

The 'Country Health Profiles' are prepared by the OECD and the European Observatory on Health Systems and Policies in cooperation with the European Commission and they are published yearly. The last one was issued in 2017.

The profiles use a standard structure and methodology, but the content is adapted to what is relevant for each EU country. EU countries are not ranked according to their overall performance but assessed according to their national specificities and progress made. The

[49] https://ec.europa.eu/health/

[50] https://ec.europa.eu/health/state/country_profiles_en

[51] https://ec.europa.eu/health/state/glance_en

Country Profiles are published in English and in all EU languages in use in the Member Countries, all together 22.

A search into the profile of some States, using the strategy reported above produced the result that several EU countries have adopted policies against air pollution, a problem that is linked to the long terms effects of climate change and considered related also to anthropogenic factors, such as mobility and traffic pollution, heating systems in urban areas, etcetera.

No mention was found concerning healthcare systems nor healthcare infrastructure.

The DG Environment, is "*the European Commission department responsible for EU policy on the environment. It aims to protect, preserve and improve the environment for present and future generations, proposing and implementing policies that ensure a high level of environmental protection and preserve the quality of life of EU citizens. It also makes sure that Member States apply EU environmental law correctly and represents the European Union in environmental matters at international meetings*"[52].

We have already explored its most recent work on "climate change adaptation and disaster risk reduction in Europe". It is the EU Agency that provides useful information regarding adaptation, but again with no specific reference to healthcare facilities.

The DG Energy "*works to develop and implement the EU's energy policy – secure, sustainable, and competitive energy for Europe*".

That is, it deals with aspects related to increase energy efficiency, use of renewable sourced and in general policies for reduction of GHGs emissions. The DG has launched a platform called Build UP, which acts as the European Commission's interactive web portal, that provides access to provide a wide range of information on implementing the Energy Performance of Buildings Directive (EPBD).

Eurostat's statistical studies and data analysis [53] point out that the health care system is responsible for at least 5% of the GHGs production.

Build UP doesn't pay specific attention to the health facilities sector, so it may be supposed that healthcare services and their infrastructure are implicitly included in the general category of 'services'.

The general conclusion from the above research and findings is that the DGs which potentially have the closest links to the issue of the effects of climate change on healthcare infrastructure do not, in fact, demonstrate significant interest in this area.

[52] http://ec.europa.eu/environment/index_en.htm

[53] **Eurostat** is a Directorate-General of the European Commission located in Luxembourg. Its main responsibilities are to provide statistical information to the institutions of the European Union (EU) and to promote the harmonisation of statistical methods across its member states and candidates for accession as well as EFTA countries.

4.2 Hospital general and technical management understanding of the resilience factor

The 'top-down' overview of policies which address Climate Change disaster risk reduction has shown there is very little material from the main agencies of the European Union which directly addresses the need for public healthcare facilities to enhance their preparedness and resilience in the face of climate change-related disasters.

Such policies could have great importance, but we should also give due prominence to awareness and actions arising from the 'bottom-up'.

As a consequence, the authors of this research study considered it very important to have information from hospitals managers, whether general or technical, about their attitude in respect of the strategic role of hospitals, and actions undertaken or to be planned at local health authority level to assess and improve health care facilities resilience to climate-related disasters.

Our literature review revealed, as expected, that most such interventions have a sustainability focus, mostly on improvement of energy systems, or saving of natural resources (such as water), or on policies regarding waste and special hospital waste.

The lack of data from hospital managers suggested to the authors that it would be worthwhile to conduct a survey among managers and technicians of EU countries.

The survey will use a questionnaire, with a methodology similar to one successfully used during the RES Hospitals project. It aims to increase knowledge of the European situation with regard to the issue that can be summarized as: Hospital General and Technical Management understanding of the resilience factor. The word understanding includes the willingness to act in several directions, which have as basic condition the promotion of alliance with the governing bodies of the local governments and above.

A questionnaire has been prepared and it is attached as an Appendix**.** It has been executed in a test form within the framework of this study. In the case that IFHE-EU approves the initiative and decides to participate, a larger number of people will be involved.

The preparation of the questionnaire and of the modality of its administration was made by the research group enlarged to the Director of EuHPN, and an associate member, expert in ICT, with the supervision of the President and of a SIAIS working group, ad hoc created to carry out this study, as it has been done for other similar activities.

The few answers from the pilot don't have statistical significance, but this version was intended to test the instrument and to give a better possibility to communicate it, waiting for comments and suggestion, in case its use is approved.

4.3 Improvement of toolkits

Given the importance of climate change adaptation, and reduction of risks from extreme weather events, the agenda of EU policy makers should include healthcare system infrastructure and within this framework.

However, this is not the only activity in which IFHE –EU, SIAIS, EuHPN, and other non-profit European organisations should be involved: there is also an urgent need to improve the tools for supporting healthcare facilities to develop management strategies and actions for resilience. Some useful groundwork is reviewed in the following sections.

The Canadian work of Jaclyn Paterson

Paterson's research group has produced an article "Health Care Facilities Resilient to Climate Change Impacts" (see footnote 32). Here the authors begin by saying: "*Health care facilities will need to assess climate change risks and adopt adaptive management strategies to be resilient, but guidance tools are lacking*". Their study in fact developed a set of important indicators aimed to allow healthcare facility officials to assess resilience to climate change impact. Their toolkit consists of a checklist[54] for officials who work in areas of emergency management, facilities management and health care services and supply chain management, a facilitator's guide for administering the checklist, and a resource guidebook to inform adaptation. Their work was then used in six facilities of three Canadian Provinces. The long checklist presented is a relevant point of departure.[55]

Two USA documents from the U.S. Climate Resilience Toolkit

This toolkit stems from the National Oceanic and Atmospheric Administration, and is addressed to individuals, businesses and communities and aims to provide help in identifying "*climate vulnerabilities and select actions to address them."*[56]

There are five 'Steps to Resilience':

Step 1 – Explore Climate Threats
Step 2 – Assess Vulnerability & Risks
Step 3 – Investigate Options
Step 4 – Prioritise Actions
Step 5 – Take Action

[54]The check list n.1 relevant for the point made here, is attached as Annex of the report, for an easier consultation, but it will attached at the moment only for the presentation to the IFHE-EU ExCo meeting of March 22nd. The permission for re use is in fact still pending.

[55]One of the six provinces is Nova Scotia. The toolkit, "Health Care Facility Climate Change Resiliency Checklist" administered in 2013 by the Canadian Coalition for green healthcare – of Nova Scotia" CCGHC – Healthcare Facilities Resiliency Checklist, shows how the study of the Jaclyn Paterson has been used in a concrete action. http://greenhealthcare.ca/climateresilienthealthcare/.

[56] U.S. Climate Resilience Toolkit https://toolfit.climate.gov/topis/human-health/buildings-climate-resilience-health-sector

For each step there is a detailed description of the roadmap to follow to reach decision points, which are crucial for the strategic direction taken. The road defined should translate vulnerability level into a risk matrix. The document itself recognises that the path would result in a qualitative matrix, that would require other evaluations and algorithms to quantify risk.

This toolkit is clearly designed for the USA environment. For each step it provides the important sectors of Land Use, Building Design and Regulatory Context, and the American Society of Civil Engineers (ASCE), US Environmental Protection Agency, University of Michigan and U.S. Green Building Council and other Institutes and Universities are listed as sources of data and information.

Such an inventory would be extremely useful also for Europe, where many such important sources are relatively unknown or inaccessible, e.g. the Institute of Hazard and Risk Research of the University of Durham (UK)[57], and the ISPRA centre of JRC in Ivrea (Italy)[58]. Data banks in the EU Member States should also be mapped to help in creating suitable and relevant toolkits.

The U.S. Department of Health and Human Services, under the HHS Sustainable and Climate Resilient Health Care Facilities Initiative (**see note 29**),published in the Autumn of 2014 the document "Primary Protection: Enhancing Health Care Resiliency For A Changing Climate",

In Part 2 'The Current State of Health Care Infrastructure Climate Resilience to Extreme Weather Risks' and Part 3′Solutions for the Future Infrastructure Solutions for Improved Health Care Climate Resilience' five best practices were illustrated.

In Part 2 the document usefully categorises adaptation measures which respond to the risks of climate change–related events:

- *"Increasing design thresholds to recognize more severe weather **intensities** (design thresholds include design temperatures, wind velocities, mean flood elevations)*

- *Increasing warehousing and storage capacities to recognize more severe weather **durations** (increasing the minimum amounts of on-site food, water, and fuel storage)*

- *Enacting requirements for hardening facilities in new geographic regions to respond to changing extreme weather **frequencies and patterns** (adopting requirements for exterior*

[57] https://www.dur.ac.uk/ihrr/

[58] https://ec.europa.eu/jrc/en/about/jrc-site/ispra. JRC research supports the EU's aim of addressing, mitigating, monitoring and adapting to the effects of climate change. This includes assessing and monitoring the impact of climate change, evaluating the increased risk of climate change hazards, and assessing the sustainability of climate policies.

building envelope or electro-mechanical system resilience in geographic regions that have historically not required such measures but may be vulnerable in the future)

- *Increasing capabilities for "**islanding operation**" that recognizes that onsite infrastructure, staff, and supplies may be required for extended periods of time following weather events because of **damaged community infrastructure** (regional electrical grid, municipal potable water supplies, roads and transportation networks, communication systems) and that facilities may need to operate for more than 96 hours without aid from the community."*

The successive paragraph dedicated to **Hospital Resilience,** describes the procedures of USA regulations, codes and standards in the Country which underline the difficulties generated by the multiplicity of national state and municipal authorities that are involved in the definitions and updating of codes. This results in a lack of alignment between the editions of reference standards:

"*Following extreme events that include hospital evacuations, local regulations often shift to redefine, for example, minimum flood elevations and revise requirements for critical infrastructure placement. However, the wide variation in established practices leads to limited cross-industry sharing of lessons learned. Regional differences between extreme weather event types and limited understanding of future hazard risks further contribute to inconsistency of best practices."*[59]

The "National Response Framework for communitywide emergency planning" issued by FEMA (the Federal Emergency Managing Agency) indicate minimum requirements and is generally updated periodically and specifically after disasters.

The guide reports case studies that show how hospitals around the Nation have adopted adaptation and mitigation measures according to the past history of local disastrous events or possible future events, as the climate change related risks increase. Among those the most interesting for Europe situation are the ones related to temperature extremes:

- Heat and Cold Waves. University of South Alabama Medical Center, Mobile, Alabama
- Inland Flooding from Extreme Rain: Mercy Medical Center, Cedar Rapids, Iowa
- Drought and Wildfires: Memorial Hospital, Colorado Springs, Colorado

The details of these case studies can be found in the document of footnote 46.

[59] Page 10 of https://kresge.org/sites/default/files/Healthcare-Climate-Resilience-Guidance-HHS.pdf

Part 3 is dedicated to the "Infrastructure Solutions For Improved Health Care Climate Resilience". The table that follows synthesises the important elements and the related recommendations.

Element 1	Multi-hazard Assessment- Understanding Climate Risk	Maintain up-to-date data on climate hazards and infrastructure vulnerabilities, prepare risk assessments and use these to inform infrastructure planning and decisions. Keep a well-maintained data base of disaster losses.
Element 2	Land Use Planning, Building Design and Regulation	Understand the building regulatory, design and land use planning context within which the facility is situated. What codes were in place when the building was constructed? Is the enclosure vulnerable? What are the larger local and community land use issues, stormwater or other weather hazard management issues?
Element 3	Infrastructure Protection and Resilience	Not all hazards are destined to cause disasters. Pre-emptive measures can help avoid disruption, incapacitation or loss of use of critical infrastructure services. Invest, design and construct new sustainable infrastructure in appropriate locations and to a higher standard of hazard and climate resilience to withstand future events.
Element 4	Protect Vital Facilities and Functions: Clinical Care and Personnel	Hospitals serve essential functions during and after a disaster, as they continue to shelter patients in place as well as accommodate and treat survivors. ED's and imaging areas must remain operational. Nursing homes and residential facilities house medically fragile and vulnerable populations. Vital service functions: kitchens, laundry, etc, may also be vulnerable. Research facilities often house animals, years of valuable research samples and data. Understand priority and vulnerable functional needs and areas; prioritize resilience of those facilities. Understand personnel commuting patterns; put in place systems for accommodating personnel and families during and after events.
Element 5	Environmental Protection and Strengthening of Ecosystems	Protect ecosystems and natural buffers to mitigate floods, storm surges and other hazards to which your building, campus or city may be vulnerable. Adapt to climate change by building on good risk reduction practices.

For each of these defined 'elements' the guide provides a case study, that is, a hospital that has activated solutions in order to improve its resilience.

Among the important methodological tools that this guide provides, is the value is that it places on healthcare facilities, especially on hospitals, but addressing also aspects of other healthcare infrastructure, e.g. residential healthcare facilities for elderly, community based ambulatory facilities. They are considered strategically important and worthy of interventions for improving their resilience.

The guide recognises what seems to be disregarded by many other documents: healthcare infrastructure failures caused by extreme weather events ultimately disrupt the continuum of health care delivery when the community and people need more help and assistance, during such events and in their aftermath.

5. Conclusions

This study has been aimed to analyse a set issues concerning:

- *The level* of awareness and consequent preparedness of EU institutions in preventing risks and tackling disasters related to climate change in Europe.
- *The contributions* presented by international and national institutions regarding guidance and methods for mitigation and disaster risk reduction.
- *The factors* that need to be addressed for the recognition of health infrastructures, especially hospitals, strategic role in reducing risk and mitigating climate related disasters, that can be foreseen within the European Continent.

The conclusions will be focused on the points that should be, and we assume that will be, of interest to our organisations, that will propose ideas and activities to the Federation of Hospital Engineering and its Country Associations in performing their role of being a central hub for knowledge exchange, in response to the old and new challenges and needs of the healthcare engineering community as well as the society as a whole, are facing.

I.) The examination of the documents by European authorities, that are responsible for planning and orienting the implementation of adaptation strategies and policies for disaster risk reduction, has brought us to the conclusion that the major responsibility at EU level has been of the Environment Directorate General and its European Environment Agency. The latter has produced interesting reports, but it is clear that there are no studies and specific policies at the EU level that take into consideration the complete picture regarding climate change, related risks and the healthcare infrastructures strategic role.

In fact, the documentation available from the EU institutions indicate that their position is that the climate related risks and problems have to be considered "regional" and they should be dealt through the Cohesion Policy and "the funding opportunities for disaster risk management within EU Cohesion Policy".[60]
Moreover, it is known that type of funding is not available for all Members Countries. For the Agenda 2014-2020 the EU Countries eligible are reported in the note[61].

<u>One of the line of actions that comes from these documents is therefore to stimulate, at least in the Countries represented in IFHE –EU, initiatives aimed to raise the awareness of the need for a new approach and strategy by the European Institutions towards climate change risks.</u>

[60] http://ec.europa.eu/regional_policy/en/policy/themes/climate-change/ "Cohesion Policy plays an important role in supporting risk prevention efforts to adapt to the present and future impacts of climate change."
[61] http://ec.europa.eu/regional_policy/en/funding/cohesion-fund/ For the 2014-2020 period, the Cohesion Fund concerns Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and Slovenia.

This research, amongst others, has provided evidence of the vulnerability of our continent and that there are risks involving several, if not all, European Countries.
Common policies and strategies addressing adaptation and mitigation formulated by the EU Institutions would certainly enhance the national and regional policies of individual member states.

The above suggested actions have to be carried out in parallel by organisations like IFHE, SIAIS, the country members of pan-European organisations at the EU level in order to stimulate European Policies and Strategies. This activity should also focus on raising the awareness of the need to involve these infrastructure in planning and implementing adaptation strategies for the reduction of climate change-related disasters.
In those nations where hospitals are not recognised as strategic infrastructures, the first important goal would be to obtain the recognition of this status.

The President of the Austrian organisation, member of IFHE-EU has reported the success in reaching the recognition of the hospital as a strategic infrastructure only after three years of persistent action.

II.) AS stated the hospitals have to be considered strategic institutions for the risks prevention plans and strategies and for the disaster mitigation. To perform these roles, naturally, they have to part of a network of territorial highly coordinated activities. In this regard, we have previously stressed, that it is not accettable the fact that that the Covenant of Mayors, an organisation that is becoming increasingly important at European level, seems to not consider health institutions and facilities in their programs [62]

An activity of our organisation should therefore be to interact with the Covenant of Mayors and other selected prominent organisations at European level, as well as national level in order to make them reach a different understanding of the importance of the health sector and of healthcare infrastructures.

III.) The study has analysed the documentation that has been produced outside of Europe and the work done by relevant worldwide organizations. Important contributions come from the nations that have suffered many disasters and were able to learn from them. These nations are USA and Canada, which have strong central government agencies, and lower levels of decision making authorities. They have to face a divers geographic situations with a large variety of climate change-related risks and disasters, The coordination between the national and lower levels of planning and organizing the interventions have been the key for been able to provide fast and efficient help.

[62] That is made evident also the "Sustainable Energy and Environment Action Plans" –SEEAP produced by municipalities of Europe members of the Covenant of Mayor which in most of the cases don't involve health infrastructures in such plans.

The other relevant contribution, that we have presented in the report, is coming from WHO. This worldwide institution has been working, for more than two decades on the need to have safe hospitals. In 2015 it has produced the second edition of the most comprehensive guideline/check list for evaluators of hospital conditions. We have commented the WHO documents and the fact that the typology of risk and disasters taken into account suggests that their studies addressed parts of the world outside Europe. This obviously does not undermine the importance of the contribution,

In the complementary document "Comprehensive Safe Hospital Framework" it is stated that "seventy-seven countries across the world have reported that they are implementing safe hospitals activities". No further information is given on the countries nor on the nature of the implementation. The major points are that not even the impressive work of WHO can be qualified as a toolkit. In fact it is presented as "Guide for Evaluators".

The next and relevant step is to go towards a toolkit focused on climate change. The framework of a common methodological work should include the flexibility of being further adaptable in countries or in areas facing the same risks. The variety of other differentiation, including the one deriving from different norms and laws, should be studied and taken into account. It is clear that this would required a large amount of work by specialised working groups.
The impressive production of WHO is an example.

It could be envisaged that a group of promoter, of which IFHE – EU could be an originator in alliance with WHO and other institutions and associations, e.g. the mentioned Covenant of Mayors, could induce the European Commission to engage in constituting and funding such a research work, maybe in the renewed Framework Programme 9, that is under preparation. There is no doubt that to reach such objective it would require policy making power at European level and involvement in many scientific areas, in addition to hospital engineering.

From the hospital engineering point of view this is not even the final point of arrival which is the possibility to produce methods that can give flexibility regarding the potential risks of each facility, the appropriate set of tools, algorithms, etc, for evaluating the level of resilience related to such risks, and the knowledge base for comparing social and economic benefits of increasing resilience with the costs of improvement.

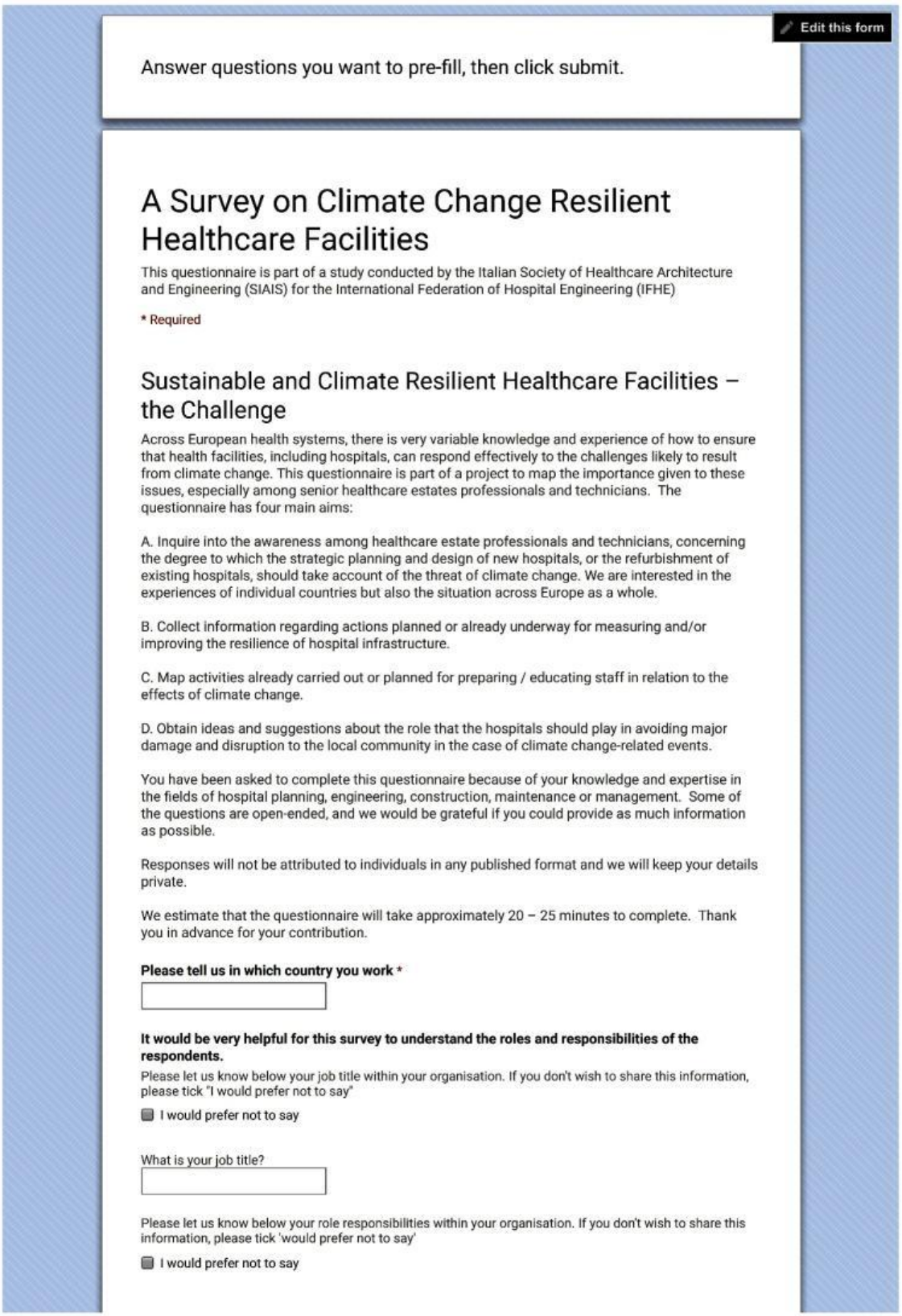
Such a consideration stimulates the final proposal for further action by IFHE – EU.
The point of departure is the question we raised in proposing this study: <u>is hospital resilience necessarily an aspect to be considered of importance with priority for policy makers at all levels, especially among the management of hospitals?</u>
Since we believe that IFHE – EU has a significant presence of several EU Countries, it would be important to start by knowing the level of this awareness present in the respective countries.

To acquire this knowledge is fundamental; therefore, at the conclusion of the study, the authors propose to IFHE-EU, SIAIS, their members and also to associated organisations, such as EuHPN, to conduct an survey, be distributed to general and technical hospital managers, as well as healthcare policy makers, in order to acquire some knowledge of the present perception of the climate change risks and needs with focus, among others on hospitals resilience.
A draft of the questionnaire is attached (Appendix 6). Maybe other members of IFHE – EU have already collected data or can have suggestions to change and improve this draft. A specific plan should be agreed at ExCo level and then proposed to each national member association for its implementation.

This effort and the consequent knowledge could become the beginning of a bottom up initiative, which could provide a common focus on the best practice around Europe, and could contribute in developing an integrated approach between hospitals (and more generally, healthcare facilities), local governments and communities in adapting and mitigating the worst effects of climate-related impacts.
The success of this set of actions would have an impact on higher levels of policy makers in the direction mentioned above and allow the hospitals to be recognised in their strategic role in one of the most important "battle" of our time.

For SIAS Working Group
Daniela Pedrini and Simona Ganassi Agger

6. Appendix: pilot questionnaire



Edit this form

Answer questions you want to pre-fill, then click submit.

A Survey on Climate Change Resilient Healthcare Facilities

This questionnaire is part of a study conducted by the Italian Society of Healthcare Architecture and Engineering (SIAIS) for the International Federation of Hospital Engineering (IFHE)

* Required

Sustainable and Climate Resilient Healthcare Facilities – the Challenge

Across European health systems, there is very variable knowledge and experience of how to ensure that health facilities, including hospitals, can respond effectively to the challenges likely to result from climate change. This questionnaire is part of a project to map the importance given to these issues, especially among senior healthcare estates professionals and technicians. The questionnaire has four main aims:

A. Inquire into the awareness among healthcare estate professionals and technicians, concerning the degree to which the strategic planning and design of new hospitals, or the refurbishment of existing hospitals, should take account of the threat of climate change. We are interested in the experiences of individual countries but also the situation across Europe as a whole.

B. Collect information regarding actions planned or already underway for measuring and/or improving the resilience of hospital infrastructure.

C. Map activities already carried out or planned for preparing / educating staff in relation to the effects of climate change.

D. Obtain ideas and suggestions about the role that the hospitals should play in avoiding major damage and disruption to the local community in the case of climate change-related events.

You have been asked to complete this questionnaire because of your knowledge and expertise in the fields of hospital planning, engineering, construction, maintenance or management. Some of the questions are open-ended, and we would be grateful if you could provide as much information as possible.

Responses will not be attributed to individuals in any published format and we will keep your details private.

We estimate that the questionnaire will take approximately 20 – 25 minutes to complete. Thank you in advance for your contribution.

Please tell us in which country you work *

It would be very helpful for this survey to understand the roles and responsibilities of the respondents.

Please let us know below your job title within your organisation. If you don't wish to share this information, please tick "I would prefer not to say"

I would prefer not to say

What is your job title?

Please let us know below your role responsibilities within your organisation. If you don't wish to share this information, please tick 'would prefer not to say'

I would prefer not to say

What are your responsibilities in your role?

A. Inquire into the awareness among healthcare estate professionals and technicians, concerning the degree to which the strategic planning and design of new hospitals, or the refurbishment of existing hospitals, should take account of the threat of climate change. We are interested in the experiences of individual countries but also the situation across Europe as a whole.

A1. Do you think that the potential effects of climate change is an important issue for the strategic planning and design of hospitals, whether new or refurbished? *

- YES
- NO
- NO OPINION

How would you rate the importance of the issue on a scale 1 to 5, with 1 the least important and 5 the most important *

- Least important
- Somewhat important
- Fairly important
- Quite important
- Most important

Please indicate the most important reasons for your evaluation? *

Why don't you consider this issue important?

If this is not an important issue, which ones are the important ones, in relation to the strategic planning and design of hospitals?

B. Collect information regarding actions planned or already underway for measuring and/or improving the resilience of hospital infrastructure.

B1. Does your organisation's management already have ways to measure, and to improve, the resilience of hospital infrastructure? *

- ○ YES
- ○ NO

Please indicate if the interventions concern:

- ☐ The built environment
- ☐ The electrical system
- ☐ The heating and ventilating system
- ☐ Measures in the area surrounding the hospital
- ☐ Other:

B2. Is your hospital organisation actively planning to improve the resilience of the physical infrastructure? *

- ○ YES
- ○ NO

Can you describe what is involved in the measures planned or being planned

- ☐ The built environment
- ☐ The electrical system
- ☐ The heating and ventilating system
- ☐ Measures in the area surrounding the hospital
- ☐ Other:

B3. If the issue of the hospital's resilience is not a priority for the organisation's management, do you agree with this view? *

- ○ YES
- ○ NO
- ○ NO OPINION

Please give us your reasons:

C. Map activities already carried out or planned for preparing / educating staff in relation to the effects of climate change.

C1. Has your hospital management organised activities to assure that staff are prepared to cope with extreme weather events, where these will result in mass casualties or extensive requests for hospital support? *

- ○ YES
- ○ NO

Please give a description of these activities, indicating which staff groups were involved.

C2. If your hospital management has not organised activities to assure that staff are prepared to cope with such extreme weather events, is it planning to do so? *

- YES
- NO
- NOT APPLICABLE

Please give a description of these activities, indicating which staff groups were involved.

C3. If no such activities have taken place, and are not planned to take place, do you think this should be prioritised by the management of the hospital organisation? *

- YES
- NO

D. Obtain ideas and suggestions about the role that the hospitals should play in avoiding major damage and disruption to the local community in the case of climate change-related events.

D1. Do you think that hospitals should contribute to mitigating the effects of climate change through: *

- Reducing resource use
- Reducing fossil fuel use
- Reducing emissions of greenhouse gases of buildings
- Reducing transportation impacts
- Reviewing the environmental performance of the supply chain
- Other:

D2. Do you think that the hospital should contribute to preparedness in coping with extreme weather events and support the community by: *

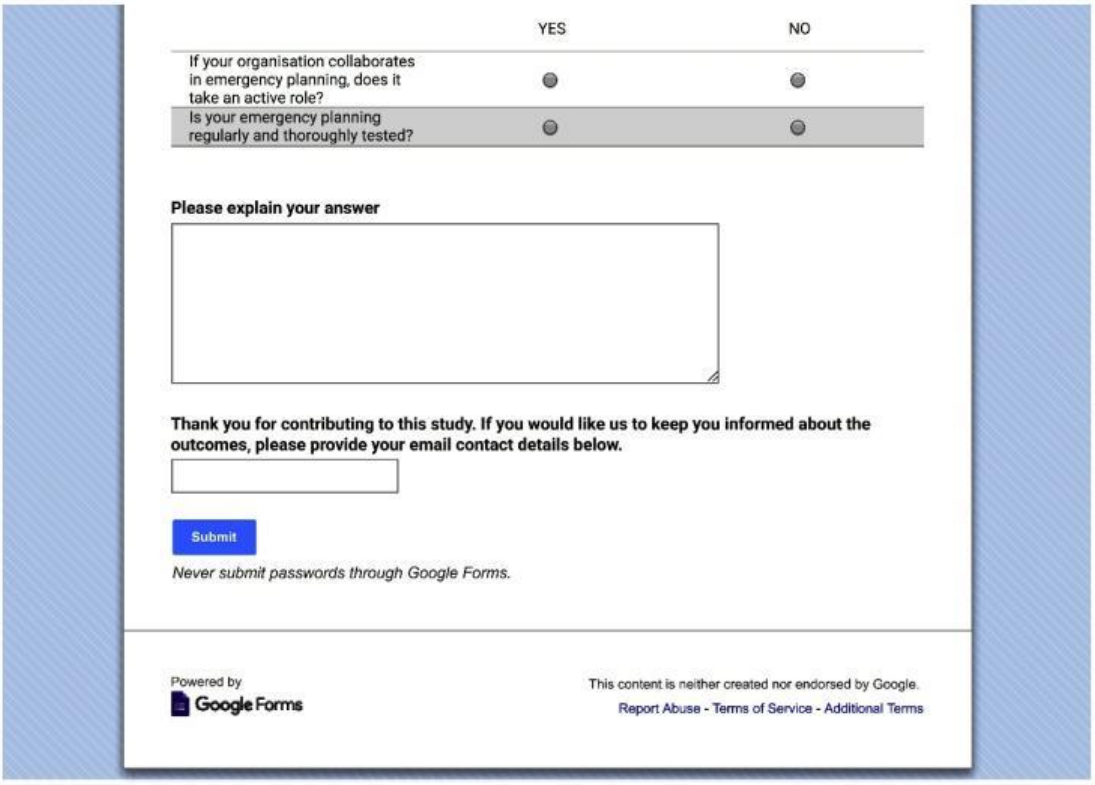
- Improving its infrastructure
- Including in its strategic planning engagement with the community
- Getting involved in sustainability and educational initiatives on climate change awareness

D3. Does your hospital organisation's management collaborate with other civil agencies or authorities in your community or region to mitigate the effects of climate change? *

- YES
- NO

Please answer the following questions: *

	YES	NO
Does your hospital organisation plan for emergencies in common with other civil agencies?	○	○



	YES	NO
If your organisation collaborates in emergency planning, does it take an active role?	○	○
Is your emergency planning regularly and thoroughly tested?	○	○

Please explain your answer

Thank you for contributing to this study. If you would like us to keep you informed about the outcomes, please provide your email contact details below.

Submit

Never submit passwords through Google Forms.

Powered by Google Forms

This content is neither created nor endorsed by Google.
Report Abuse - Terms of Service - Additional Terms

7. References

Note for the reader:

The footnotes, with links to relevant documentation consulted for the study, are listed in the first part of the references, just as a matter of facilitating the consultation. In the second part are indicated books or other contributions for scholars interested in pursuing the many issues of the themes we have started to explore here. This documentation is mostly accessible through online sources.

Part 1

01.EU Parliament - DG INTERNAL POLICIES OF THE UNION Policy Department Economic and Scientific Policy Climate Change "Climate Change and Natural Disasters: Scientific evidence of a possible relation between recent natural disasters and climate change"
(IP/A/ENVI/FWC/2005-35) Briefing Note –IPOL/A/ENVI/2006_19
02. Intergovernmental Panel on Climate Change (IPCC) has been producing reports on these matters starting in 2001 http://www.ipcc.ch/ipccreports reachable through http://www.ipcc.ch/
03. www.thelancet.com/panetary-health. Other contribution are in: https://www.journals.elsevier.com/the-lancet-planetary-health/recent-articles
04. http://ar5-yr.ipcc.ch/ipcc/ipcc/resources/pdf/IPCC_SynthesisReport.pdf
05. European Environment Agency: "Climate change adaptation and disaster risk reduction in Europe" EEA Report/No 15/2017 – EEA publics periodical reports
06. See document reported in footnote 1.)
07. IPCC – 2011 report http://www.ipcc.ch/report/srren/
08. www.icpdr.org/main/sites/default/files/nodes/documents/icpdr_floods-report-web_0.pdf
09. hhttps://www.theguardian.com/world/natural-disasters
https://www.theguardian.com/world/2016/jun/02/deaths-as-flash-floods-hit-france-germany-and-austria
10. www.bbc.com/news/world-europe-40554842
11. http://www.bbc.com/news/world-europe-42856634
12. EEA report see document 05
13. On cold waves https://en.wikipedia.org/wiki/Cold_wave
14. http://metro.co.uk/2018/03/02/__Newspaper on line
15. EEA report – see document 05
16. EEA report - see document 05
17. Joint Research Centre of European Commission JRC Technical Reports – 2017 "Covenant of Mayors: key criteria for adaptation to climate change in local plans" PdF EUR 28730 EN
18. https://ec.europa.eu/jrc/en/publication/covenant-mayors-key-criteria-adaptation-climate-change-local-plans
19. https://ec.europa.eu/jrc/en/publication/resilience-large-investments-and-critical-infrastructures-europe-climate-change
20. Increasing risk over time of weather-related hazard to the European population: a data-driven prognostic study" – www.thelancet.com/planetary-health Vol 1 August 2017
21. study, published in December 2017 by BioMed Central in the category of Environmental Health, reports on the "Impact of extreme weather events and climate change for health and social care systems"
https://www.ncbi.nlm.nih.gov/pubmed/29219105
23. Flood Risk Management Plan for the Danube River Basin District by International Commission for the Protection of the Danube River - ICPDR
https://www.icpdr.org/main/sites/default/files/nodes/documents/1stdfrmp-final.pdf
24. European Climate Adaptation Platform Climate-Adapt
http://climate-adapt.eea.europa.eu/eu-adaptation-policy/strategy
25. The European Environment Information and Observation Network – EIONET
http://www.eionet.europa.eu/
26. UN and International Strategy for Disaster Reduction (ISDR)
https://www.unisdr.org/2009/campaign/pdf/wdrc-2008-2009-information-kit.pdf
27. Gary Cohen, Presidente and founder of Health Care Without Harm www.noharm.org
28.The Oceanic Atmospheric Administration US Toolkit https://toolkit.climate.gov/content

29. US Department of Health and Human Services https://toolkit.climate.gov/topics/human-health/building-climate-resilience-health-sector
30.https://toolkit.climate.gov/sites/default/files/SCRHCFI%20Resource%20Sheet%20Composite%20082615.pdf
31.Kresge Foundation aimed to expand opportunities in America's cities
https://kresge.org/sites/default/files/Healthcare-Climate-Resilience-Guidance-HHS.pdf
32. see the preceding 31.
33.National Centre for Biotechnology Information – National Library of Medicine – National Institutes of Health have contributed in the diffusion of the article referred in this report:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4276665/
34. Canadian contribution to the resilience of healthcare facilities
http://www.greenhealthcare.ca/climateresilienthealthcare/
35. Australian Government frame work: http://www.environment.gov.au/climate-change/adaptation/publications/national-climate-change-adaptation-framework
36. World Health Organisation: "Framework for an holistic understanding on how to build resilience of health systems: http://www.who.int/globalchange/publications/building-climate-resilient-health-systems/en/
37. see document 36
38. Pan American Health Organisation – PAHO contribution
http://www.paho.org/disasters/index.php?option=com_content&view=article&id=1742:smart-hospitals-toolkit&Itemid=1248&lang=en
39. American Journal of Preventive Medicine – article on building human resilience
http://www.ajpmonline.org/article/S0749-3797(08)00687-9/fulltext
40. European Community Directorate General for Health: https://ec.europa.eu/health/
41. European Countries health profile https://ec.europa.eu/health/state/country_profiles_en
42. European Countries updating: https://ec.europa.eu/health/state/glance_en
43. EU Directorate General for Environment: http://ec.europa.eu/environment/index_en.htm
44. Eurostat is a Directorate-General of the European Commission having as its main responsibilities to provide statistical information to the institutions of the European Union (EU)
https://ec.europa.eu/eurostat
45.Canadian contributon to healthcare facilities resilience http://greenhealthcare.ca/climateresilienthealthcare/.
46. U.S. Climate Resilience Toolkit https://toolfit.climate.gov/topis/human-health/buildings-climate-resilience-health-sector
47. Durham University Institute of Hazard Risk and Resilience: https://www.dur.ac.uk/ihrr/
48. https://ec.europa.eu/jrc/en/about/jrc-site/ispra
49. see reference n. 35

Part 2

2.01 EEA, 2012a, Climate change, impacts and vulnerability in Europe 2012, EEA Report No 12/2012, European Environment Agency.
2.02 EEA, 2016b, Mapping and assessing the condition of Europe's ecosystems: Progress and challenges, EEA Report No 3/2016, European Environment Agency.
2.03 EEA, 2016c, Urban adaptation to climate change in Europe 2016 — Transforming cities in a changing climate, EEA Report No 12/2016, European Environment Agency.
2.04 EEA, 2017a, Climate change, impacts and vulnerability in Europe — An indicator-based report, EEA Report 1/2017, European Environment Agency.
2.05 IPCC, 2014a, 'Annex II: Glossary', in: Barros, V. R., Field, C. B., Dokken, D. J., et al. (eds), Climate change 2014: Impacts, adaptation, and vulnerability — Part B: Regional aspects — Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom, pp. 1757–1776.
2.06 IPCC, 2014b, Climate change 2014: Impacts, adaptation and vulnerability — Part B: Regional aspects — Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom
2.07 UNISDR, 2009, 2009 UNISDR terminology on disaster risk reduction, United Nations International Strategy for Disaster Reduction, Geneva, Switzerland.

2.08 UNISDR, 2017, 'Terminology'
(http://www.preventionweb.net/english/professional/terminology/). accessed July 2017.
2.09 UN, 2015, Sendai Framework for Disaster Risk Reduction 2015–2030, United Nations Office for Disaster Risk Reducton, Geneva, Switzerland.
2.10 JRC, 2015, Guidance for recording and sharing disaster damage and loss data: Towards the development of operational indicators to translate the Sendai Framework into action, JRC Science and Policy Reports, Joint Research Centre, Ispra, Italy.
2.11 UNFCCC, 2014, UN Framework Convention on Climate Change - Synthesis report on methods and tools for, and good practices and lessons learned relating to, adaptation planning processes addressing ecosystems, human settlements, water resources and health, and good practices and lessons learned related to processes and structures for linking national and local adaptation planning, UN Framework Convention on Climate Change, Bonn, Germany.
2.12 UNFCCC, 2015, Adoption of the Paris Agreement, UN Framework Convention on Climate Change, Bonn, Germany.
2.13 UNFCCC, 2016, Marrakech action proclamation for our climate and sustainable development, UN Framework Convention on Climate Change, Bonn, Germany.
2.14 EC, 2016, Mayors Adapt Knowledge Base Strategy: 'Urban adaptation knowledge gaps in Europe', Executive Summary for European Commission, EC.
2.15 EEA, 2016, Urban adaptation to climate change in Europe 2016 — Transforming cities in a changing climate, EEA Report No 12/2016, European Environment Agency.
2.16 EEA, 2017, Financing urban adaptation to climate change, EEA Report No 2/2017, European Environment Agency.
2.17 New York City Chapter of the American Institute of Architects [NYC AIA]. (2013). Building better, building smarter: Opportunities for design and development. Retrieved from http://postsandyinitiative.org/wp-content/uploads/2013/05/Post- Sandy-Report_Full.pdf
2.18 FEMA https://www.fema.gov/media-library-data/20130726-1609-20490-1678/fema577.pdf The book “Design Guide for improving Hospitals safety” has also indication of other book published by FEMA in the Risk Management Series.
2.19 https://share.kaiserpermanente.org/article/kaiser-permanente-brings-health-focus-to-2015-paris-climate-summit/ Health Care as Part of the Climate Problem and Part of the Climate Solution
2.20 FACT SHEET: Strengthening the Climate Resilience of the Health Care Sector https://obamawhitehouse.archives.gov/administration/eop/ceq/Press_Releases/December_15_2014
2.21 Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R et al., 2009. Managing the health effects of climate change. London: The Lancet, Vol 373, no. 9676, pp.1693—733
2.22 http://greenhealthcare.ca/wp-content/uploads/2016/10/GS02-03_Paterson_CRHNet_2013-11-06.pdf
2.23 For links to publications and guidance on the impacts of climate change on delivery of health services see http://www.energysavingtrust.org.uk and follow the links from England to Nottingham/ Nottingham-Declaratoin/localservices/Health/health-trusts
2.24 'DeDeRHECC' project on adapting hospital buildings to be resilient to hotter temperatures: http://www.arcc-cn.org.uk/
2. 25 Kaiser Permanente - Emergency preparedness http://www.calhospitalprepare.org/hazard-vulnerability-analysis
2.26 BIOPICCC project https://www.dur.ac.uk/geography/research/researchprojects/biopiccc/.
2.27 Research Centre UK http://www.rcuk.ac.uk/research/xrcprogrammes/lwec/
LWEC - Living With Environmental Changes http://www.lwec.org.uk/

Cover Photos - credits

Top left - Memorial Medical Centre in New Orleans - **Photo: Bill Haber | AP (Associated Press)**
Top right – Methodist Hospital in New Orleans- **- Photo: John McCusker, Times-Picayune archive**
Bottom right - Joplin Saint John’s Medical Centre – **Photo:: AP/Mark Schiefelbein**
Bottom left - Hospital complex **Picture FEMA News Foto**